G.A. AVETISYAN

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APIMONDIA PUBLISHING HOUSE
1978

Gurghen Artashesovich AVETISYAN

FOREWORD

I am very pleased to present to the English speaking readers the book "Apiculture" written by one of the steadiest promoters of the biological reality, one of the most active researchers of this reality in the world of the bee — Professor Gurghen Artashesovich AVETISYAN.

Chief of the Genetics and Apiculture Chair of the Agriculture Academy "Timiriazev", Moscow, since 1956, professor AVETISYAN, though 70 years old, is a tireless leader and adviser of his students and of a great number of famous specialists. Author of apicultural films, participant in expeditions in the Far East, in the North of Russia or in India, he is a permanent example of an active scientist. His lectures with the Academy, a modern combination of theory and practice which the future graduates will be faced with, are attended, every year, by students from various countries who come to specialize in apiculture.

His lectures delivered during one of the post-university courses at the International Beekeeping Technology and Economy Institute in Bucharest are still in our minds and were an example of advanced ideas in apiculture.

As a recognition of his special merits in his teaching and research activity and as a token of appreciation for his broad orientation in one of the Soviet apicultural schools, APIMONDIA has elected him among his honorary members. In the present book, starting from the place and role of apiculture in the national economy, the author understood to impart his comprehensive scientific and didactic beekeeping experience, and its application in the social-economic practice of the Soviet apiculture and agriculture, under the pedoclimatic conditions specific to the various zones where bees are kept. In addition to presenting the apiculture in the USSR, reference is also made to the pertinent aspects of apiculture in a number of other countries.

Approached from the point of view of the biologist, professor and beekeeper, here are clearly presented the ways and means of keeping bees, the application of advanced and high productivity techniques and the increase of economic efficiency as well as other necessary knowledge for the management of beekeeping units.

Special attention is granted to the peculiarities connected to the preparation of the bee colonies for foraging, to the rearing of queens and selection of bees, to the migratory beekeeping and production of package bees.

Written as a manual for the students of agronomic and zootechnical universities, this book is also a practical and efficient instrument for the multilateral training of beekeepers especially of those who are working in commercial apiaries.

I warmly recommend this book which appeared in Russian at the KOLOS Publishing House in 1975 both as a manual for the beekeeping students and as a means for the reader to get acquainted to the achievements of the Soviet apiculture which are presented by this great professor and distinguished friend of the beekeepers everywhere.

Prof. Dr. Eng. V. HARNAJ
President of APIMONDIA

INTRODUCTION

The Importance of Apiculture for National Economy. The importance of this branch is determined on the one hand by the existence of numerous valuable products obtained directly from the apiary and on the other hand by the huge part played by the honey bees in cross pollination, increase of crop and improvement of quality of the entomophilous farm seeds and fruit yields.

The honey produced by most bees is a valuable food, with therapeutical and dietetic qualities. Unlike common sugar (sucrose-disaccharide), which is usually met in consumption, honey is mainly made up of monosaccharides, which are easily and directly assimilable by the human body. During the process of turning the floral nectar into honey, the most disaccharides are decomposed under the action of invertase secreted by special glands of the bee, into glucose and fructose — simple sugars. Floral honey contains 75—80% glucose and fructose. Ripe honey has a 18—20% water content. Honey also boasts salts of hydrochloric, phosphoric, carbonic and sulphuric acid, easily assimilable by the human body, as well as mineral substances (ferrum, manganese, calcium, magnesium, sodium, cobalt, etc.) necessary for the latter's normal development. Honey also includes small quantities of enzymes (invertase, diastase, catalase, etc.) and vitamins. Honeys are differentiated by their specific flavour and the different oils that lend them a pleasant, characteristic aroma. Honey has bactericid properties. From times immemorial it has largely been used not only as a valuable food but also as a therapeutical means in treating gastric and intestinal affections as well as against other diseases. Honey contributes to the improvement of the general condition of the human body. It is highly efficient with children. Honey is used in confectionary and beverages e.g. mead etc.

The average annual marketable honey production in the USSR ranges between 120 and 150 thousand tons.

The second important bee product is beeswax. Three quarters of the wax obtained in the country under the form of raw material is processed by factories producing comb foundation for apiaries. The remainder is used in several important industries : the electrotechnics and radiotechnics — for turning out insulating materials and condensers, aviation — for various covering and imbibing emulsions, in textile and leather industries, wood-processing industry, pulp and paper industry, glass industry, laquers and dyes industry, perfumery and pharmaceutical industry, etc. Wax is used to prepare grease for skis, for moulds in sculpture and it is also part and parcel of grafting mastic.

In addition to honey and wax, further products are obtained from honey bees: bee venom, royal jelly, propolis and pollen. *Bee venom*, under the form of preparations turned out by pharmaceutical industry, is used for treating radiculitis, sciatica, polyarthritis, rheumatism and other diseases. The preparations with royal jelly (Apilac and others) are used in medical practice for treating cardiovascular diseases and for activizing hematopoiesis. *Royal jelly* is used in perfumery, in preparing special creams and ointments. *Propolis*, which has bacteriolytic properties, has been lately used in human and veterinary medicine to an ever greater extent, in treating a great number of diseases. Finally, *pollen* has aroused a great interest among the physicians and dieteticians in this country and abroad: it possesses a high content of vitamins and mineral substances and it holds an important place in the marketable production of sovkhozes specialized in bee keeping. With every passing year increasing numbers of *queens* and *package bees* are produced.

Thus, in 1973 the breeding apiaries sold over 300,000 queens and 50,000 package bees.

The pollination of entomophilous crops by honey bees acquires a great economic importance in the large-scale farm approach. In the areas of intensive farming, in the conditions of concentrating and specializing agriculture, bee-keeping becomes an important help for growing crops and improves the quality of fruit and seeds with many entomophilous, fodder, fruit, berry, leguminous, technical and medicinal crops.

The evolution of the higher flower plants has been conditioned by the evolution along times of pollinating insects. In the process of evolution special adaptions have developed ensuring the cross-pollination of plants by insects preventing pollination of flowers with their own pollen.

The role of cross-pollination in increasing crops has been known by farmers from times immemorial. The possibility of artificial pollination of date palm was discovered in ancient Assyria, several thousand years B. C. The plant-growers knew the capacity of pollen to preserve its fertilization capacity for many years and they stored male inflorescences for artificially pollinating the female flowers.

The first attempts in Australia of using imported clover for producing seed crops failed. The clover grew, developed and bloomed in the best of conditions but it did not set seed because pollinating insects missed from Australian fauna. It was only after the importation of bumble bees, then of honey bees, that the production of clover seeds became possible. The same was true with fruit-trees.

Two centuries ago the famous agronomist A. T. Bolotov wrote that "the fertilization of seeds is possible not only by means of wind..." but also "with the help of insects, especially bees..."

Charles Darwin theoretically grounded the importance of cross-pollination of plants in his work "Action of Cross-Pollination and Self-Pollination in the World of Plants". For 11 years he had made experiments with 57 plant species after which be reached the conclusion that in case of self-pollination either seeds and fruit were not produced, or if any, the crops were low and of poor quality. Cross-pollination contributes to essentially increasing yield and improving the quality of seeds and fruit.

The productivity and vitality of plants resulted from seeds obtained by cross-pollination and their capability of resisting unfavourable weather conditions are higher than with plants resulted from self-pollination. These advantages are preserved by future plant generations too. Similar conclusions were reached by K. A. Timiriazev and I. V. Michurin. Increased vitality, higher seed and fruit yield and improved quality can be obtained when flowers are pollinated with a great amount of pollen coming from different varieties, the selectivity of fertilization being at the same time ensured.

The biological importance and the efficiency of cross-pollination of entomophilous crops are heightened by the conditions of concentrating, specializing and modernizing farming practice.

Unlike small farms, in the large farms the massive entomophilous crops which flower simultaneously cover huge areas and the pollination cannot be ensured by wild insects (bumble bees, solitary bees, etc.) whose number drops with every passing year. Under these conditions, the main pollinating agents of entomophilous plants are honey bees. The fact worthy of mention is that the higher the level of agrotechnics and farming and the better the conditions of plant growing and developing, — the more efficient proves to be cross-pollination as well as the indisputable increase of crops. Soil amelioration, irrigation, fertilizing — techniques largely used in our country — contribute to a higher nectar secretion of plants, to their being more frequently visited by bees and to a more efficient cross-pollination of flowers.

The long-term plans concerning the development of agriculture in the USSR include the increase of agricultural crops especially on account of a more rational use of the farming areas and the increase of crops productivity.

The pollination by bees of entomophilous crops is one of the main reserve for fulfilling this task on an all-country level. In 1973 the ministries of agriculture and the ministries of sovkhozes in the union republics forwarded measures to be taken for developing bee-keeping and improving the use of bees for pollinating the agricultural crops in kolkhozes and sovkhozes. Under these circumstances, a part of the expenditure for maintaining the apiaries (from 20 to 60%) used for pollinating entomophilous crops, must be recovered from the respective outputs.

About 150 species of entomophilous plants are cultivated in the Soviet Union, which need cross-pollination by bees or by other insects. They are stretching over 20 million hectares. The economic efficiency of the crop pollination by bees has been demonstrated by the following examples.

As it is well known, leguminous plants are very important for improving the fodder base in animal breeding, for turning to best use crop rotation and for increasing the soil fertility. The leguminous seed plots cover more than 1.8 million hectares (red clover over 0.91 million hectares, lucerne — 0.40 million hectares). Nevertheless, the present amounts of seed of leguminous plants do not meet the ever growing requirements of beekeeping. The cause is the low productivity : about 1 quintal of clover and lucerne and less than 4 quintals of seed of sanfoin for 1 hectare. In the conditions of a correct organization of pollination of the seed crops, the seed yield can double.

Thus in the "Miloslavski" sovkhoze (Moghilevsk region, the Bielorussian SSR), where 120 bee colonies have been used for pollinating 100 hectares of red clover seed crop 248.3 quintals of seed were scored. On many farms of the Baltic Republics 2 to 3 quintals of clover seed crops per hectare are obtained thanks to bee-pollination; the "Tynia" kolkhoze (Liepaiski region, Letonian SSR) has obtained seed yield of 5.2 quintals per hectare, in the conditions of saturation of crops with bees.

Employment of bee pollination yields good results in oil plants, especially in sun-flower crop, which occupy about 4.5 million hectares in our country.

The self-pollination is hampered at the flowers of this plant by the maturation at different times of male and female reproduction organs (proterandry). The sun flower inflorescence (capitulum) holds 1,000—2,000 flowers whose blossoming starts from peripheral areas to the centre. In the first day takes place the so-called male stage of the flowering, the anthers open and the pollen is collected by insects. It is only the next day, that the stigmas of the pistils mature and become apt for taking over the pollen for fertilization and that is why they are fertilized by the pollen of another plant.

According to the data issued by the apicultural chair of the "Timiriazev" Agricultural Academy, setting of sun flower seeds (Zerdanov 8281 variety) in the conditions of isolation from insects stood at 8.8%, of hand pollination — 40.3%, of pollination by bees — 86.9% with the corresponding weight of the seeds in the capitulum of 45.8, 67.8 and 112.6 grams respectively.

An average per hectare output of 18 quintals seeds was obtained in "Ukraina" kolkhoze (Galiaipol district, Zaporozhie region) in 1972 using 320 bee colonies for pollinating 834 ha of sun flower while from the areas far from the apiary only 14 quintals were scored. Thanks to bee pollination the kolkhoze scored a supplementary production of 3,372 quintals of seed worth 100.2 thousand roubles and 20 kg. honey from each bee colony.

Highly efficient is the bee pollination of buckwheat. It is a good melliferous plant, ensuring the main flow in many districts of the country. The buckwheat flowers have a special structure : some of them have short stamens and long pistils, while others, on the contrary, have short pistils and long stamens (heterostyly). The best set of seed and the highest productivity of the new generation was obtained when the pollen on the long stamens reached the stigmas of the deep pistils and correspondingly the pollen on the short stamens fell on the short pistils (natural pollination).

Under identical soil and agrotechnics conditions, but with a saturated bee pollination of every hectare under buckwheat the "Bobrovski" sovkhoze, Pavlodar region, the Khazakh SSR, scored about 20 quintals of seed, 17.3 quintals on areas 500 m. away from the apiary, while from the areas which did not take advantage of bee pollination — only 13.9 quintals. Best results of bee pollination of buckwheat were obtained in the yield of hybrid seeds — a fact explained by the intensification of the most efficient type of pollination — the natural one.

Under the conditions of a correct bee pollination the cotton yield grows by 15—20% and its quality is better. Taking into account that this crop holds over 2 million hectares in the Central Asian and Transcaucasian republics one must pay due attention to cotton pollination by means of bees.

Over 3 million hectares in our country are under fruit trees and berries, the bulk of these crops being fully or partially self-sterile. Without cross-pollination they do not yield any fruit or they yield low crops of fruits and berries. The same applies to entomophilous pumpkin, leguminous, oleaginous crops, etc. Their efficient pollination can be ensured only by bees.

A great deal of attention is paid to organize pollination by bees of farm crops in Canada and the USA. For instance, in the state of California, where leguminous fodder seed crops are concentrated, a special trust operates over 75,000 bee colonies, used exclusively for pollinating agricultural crops. In common agreement with farmers, at previously established dates, the trust moves the necessary number of bee colonies of a certain strength to the fields and crops. The farmer provides for the location of hives intended for pollination and commits himself not to apply

Fig. 1 — Study of bees in man-made hollows in Burziansk *reservation in the Bashkirian SSAR*

chemicals on plants lest the bees should be harmed. The farmer pays a rent ranging between 8 and 12 dollars for every bee colony according to the crop. In case a greater crop than the envisaged one is obtained the farmer pays an extra rent to the trust.

Short Historic Account on Bee-keeping. Bee-keeping is the oldest occupation of many peoples of our country. Historic records testifv that people in Armenia and Georgia practised beekeeping already in ancient times.

The accounts of Herodotus, the historian of ancient Greece (about Vth century AD), about the Scythians are well known; they lived in the steppes of Eastern Europe and extensively traded with honey and wax. In olden times, before beekeeping appeared, hunting was one of the basic occupations of Slavonic people.

At that time wild bees lived in large forests and honey and wax were obtained from their nests. Nonetheless later on being no more content with finding these products in nests at random, our forefathers started to put a special mark on the trees with bee nests with the aim of using them in the years to come. The next step was hollowing out trees for making shelters for bees. Such a tree was called "hollow tree" and a plot with such trees was called "plot with hollow trees". Such trees with man-made hollows and forest bees, originating in Central Russia, have been preserved down to our days in the Burziansk reservation in the Bashkir Socialist Soviet Autonomous Republic.

They are of a great scientific and practical interest, since Bashkiria is the only place which has faithfully preserved the forest bee of Central Russia, characterized by an exceptional resistance to wintering and by high productivity.

Concurrently with the development of agriculture and felling down forests, parallel with maintaining bees in man-made hollows, bee-keeping with primitive hives began to be practised in "apiaries" not too far from human settlements. During Kiew Russia the bee-keeping in our country greatly developed. Honey was for a long time in Russia the most common sweet the beet sugar being not known yet. Wax was the basic material for candle manufacturing which served for lighting. Many dishes were cooked and national beverages prepared out of honey, including the famous "fermented honey" (the Russian mead). Many apicultural products were exported too.

Forest bee-keeping was widely spread until the 17th century. The apiarists on the Lebedinski estate (Kiew region) alone scored no less than 24,000 pounds of honey.

As reported by N. M. Vitvitsky such apiaries could have one thousand bee hives. Villages and hamlets existed in these regions which entirely devoted their activity to bee-keeping. The technique of forest bee-keeping was the most primitive. It confined itself to hollowing trees, attracting swarms, spring cleaning of hollows, collecting honey and defending the hollows from animals. Neither was primitive bee-keeping in apiaries more complicated. Bees would be always killed. Bee-keeping proceeded as follows : every year the strongest colonies, which produced the greatest quantity of honey, were chosen. They were smoked with sulphur, killed and the honey combs together with the nest were taken out and melted. Thus weak and less productive colonies proliferated. In this way a negative accidental selection operated according to Darwin's appreciation — which was detrimental to productivity and swarming. The apiarist could not actively interfere in the life of bee colony and control the activity of the bees in the primitive hives. The possibilities were very limited to act upon bee colony by rational methods of feeding, maintaining and breeding. Apiculture as a branch of zootechnics practically did not exist.

With time passing life has started to require the rationalization of bee-keeping methods as well as raising the apiaries productivity. A substantial contribution in this respect was made by remarkable Russian bee-keeper Piotr Ivanovich Prokopovich. He was the first in the world apicultural practice to use the modern frame hive (1814). On its basis he elaborated a system of measures of bees feeding, of upkeeping, of artificial reproduction, of controlling diseases, of improving and of rationally using melliferous base.

Thus P. I. Prokopovich laid the bases of modern apiculture. In 1800 he organized an apiary which a few years later possessed over 500 hives and by the end of the inventor's life — 3,000. At the special apicultural school set up by him, where people from all over the country came to learn, Prokopovich presented the new beekeeping management methods in modern hives unfolding a broad propaganda in favour of the new technique. By this he largely contributed to extending the use of the new hive. The well-known American apiarist Amos Rooth wrote that Prokopovich's super frame had looked very much like modern frames for sections, with a way for allowing bees to pass and that Prokopovich had really been a highly gifted apiarist, who initiated methods which surpassed by far the epoch he lived in. Rooth denied Dzierdzon of Germany to have been the inventor of movable frames.

The advantages of the modern hive could be fully taken of by using wax foundation and a centrifugal honey extractor that doesn't damage the cells. The first foundation-manufacturing machine was invented in 1857 by Johannes Mehring (Germany) and the first centrifugal extractor in 1865 by F. von Hrushka (Austria). Ten years later the rollers for turning out foundations were invented abroad and in 1882 also in Russia by Odessa worker K. A. Kuzimenko. An important contribution to perfecting the technique of turning out foundation and bee-keeping equipment was made by engineer V. I. Lomakin. An important part in improving bee rearing methods was played by the "queen-breeding device" as well as by queens' artificial breeding, suggested in 1860 by the Russian apiarist E. P. Gusev, which with only slight changes have been generalized in many countries of the world.

A great part in developing bee-keeping in our country was played by scientific research concerning the bee biology in general, local races, honey sources, bee diseases and enemies, etc.

A great contribution in this field of knowledge and in developing apiculture, was made by outstanding scientists: P. I. Rychikov, corresponding member of the Academy of Sciences of Russia and Academician A. M. Butlerov, both professors at the „K. A. Timiriazev" Academy of Agricultural Sciences, Academician I. A. Kablukov, Academician N. M. Kulaghin of the "V. I. Lenin" Union Academy of Agricultural Sciences, V. I. Taliev, P. N. Veprikov, A. F. Gubin, professor I. A. Kozhevnikov of the Moscow State University, professor I. L. Serbirov, researchers F. A. Tiumin, A. P. Mikhailov, K. A. Gorbachov and others. Topical problems linked to apicultural practice have been tackled by A. P. Butkevich, P. L. Snejnevski, I. P. Kalaitan, A. E. Titov, I. A. Titov and others. Among foreign researchers and practicians who have positively influenced the development of apiculture, worthy of mention are J. Swammerdam, the well-known physicist, R. Réaumur, F. Hubert, J. Dzierdzon, E. Zander, E. Phillips, R. Snodgrass, K. Frisch, A. Root, Ch. Dadant and others.

In pre-revolutionary Russia very much like in other countries, various apiarists' associations and experimental apiaries played a positive role in developing bee-keeping. Among the latter worthy of mention are the Izmailovskaia apiary in Moscow, the apiaries of the Petrovskaia Academy (Timiriazev) and the private boyars' schools of apiculture close to Kiev and others. Nevertheless, in spite of the great development of theoretical research and the approach of bee-keeping management problems, the social-economic conditions in pre-revolutionary Russia hampered the development of this branch. In 1900, out of 5.3 million bee colonies, only 25% were kept in modern hives, the remainder being maintained in primitive hives of various types.

In 1910 the number of colonies rose to 6.3 million and the percentage of modern hives stood at 35%. In spite of the existence of very abundant honey sources, because of the low level of beekeeping methods, the average marketable honey production per bee colony did not surpass 5—6 Kg. and the apiaries were made up of 6 bee colonies on an average. Bee-keeping was pre-eminently concentrated on the landlords' and koulaks' estates. Large apiaries belonged to monasteries because they needed wax for candles (that of Novo Afonski Monastery owned over 1,500 bee-hives).

After the October Revolution, in the years of intervention and of civil war the number of bee colonies dropped to 3 million in 1919. Of a great importance for re-making and developing bee-keeping was the decree of the Soviet of People's Comissars ("Decree on Protecting Bee-Keeping") signed by V. I. Lenin in 1919. A rapid pace of development was re-established in apiculture also during the period of peaceful construction and collectivization of agriculture. In 1930 the number of bee colonies stood at 5.5 million, 60 per cent of which in modern hives; 1938 already saw 9.6 million and at the beginning of the Great Patriotic War their number topped 10 million (95% of which in modern bee-hives).

The bee-keeping was seriously affected during the Great Patriotic War (1941—1945). In the districts temporarily occupied by fascist invaders, the apiaries of sovkhozes and kolkhozes were destroyed; the number of bee colonies — private property of citizens dropped to a considerable extent. By the end of the Great Patriotic War the number of bee colonies did not surpass 5 million. After driving away the fascist invaders from the territory of the Soviet Union, steps were taken for remaking apiculture. The decision of the Soviet Government (February 26, 1945) concerning the "Measures for Developing Apiculture" showed that apiculture was greatly important for the entire national economy not only as a source of valuable food and an important raw material for industry, but especially as a means of raising crops and extending farm seed crops.

This decision provided for concrete measures for training cadres with a general, medium and higher skill, for organizing a network of apiaries, improving the endowment of apiaries with beekeeping equipment and bee-hives. Following the measures taken, the apiculture was rehabilitated in a short time.

Condition and prospects of developing apiculture in the USSR. By the beginning of 1974 there were 9,956.6 thousand bee colonies in our country (4,517.5 thousand of which in kolkhozes, sovkhozes and other state organizations and 5,439.1 thousand colonies as private ownership of the population). The distribution of the bee colonies in the Union republics is presented in Table no. 1 (see also the diagramme).

The pride place in the Soviet Union — both in terms of number of bee colonies and of honey and by-products production is held by the Russian Federation. In point of number of bee colonies it holds the first place in the world while in point of honey production the second place

Table 1

Distribution of Bee Colonies in the Union Republics of the USSR (according to the data of the Central Board for Statistic on January 1, 1974)

	Number of Bee Colonies		Public Sector Included	
	(total) (thousand)	%	(total) (thousand)	%
USSR	9956.6	100.0	4517.5	45.4
RFSSR	5487.4	55.1	2452.4	44.7
Ukrainean SSR	2456.8	24.7	1187.0	48.3
Bielorussian SSR	371.6	3.7	88.2	23.7
Uzbek SSR	120.0	1.2	74.8	62.3
Khazakh SSR	276.5	2.8	196.4	71.0
Georgian SSR	168.0	1,7	71.8	42.7
Adzerbaidjan SSR	109.4	1.1	55.8	51.0
Latvian SSR	213.4	2.1	49.3	23.1
Moldavian SSR	144.8	1.5	97.8	67.5
Lithuanian SSR	190.0	1.9	53.9	28.4
Kirgiz SSR	115.2	1.2	77.3	67.0
Tadjik SSR	75.9	0.8	18.9	24.9
Armenian SSR	94.8	0.9	53.9	56.8
Turkmenian SSR	34.4	0.3	20.6	59.9
Estonian SSR	101.4	1.0	19.4	19.1

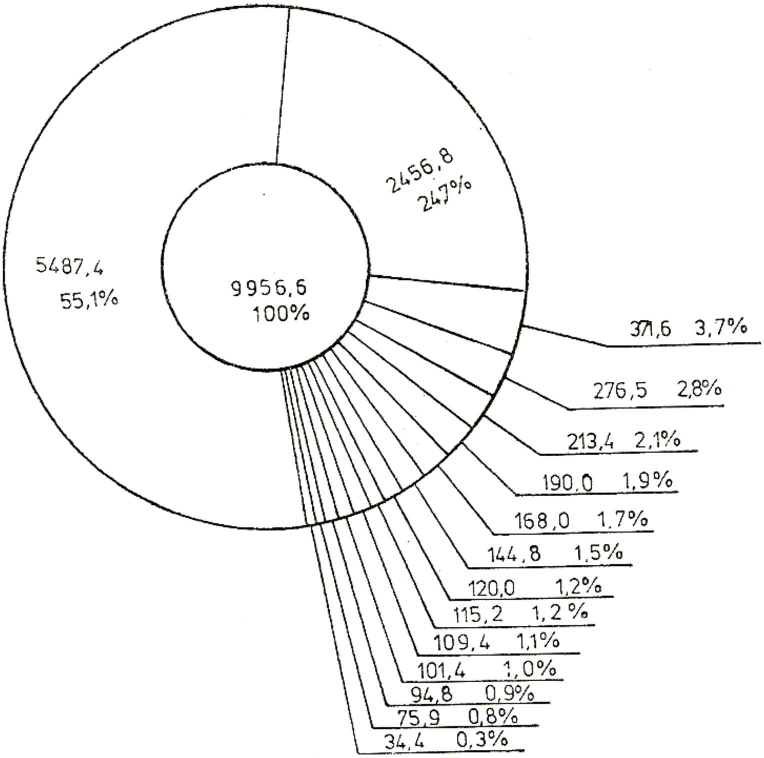
next to the USA. The RFSSR avails of great opportunities of natural melliferous resources to increase honey production in Siberia, the Far East and the Urals region. A number of district of the RFSSR do not cover the need of bees for pollinating the entomophilous crops.

Runner up as concerns the number of bee colonies in this country is the Ukrainean SSR, where bee-keeping is especially intended for pollination and hence for using the farm crops as forage.

The huge availabilities of developing bee-keeping are not enough used in Central Asian republics and in the Khazakh SSR. In the plain and foothill districts of these republics (especially in Uzbekistan, Tadjikistan and Turkmenia) exceptional conditions prevail for producing queens and early package bees. An acute shortage of bees is felt in the republics of Central Asia also for pollinating the entomophilous crops (lucerne and orchards). Suffice it to say that over one million bee colonies are necessary only for pollinating the entomophilous crops in the Uzbek SSR, which stretch over more than two million hectares. The mountain districts in Central Asia and Khazakhstan have favourable conditions for industrial production of high-quality honey. Nonetheless, in this area of the country only a low number of bee colonies are to be found.

Broad prospects for developing queen and package bee production are in the Transcaucasian Republics.

A relatively higher saturation with bees is noticeable in the Bielorussian SSR and in the Baltic Republics. There bee-keeping is streamlined for pollination and honey production but only a few large apiaries exist.



Distribution of the honey bee colonies in the different republics of USSR (early 1974)

USSR	(9956.6 100 %)	Moldavian SSR	(144.3 1.5%)
RFSSR	(5487.4 55.1%)	Uzbekh SSR	(120.0 1.2%)
Ukraine	(2456.8 24.7%)	Khirghiz SSR	(115.2 1.2%)
Bielorussia	(371.6 3.7%)	Azerbaidjan SSR	(109.4 1.1%)
Kazakh SSR	(276.5 2.8%)	Estonian SSR	(101.4 1.0%)
Lituanian SSR	(213.4 2.1%)	Armenian SSR	(94.8 0.9%)
Letonia SSR	(190.0 1.9%)	Tadjik SSR	(75.9 0.8%)
Georgian SSR	(168.0 1.7%)	Turkmen SSR	(34.4 0.3%)

The variety of natural and flow conditions in our country essentially influence the development of apiculture in various natural areas. Data on the development of apiculture in various natural areas of the USSR are presented in table no. 2 (see also the map on the first flyleaf of the book).

The fact must be also mentioned that no branch of zootechnics is so closely conditioned. That is why, in ensuring profits from the beekeeping operation — chosen according to the local climate and honey sources — use of specific management and production methods is of utmost importance.

Tundra and forest-tundra area. In spite of a relatively rich melliferous base (willow thickets, tundra bramble, bilberries, raspberries, fireweed and mixed herbaceous plants) apiculture has not been developed there mostly because of the long and severe winters and because it is not profitable to keep bees in the Far North conditions all the year round. Nevertheless, apiaries do exist in this area for pollinating the

Table 2

Distribution of bee colonies per natural zones in the USSR (according to general data at the beginning of 1973)

Natural zones	total (thousand)	Number of bee colonies		
		(%)	per 100 ha farming area	per 100 ha entomophilous crops
Forest area	3655	38.6	4.4	154
Forest steppe area	3116	33.9	3.5	94
Chernozem area	1600	16.9	1.5	43
Dry steppe area	58	0.6	0.2	22
Semidesert area	58	0.6	0.2	22
Desert area	359	3.8	0.4	16
Subtropical area	66	0.7	0.7	57
Mountain area	558	5.9	2.7	107
Total — in the USSR	9470	100.0	1.9	54

entomophilous crops in hothouses. Although successful results have been scored with bees wintering beyond the Polar Circle (in the "Arktika", "Pecengonichel" sovkhozes and in several other farms in the Murmansk area), package bees are however bought from the Southern districts, at the beginning of spring: they are used for pollinating hothouse cucumbers, but to the end of the season the colonies become very weak. On the basis of using wild honey plants in this zone, honey production will be possible in the future by purchasing package bees from the Southern districts of the country and their smoking out after obtaining honey.

Forest area holds more than half of the territory of the Soviet Union.

The bulk of the districts in this area are worthy of mention by their abundand wild honey sources. Here for instance, there are almost 2 million hectares of lime-tree plantations and over 50 million hectares of fell and burnt down forests, which allow for important melliferous plants to grow — raspberry, gooseberry, fireweed and many thickets and melliferous herbs. In addition, within the fell area there is over 1.5 million hectares under buckwheat (60% of the entire area under buckwheat in the country). In spite of the huge idle honey potential, the bee population in this area is relatively low; only 38.6% of our country's bee colonies are to be found there. Practice has proved that many districts of forest area can yield maximum honey productions. The daily extra quantity of the control hive at many apiaries in the Primorsk region reaches 20 Kg. in Siberia during the lime tree flow; strong colonies forage up to 10—12 Kg. honey during the raspberry and fireweed flow. Bumper crops are also yielded in the forest area. In the years congenial for bee-keeping the gross honey production per bee colony in the Primorie region surpasses 50 Kg. on the average; in the Bashkirian ASSR — 40—50 Kg.; in districts in Altai, Siberia, Far East and Eastern Kazakhstan — 60—70 Kg. A number of large specialized apicultural sovkhozes and bee-keeping farms of sovkhozes and kolkhozes have been set up in this area. For instance in the Eastern Kazakhstan there is Chereshamski apicultural sovkhoze with 17,000 bee colonies, Putintsevskii apicultural sovkhoze with about 25,000 hives while in the Primorie and Habarovsk regions there are Iakovlevski and Spasski sovkhozes with 5,000—8,000 bee colonies each.

In 1973 the average marketable honey production per bee colony in the Primorie region stood at 50 kg. Iakovlevski sovkhoze scored 569 tons of honey in the 1971—1973 period. The Iuzhnyi sovkhoze in the Primorie region obtained 113 kg. honey on an average from each of its 2,718 bee colonies in 1973. A progressive apiarist on this farm, M. K. Moskalets has obtained from each of the 144 bee colonies which he attended to an average output of 155.4 kg. honey. An apiarist in the "Za Kommunizm" kolkhoze (Bogotolski district, Kransnoiarsk region), A. I. Demko, who obtained from each of his 160 bee colonies about 180 kg. honey, has been awarded the title of Hero of Socialist Labour.

The farm honey crops do not play an important part in the honey sources of most districts in the forest area. Beekeeping here is aimed at honey production, pollination of agricultural crops by bees being a secondary preoccupation. In the future, parallel with the multilateral development of the large stationary apiaries for large-scale production of honey, the apiarists in this area will use package bees, brought from the Southern districts of the country early in spring.

Forest steppe area. Concurrently with the wild honey sources a great weight is also carried by the farm melliferous crops, buckwheat, sunflower, fruit-trees, berry plantations as well as fodder leguminous plants. As many as 33% of the total buckwheat crops (nearly 0.9 million hectares) and 26.6% of sunflower grow in this zone. Both pollination and honey production are aimed at in most of the districts in the area.

Steppe area. Farm honey crops —sun-flower, fruit-trees, coriander and to a certain extent the fodder leguminous plants (alfalfa, esparcet, etc.) hold pride of place within the melliferous base of this area. Over 55% of the sun-flower crops (2.5 million ha) and an important part of the fruit-tree plantations are to be found in the steppe area of this country. Wild honey plants are pre-eminently represented by foothill forests which ensure an early, though not too abundant maintenance nectar flow (it contributing to the development of bee colonies in spring and the obtaining of queens). About 17% of the bee colonies in this country (over 1.7 million) are to be found in this area. The main preoccupation of the bee-keeping farms in this area is pollination. In the future, concurrently with orchard pollination the apiarists in the southern districts of the steppe area (Krasnodarsk and Stanopolski zones, Crimea, etc.) should specialize themselves in the production of queens and package bees for supplying the northern districts of the country.

The Kislovodski sovkhoze in the Stavropolski zone specialized in bee-keeping may serve as an example of high productivity in obtaining queens and package bees. From 2,500 bee colonies over 50,000 queens and several thousand package bees for sale are obtained here every year.

Subtropical area, the desert and semi-desert oases. The Black Sea coast in Caucasus and Crimea, the plain and foothill areas in the Transcaucasian and Central Asian republics as well as the zones in the Southern Khazakhstan are **congenial** by their very nature for production of early queens and package bees on a large scale. An early spring, prolonged growing cycles, plenty of warm and sunny days, an early and prolonged maintenance nectar flow offer exceptionally favourable conditions. Here the bees play an important part in pollinating orchards, subtropical crops, cotton, alfalfa seed crops, etc. There are over 2 million hectares in this area under cotton and large areas under fruit trees. Nonetheless, the bee-keeping here, especially in the Central Asian republics is not up to the existing possibilities. Less than 5% of the bee colonies of this country are to be found in the subtropical, desert and semi-desert areas.

A profitable queen-breeding centre is Krasnaia Poliana apiary belonging to the Institute of Apiculture. It produces over 120,000 mountain grey Caucasian queens per annum to the value of over 500,000 roubles. The production of queens and package bees is well organized in the "Bekanskii" sovkhoze specialized in bee-keeping in the Autonomous Republic of Northern Osetia, which in 1973 obtained 27,000 Carpathian queens and many colonies of package bees.

Beekeeping abroad. Beekeeping is practised on all continents and in all climatic zones, from the tropical areas in Asia, Africa and America to zones in the Far North in Finland, Norway and Canada (see the map of world distribution of bee colonies on the end flyleaf of the book). According to incomplete data (provided by UNESCO and from other sources) there are 45 million bee colonies in the world, 22% of which in the USSR. Of the capitalist countries, the USA has the most advanced beekeeping. The USA hold the second place in terms of number of bee colonies and labour productivity, level of mechanization of apiaries, and of queen breeding and package bee production.

Mountain districts. As it is known in the mountains the soil and climatic conditions change with altitude. Very much like natural geographical areas the mountain tiers display a full range of varieties, from subtropical, mountain steppes and forests up to sub-alpine and alpine pasture lands, mountain tundra and eternal snow areas. As a result one may notice a great variety of natural conditions within the limits of not too large an area. The specialization of the bee-keeping farms as well as the large utilization of migratory bee-keeping is thus possible there for exploitation of several abundant nectar flows available in various periods and areas corresponding to the above-mentioned conditions and the character of the honey plants.

Apiculture already plays an important part in almost all natural areas and republics of our contry for obtaining valuable food products and growing the entomophilous crops. A well organized and efficient bee-keeping farm is a reserve of increasing the profitableness of sovkhozes. However, all sovkhozes and kolkhozes do not use properly this reserve. The present condition of bee-keeping does not correspond to the heightened requirements of the national economy. The apiarists' labour productivity is still very low, inefficient small apiaries go on functioning in many districts. Whereas a bee-keeping farm of sovkhozes in the Bashkir ASSR has 950 bee colonies on the average the same farm owns 975 in the Tartar ASSR, 1450 in the Primorie region and about 3 000 in the Habarovsk region, the apiaries in the sovkhozes and kolkhozes in the Baltic Republics and some north-western regions in the RFSSR do not avail more than 50—60 colonies.

Apiculture plays an important part within the preoccupations of solving the problem of continuously increasing the agricultural production on an all country level. It is necessary to raise not only the direct production of apiaries but more completely to use bees for pollinating entomophilous crops. Honey production should be raised especially on the account of higher performance of bee colonies up to an average amount of 20 Kg. on the country level. With this aim in view the number of bee colonies in the public sector must stand at 10,000,000. Beekeeping very much like other branches of agriculture, will develop on a base of intensive practice, raising labour productivity and dropping the cost price of production. Special attention must be paid to rational

Fig. 2 — One of the queen rearing station of the Krasnaia Polyana Farm belonging to the Bee Institute. In 1973 the farm sold 120 thousand mountain grey Caucasian queens

siting of apiaries and to their specialization according to the natural and economic local conditions, peculiarities of honey sources and to the requirements of the main branches of agriculture for pollinating entomophilous crops. The bee-keeping farms and the sovkhozes in Ural, Siberia, Far East and the alpine districts of Central Asia, which has huge areas under wild honey plants not fully used, must get specialized in producing honey, while the farms of the plain and foothill areas of the Asian and Transcaucasian republics, as well as the Black Sea coast in the Caucasus area — in mass production of queens and package bees, concurrently with the pollination of fruit-tree plantations.

Highly important for increasing labour productivity is the expansion of apicultural farms and apiaries, increasing the number of colonies handled by man alone up to 150—200 as compared to 50—60 bee colonies in common practice today. The mechanization of uncapping, honey extraction, fitting foundation into frames, of loading and unloading bee-hives when going on the migratory beekeeping — which call for a large volume of work — as well as material cointerestedness of apiarists and raising the marketable honey production and plant pollination of farm crops — here are a few efficient means for increasing labour productivity in apiaries and their profitableness. To this effect highly efficient are the measures of simplifying and perfecting bee feeding and management methods, ensuring plenty of food in high-quality foundation keeping bees in large hives (multiple-storey hives, two-body hives and long hives), passing from natural swarming to artificial swarming not only for obtaining extra amounts of honey but also for ensuring strong colonies for the main nectar flow, organizing selection work in apiaries, tracking down and removing old and unproductive queens and weak colonies, going often on migratory beekeeping for increasing production and better organizing pollinations, etc. The agronomists and zootechnicians on the farms may and must become the initiators of such measures.

The zootechnical management of this branch is entrusted to the Section of Apiculture in the USSR Ministry of Agriculture and to the apicultural boards and to specialized sovkhozes in the union republics. It is also they who provide bee-keeping farms with equipment and supplies wax foundations and purchase of raw bees wax. Zootechnical experts within regional and district apicultural bureaux work by apiaries.

Over 1,500 zootechnicians specialized in apiculture work only within the units of the Ministry of Agriculture. They unfold a rich activity to introducing the pollination of the entomophilous crops by bees, improving and rationalising the melliferous base in the practice of modern bee-keeping management of colonies.

They also organize training courses for bee-keepers to teach them the latest management methods to lead to fulfilling apicultural development programmes.

In step with beekeeping concentration and specialization, with the ever greater scope of migratory bee-keeping and with increasing deliveries of queens and bee colonies, the importance heightens of sanitary and veterinary measures for preventing and controlling bee diseases and poisoning.

The disease and poisoning preventing and controlling methods and relevant diagnosis are taken through the general veterinary system and by the veterinary surgeons working within the Apicultural Boards of the Ministeries of Agriculture and the regional apicultural bureaux.

A large activity of staff training is taking place in the Soviet Union.

The apiarists with an elementary qualification are trained by specialized vocational apicultural schools. The agricultural post-lycée schools train apiarists with a medium qualification. Within all levels of higher agricultural education (faculties of zootechny, agronomy and pomiculture) a course is taught in apiculture and pollination of farm crops by bees. Under the Institute of research in apiculture by the RFSSR Ministry of Agriculture an Institute carries on its activity for perfecting bee-keeping zootechnicians as well as permanent refreshing courses for beekeepers. Bee-researchers are trained within the Chair of Apiculture of „K. A. Timiriazev" Agricultural Academy, at the Institute of bee research at the Chairs of Ecology and Darwinism of the „Gorki University".

The apicultural research activity is covered by the Bee-Research Institute at Rybnoe, Ryazan region, by five experimental apicultural stations (Ukrainean, Khazakh, Bashkir, Georgian and Armenian SSR) and by over 20 apicultural sections and laboratories under the institutes of agricultural research and agricultural experimental stations. Besides, important scientific research is carried out by the chairs and laboratories of some higher learning institutes.

An extensive promotional activity in the field of apiculture is made by „Pchelovodstvo" („Apiculture") review, organ of the USSR Ministry of Agriculture and by the homonymous stand at the Exhibition of the USSR Economic Achievements, by the apicultural museums of the Bee-Research Institute and the Chair of Apiculture of the „K. A. Timiriazev" Academy of Agricultural Sciences.

In Europe, where beekeeping carries a great weight not only for honey production but also for pollination of farm crops, the greatest number of bee colonies is concentrated. In a number of countries (Austria, Czechoslovakia, Federal Germany, Finland, etc.) corresponding measures have been taken in support of beekeeping — supply of sugar for feeding bees — at low prices, customs fees for the honey imported from other countries, etc.

Of the European capitalist countries worth of mention as concerns the number of colonies are : Federal Germany (1.5 million), Spain (1.4 million), France 1.2 million), Italy (0.7 million). Of the socialist countries — Poland (1.2 million), Czechoslovakia (1.2 million). The honey yield per bee colony in the European countries accounts for 7—8 kg., small apiaries of amateur beekeepers being prevalent. In many countries, besides movable frame hives, bees are also kept in straw skeps. Beekeeping in bee-houses is extensively practised in Austria, Federal Germany, G.D.R., Finland and in other countries. Nevertheless, the last few years have seen a trend to use movable frame hives. Worthy of mention is the good labour organization of the queen breeding, mass production and export in Italy (the activity of "Piana" firm in the field of large scale production of Italian queens). In some countries (Austria, the GDR, Switzerland) selection work is made of local bees, by using isolated mating stations for controlled mating of queens with drones of a certain origin. In Asia and Africa people have been practising beekeeping for many thousands of years. It is known that ancient Egyptians practised migratory beekeeping, floating the hives downstream the Nile, for taking advantage of the successive nectar flows. The abundance of the nectar flow could be judged by the degree of loading the rafts. A variegated honey flora grows in the main African countries (except the desert areas). Many wild bees producing honey and wax are to be found in the African forests. The wax is exported to European countries and the USA. In spite of the great existing possibilities, beekeeping in African and Asian countries is primitive, the bees being preponderantly kept in primitive hives, and honey crops very low. Only after becoming independent could a number of Asian and African countries turn to using more advanced beekeeping methods. In South-Eastern Asian countries (China, Japan, India) the medium-sized bee of India *(Apis indica)* has from times immemorial been reared and is widely spread in wild state in this part of the world. It is to be met in wild state also in the region of Primorie. Measures have been taken lately to replace *Apis indica* by *Apis mellifica*, especially the Italian one, whose productivity is by far higher than that of the Indian bee. In the southern part of India and Indochina as well as on many islands in the Indian Ocean the giant bee *(Apis dorsata)* and the little bee *(Apis florea)* are to be met very often. The first provides for honey and bees wax. In India for instance, 80% of the honey consumed in the country is obtained from the nests of the wild giant bees from huge honey comb hanging from tree branches. Such nests are common in India, not only in trees but also under the cornices and vaults of the ancient Indian temples and palaces.

Highly interesting is the beekeeping practised in the USA, Canada and in some Latin American countries, where a maximum technical progress has been achieved, both as concerns labour productivity and mechanization of time-consuming operations, and the specialization of apiaries according to the local natural conditions. The fact is worthy of mention that in America, just as in Australia and New-Zealand (the countries which produce the highest honey crops) no native bees existed. Honey bees were brought to these countries from Europe. In 1621 black bees from Central Europe (Germany) were first imported in the USA, then in 1860 — Italian Carniolan bees, and in 1880 — mountain grey Caucasian bees. At present, Italian, Caucasian and Carniolan bees are reared in the USA and Canada. They have replaced the black bees from Central Europe. In the USA the marketable honey production per colony is 20 kg. while in Canada — 40 kg. In southern states in USA, the honey yields stand at only 6—10 kg., but favourable conditions exist for queen breeding and package bees. Only in five states over 500,000 package bees, and almost one million queens are produced, which are sent to the northern states and Canada. Thus, 6.5 kg of marketable honey are obtained on the average in the state of Mississippi where there are 82,000 bee colonies. But every year by the sale of 50,000 bee packages an income of 500,000 US dollars is obtained, i.e. 48.9% out of the total income derived from beekeeping in the entire state. Thanks to streamlining beekeeping in the northern states on producing honey, and in the southern ones on package bee and queen production, the efficiency of apiaries and labour productivity are high, and the production costs low. Yearly (in April) package bees are ordered by Canada and a number of states of the USA and are used for honey production. A package of one and half kilo usually develops into a strong colony in 7—8 weeks and during the main nectar flow it forages 50—55 kg. of honey. The beekeeper harvests all honey and kills the bees. The next year he orders package bees again. In Canada, early 75% of colonies are package bees, reared in the south. Thanks to this, honey marketable production has increased in the last few years up to 40 kg. per colony. And although during the same period, the number of apiarists and of bee colonies has declined considerably, the amount of honey produced on an all-country level has remained unchanged.

Concomitantly with specialization of beekeeping in the USA, the last decades saw its concentration and establishment of large commercial apiaries for honey and package bee production and for pollination of nectar-yielding farm crops. Alongside a great number of apiaries of amateur beekeepers (with about 10 colonies each) where less advanced methods are used and bees are often kept in traditional hives (especially in the states in the south), there are large commercial apiaries with thousands of modern hives, and one beekeeper handling hundreds of colonies; for uncapping combs and for honey extraction highly efficient equipment is widely used (radial centrifugal, electrically driven extractors for 45—50 frames), and special loading equipment and trucks. Thus, the apiarists do not waste their time with fixing foundation into frames, but they buy wired foundations : they do not rear queens but purchase mated queens from queen breeding apiaries. The apiary of John Hayfely — "Monte Vista" — of 6 thousand bee colonies, is operated by 20 workers and produces as many as 450 tons of marketable honey. The main locations of these apiaries are in the states of South Dakota and Colorado, where two honey extracting plants are to be found, equipped with electric machines for uncapping and radial centrifugal extractors. The major honey sources are the leguminous crops (lucerne, melilot, clover) and aster, which are the base for honey. After nectar flow is over bee colonies are carried, in 5 trucks, from North to South, to the state of Texas, to the citrus plantations ; the honey collected from the citrus plantations is used as food during winter.

Early in March, colonies are moved to the southernmost districts in Texas for obtaining queens and swarms by divisions ; then they are transported back to the North. The major part of the marketable honey production in the USA is supplied by such large commercial apiaries ; year by year, the number of small apiaries of amateur beekeepers declines because the latter can no more cope with the narrow competition with such specialized enterprises.

Following the example of commercial apiaries in the USA, such apiaries have also been established in Australia, New Zealand, Canada and other countries in Central and South America (Argentina, Brazil, Mexico).

In Argentina for instance the "Corasco" firm with 25,000 bee colonies is quite well known. It is operated by 16 permanent workers and as many seasonal workers are employed during honey extraction and when moving colonies into migratory beekeeping. The average marketable honey production per bee colony is 40—50 kg. In June and July colonies are moved to the North, at a distance of 1,500 km to the flow provided by citrus plantations ; later on they are moved back to the South, to Buenos Aires province.

Worth mentioning is the organization of commercial production at one of the most important firms in the world "Miel Carlotta" in Mexico. Those who laid the bases of this firm, A. Wulfrath and S. Spek started their activity in 1943 with 10 bees hives. In twenty years the number of bee colonies reached 50,000. Unlike the USA, at "Miel Carlotta" apiaries, bees are not kept in multi-storey hives but in "Jumbo"-type hives (frame sizes are 445 mm × 290) with 150 mm high honey chambers. A. Wulfrath considers that this type of hive is better fit to the local conditions for honey production in Mexico. Wulfrath explains the successes of the firm by the fact that by selection work, they have succeeded to develop a strain of bees which do not swarm and whose queens are very prolific. The firm produces 100,000 mated queens yearly, half of which are used for replacing the "old" queens of their own piary, and the other half is sold. The queens are changed every year at their apiaries. Each and every colony yields an average amount of one quintal of maketable honey.

The apiary also yearly sells royal jelly and pollen worth 300,000 and 30,000 US dollars respectively. The apiaries are operated by a group of beekeepers : they extract honey, process it and pack it in a central honey packing plant, equipped with mechanized appliances for uncapping combs, radial centrifugal extractors and honey settling tanks.

Great success in large-scale honey production has been scored by the commercial apiaries in Australia. Large honey crops are obtained there from various species of eucalyptus. More than half of the labour at commercial apiaries in Australia is required for uncapping combs and honey extraction. Therefore, special attention is paid to mechanizing these operations. For honey production, special supers are used with eight fixed and thicker combs, which can not be taken out of the super. After combs are filled with honey and capped, supers are taken to have the combs uncapped and honey extracted, without taking the combs out of supers. Highly-efficient electrically driven machines are used for uncapping combs, as well as huge centrifugal extractors, which handle up to one ton of honey per hour.

In the last decades, in a number of countries the part played by pollination by bees of farm crops has increased as part of the ever more intensified and concentrated agriculture. As reported at the XIX-th International Congress in Prague 1963 by S. Kodon, Secretary of the Czechoslovak Union of Beekeepers, the economy of the Czechoslovak Socialist Republic obtains a direct income of 121 million crowns out of bee products (honey, wax, etc.).

The income derived from pollinating activity was estimated at one thousand million crowns, i.e. 8 times more. Similar data have been reported by the German Democratic Republic, Federal Germany and many other countries. That is why the Czechoslovak government took a number of steps in support of beekeepers, including supply at low prices of sugar for feeding bees (7 kg per colony).

Outstandingly interesting is the service of pollination of farm crops by bees in the USA. About 250,000 bee colonies are used for pollinating entomphilous crops in California alone.

According to data supplied by Wilson, the indirect incomes produced by beekeeping in the USA due to increased crops of entomophilous crops following their pollination by bees, stand at 250 million dollars, while the direct incomes (honey, wax and sale of bees) — at only 20 million dollars. In this country, pollination of farm crops by bees has a broad commercial basis, with specialized apiaries for such service. The bulk of farms under entomophilous crops consider the organization of their own pollinating apiaries as unprofitable. It is more profitable to hire bees for pollinating their crops. Special trusts of apiarists handle pollinating operations. For instance, an original pollinating trust has been organized in the state of California ("Valley Pollination Service"). At the beginning the trust had 600 colonies but after ten years their number stood at 75,000. The trust got specialized only in orchard, cotton and alfalfa seed crops. In winter, farmers conclude contracts which provide for the number of bee colonies, conditions and terms of transportation to their crops. The average possible yield per acre is estimated. For every colony brought for pollinating the corresponding crop he who rents the colonies, pays 8 to 12 dollars to the Trust when obtaining the crop yield provided for in the contract. If the crop yield is bigger, the trust is granted a supplementary premium for every quintal of fruit, seed or fibres obtained over the quantity estimated in the contract. Besides this, the fruit-grower or farmer has to take necessary steps to control pests and weeds, by using methods unharmful to the pollinating bees. In the Northern states of the USA and in Canada, pollination of entomophilous crops by package bees purchased from the specialized apiaries in the Southern states is a widely used practice.

Important successes in developing apiculture have been obtained in the socialist countries too. In the Polish People's Republic for instance, instrumental insemination of queen in extensively used. Stations of instrumental insemination of queen bees have been set up under the stations of instrumental insemination of animals. An ample activity of organizing large apiaries, dealing with production and processing of bee products, is unfolded in Bulgaria by "Nectarcoop" Union.

Special mention is deserved to the activity unfolded by Romanian Beekeepers' Association which has applied a set of measures for zootechnical assistance to beekeeping, for manufacturing hives, beekeeping equipment, and in processing, packing and sale of bee products. A special complex unit in Bucharest, endowed with up-to date equipment processes over 5,000 tons of honey, produces over 170 tons of foundation, including wired ones, bee-hives, honey centrifugal extractors, and other bee equipment, medical and pharmaceutical preparations with honey, royal jelly, bee venom and other bee products. At the complex unit, also an apicultural exhibition is open, and an apicultural lycée. Several large apiaries exist in Romania, for instance the "9 Mai" state beekeeping farm, Tulcea county, with 5000 bee colonies. It produces yearly about 100 tons of honey, 1.5 tons of pollen, and sells 1,500 Carpathian queens. The apiary is operated by 18 workers. 400—500 colonies are handled by two permanent workers. Two seasonal workers are needed for transportation of bee hives during migratory beekeeping and honey extraction. Thanks to the successful work unfolded by the Romanian Beekeepers' Association, honey production and the number of bee colonies in that country increased more than three times in the last 27 years. More than half of the honey produced in Romania (almost 6—7 thousand tons) is annualy exported to Japan, Federal Germany, Austria, Italy and the USA.

The last years saw the intensification of international cooperation of beekeeping organizations in various countries, as well as the exchange of experience and information among them. A fresh contribution in this field was made by the "APIMONDIA" International Federation of Apicultural Association, which celebrated its centenary in 1974. "APIMONDIA" holds international congresses, scientific symposia and other apicultural meetings, which contribute to the exchange of experience and technico-scientific information of different countries of the world. The International Beekeeping Technology and Economy Institute of "APIMONDIA" unfolds a broad and useful activity of editing apicultural literature, organizing international exhibitions, courses of apiculture for scientific experts and beekeepers. "APIMONDIA" and its Institute issue a varied apicultural literature in five languages (English, German, Russian, French and Spanish): "Apiacta" the international apicultural review, publishes the papers presented at the international apicultural congresses, the reports delivered at the international symposia on pollination of farm crops, bee selection, use of bee products in medicine, recommendations for instrumental insemination of queens, etc.

Soviet Union has been a member of "APIMONDIA" since 1945. Her representatives take an active part in the actions initiated by this organization. As Vice-President of the Executive Council of the APIMONDIA was elected G. D. Bilash, Director of the Bee Research Institute, and a number of Soviet apicultural scientists and beekeepers are members of the international Standing Commissions on Bee Biology, (G. A. Avetisyan), on Melliferous Flora and Pollination (A. N. Melnichenko), on Beekeeping Economy (A. S. Nuzhdin), and on Beekeeping Technology and Equipment (G. F. Taranov).

An important part in the exchange of experience is played by apicultural journals. Over one hundred such publications are issued all over the world. Besides "Apiacta" worthy of mention are also the organs of International Bee Research Association — "Bee World", "Bee Research", "Apidology", and "Apicultural Abstracts" reviews which publish the results of the research work in apiculture, and abstracts of the articles printed in the world relevant journals. Of the foreign apicultural reviews dwelling on problems of industrial beekeeping, worth mentioning are "American Bee Journal", "Gleanings in Bee Culture", edited in the USA, "Canadian Bee Journal", issued by the Canadian Beekeepers' Association, "Australian Bee Journal", the organ of the Australian Beekeepers' Association.

More and more favourable conditions have been created for a multilateral cooperation of various countries of the world, in the field of apiculture. The fact is confirmed inter alia by the results of the XXIIIrd International Congress of Apiculture, held in Moscow in 1971, and by the "Apiculture — 1971" international exhibition. The Congress was attended by over 3,000 apicultural scientists and beekeeping experts from over 40 countries. The welcoming speech addressed to Congress participants on behalf of the USSR Council of Ministers pointed out that beekeeping plays a significant part in increasing the yield of many farm crops, in rationally using natural resources for obtaining valuable food produce, raw material for industry and for medicinal preparations of a high value.

CHAPTER I

BIOLOGY OF BEE COLONY

The bee colony represents an integral, complex unit from the biological and economic point of view. It is made up of several tens of thousands of workers, several hundreds of drones, which as a rule live only in the period of the effective activity of colonies, and a queen. None of these individuals can live outside the colony. Each and every member of the bee colony can fulfil its functions only in close interdependence with the other individuals. This peculiarity of the bee colony is the result of a long historic development.

SOME PROBLEMS CONNECTED WITH THE EVOLUTION OF THE BEE COLONY

The history of evolution of insects started in the Paleosoic age. The first wingless insects appeared already in the Devonian (almost 300 million years ago), when plants acceded the land. The development of flora at that time under favourable ecologic conditions led to their rapid extension. Much later, in the Jurassic period (150 million years ago) hymenoptera evolved. The most intense processes of formation of species and of biological progress with these insects coincided with the predominance on the land of angiosperms. According to the opinion of experts in palaeobotanics (D. Scott, 1927) the changes which occurred in the plant kingdom, first and foremost depended on the concurrent development of higher forms of insects. One may say that both the changes come about and the evolution of the insects — especially of hymenoptera, are linked to the history of development of flower plants.

The links between plants and insects acquire the most complex and diversified forms, from insect phytophagy and plant entomophagy up to entomophily.

Under the above mentioned conditions, of primary importance was the mutual morphofunctional adaptation of entomophilous plants and pollinating insects. The latter, ensuring the cross-pollination and selective fertilization of plants, have increased their capacity of reproduction and resistance. On the other hand, following the pollinating insects turning to feeding on nectar and pollen, the metabolic processes within their organism have improved, as well as the feeding conditions of larvae and adult individuals. The links established between entomophilous plants and the pollinating insects have contributed to the biologic progress both of flower plants and insects ; this has materialized in an accelerated rate of multiplication and formation of species, in expanding habitats, and extending to new ones. Suffice it to say that almost 80% of the plant species were flower plants, while the entomofauna of the Earth is represented by more than one million species. And there also are 10,000 bird species.

One of the main factors of evolution of the main representatives of stinged hymenoptera (Aculeata), after having adopted nectar and pollen as food, is the development of „social" instincts. Worthy of mention is the parallelism noticed in the gradual development and perfecting of these instincts with various species of wasps, bumble bees and honey bees : the gradual strengthening of the contact with the descendants and the care of them, perfecting the methods of defending the nest, increasing the number of individuals making up a colony and, linked to this — the morphofunctional differentiation of the individuals within the colony.

Many solitary bees of Halictus genus supply their larvae with food necessary for the entire period of development, only once. The contact and care of the new generation confines to this only. With other several species *(H. quadricinctus)* the contact with the future generation is a little closer. In spring, the fertilized queen digs a nest into the ground and build several cells. It deposits a mixture of pollen and nectar in every cell and then it lays eggs and continues to defend the nest until the young bees emerge. A highly well-marked dimorphism of females is to be noticed with *H. malachurus*. The over wintered fertilized female prepares in spring the nest and lays eggs out of which small females emerge, radically different from their mother. It is the generation of females with atrophied sexual organs, which forage nectar and pollen but, do not lay eggs. Large females and males emerge in autumn, in the same nest. The large females mate with males and winter. The small females and males die when winter comes.

With bumble bees one can notice a further development and perfection of social instincts. Only completely developed and fertilized females winter. In spring they build nests in the ground out of tiny blades of grass and moss, more often than not in holes abandoned by mice and other rodents (fig. 5). Bumble bees make cells for rearing brood and storing the food which is a mixture of wax and pollen. It is also here that they store large amounts of honey for adult individuals in case of unfavourable weather. Females do not confine themselves to supplying larvae with a mixture of pollen and nectar, but it also feeds them with a special mixture regurgitated by her. After three weeks, the young worker bees emerge. They are smaller in size, with atrophied sexual organs, and they finish the building of the nest, forage nectar and pollen, feed the larvae, while the large female lays eggs. Later on, some larvae, abundantly fed and maintained in larger cells, develop into large females, with a well-developed sexual system, which mate with males and winter. The other individuals die by the winter. One may notice that between the two extreme forms of females there is to be met a whole series of intermediary forms such as small queens and large worker bees.

The stingless bees may serve as an example of continued development of social instincts in insects. They live in Latin America in large colonies (up to 80—100 thousand individuals). They are the smallest representatives of the Apis genus, being up to 3 mm long. Their pecularity is an atrophied stinging apparatus. Unlike other bee genera, the wax glands in stingless bees are developed in all individuals : worker bees, queens and drones. The stingless bees build their nests out of a mixture of wax and resin, in the hollow trees, sometimes in the ground or in the abandoned nests of termites. For brood rearing, combs are placed horizontally (as in the wasps' nests), and are wrapped in several layers of wax and resin laid concentrically. For beebread and honey stores, heaps of „recipients" of various sizes (from the dimension of a pea up to that of a hen egg) are built. When honey is harvested, they are destroyed. In this way, the stingless bees — although numerous as a colony, hold an intermediary place in terms of evolution of social behaviour between wasps, bumble bees and, melliferous bees, the most advanced from this point of view.

In various bee species one may track down various degrees of development of social behaviour which have played an important role in their evolution and generated different possibilities in using them with economic efficiency. The most primitive of the four species of the Apis genus is the giant bee *(Apis dorsata)*, which lives only in India and in the nearby islands, in the tropical zone. The nest of these bees is a comb with two sides, vertically hanging from tree branches, in the open air (fig. 6). All cells (for brood rearing worker bees, drones and queens) of this comb (which may be 1 m.—1.5 m. long) are equal in size. The two-sides combs are used not only for rearing brood, but also for storing bee bread and honey. Characteristic of the giant bees is that when the nectar flow ends or in case of unfavourable weather the entire colony leaves the old nest and moves to another place, building up a new one. When cold sets in, bee colonies of this species usually make for south, while in the warm season — for the north. Judging by the large number of empty combs, they do not come back to the abandoned ones.

Unlike them, the individuals of another species — the little bee *(Apis florea)* — are the smallest of the genus. The colony of these bees also builds only one comb in the open, attaching it to the branches of bushes or of not-too-high trees. The comb does not surpass 35—36 cm in length and 15—20 cm in width, and the cells intended for worker bees, drones and queens are of different sizes. The little bee stores infinitesimal quantities of honey ; under tropical conditions where nectar flow exists almost all the year round, the fact is not very important for the survival or the species, although it hampers its spreading to the areas with severer climatic conditions. Therefore its area of distribution is rather limited : the plain regions of Southern India, Sumatra, Borneo and Jawa. This bee is not important from the economic point of view because of the tiny output of honey. It may eventually be considered useful in so far as it contributes to pollination.

A qualitative leap in the evolution of the social behaviour is noticeable with the third species — the bee from central India *(Apis indica)*. The colony of these bees build a nest with several vertical combs, with two sides, in the hollow trees or in not too large caves, which is a good shelter for them. This enables the regulation of temperature and ventilation. In this species, the functions and structure of queens, worker bees and drones as well as of the cells in which they develop are most definitely differentiated ; a strong attachment of bees to the nest is also noticeable, as well as a heightened instinct of collecting and storing food for wintertime. All this has contributed to the expansion of their area of distribution in the Northern and mountain areas. The bee of central India is spread all over India (as far as the Himalaya Mountains), and in China, Japan and Korea — where it had been domesticated since the earliest time, and has been kept in primitive hives for millenia. In may be met in wild state in the forests in the Far East of the USSR.

Of the Apis representatives described above, only in the bees of Central India the .evolution of the instincts was as such ; it not only has contributed to the biological progress but has also provided premises for its domestication and extensive use. The instinct of building has been perfected with it (a nest defended by a few two-size combs) which permitted the compact laying of brood and food stores, a controlled temperature and ventilation in the nest, and an economical consumption of food stores. Equally important for the domestication of the bee of Central India was the development of the foraging activity so as to have abundant food stores.

All the valuable characteristic features of the Apis genus have attained maximum development in the fourth species — the honey bees *(Apis mellifera)*. Thanks to it, the greatest biological progress may be noticed with it : it is widely spread in Asia, Europe and Africa and it has also penetrated far in the northern and mountain districts. Being domesticated, it has acquired a great economic importance not only in the Old World but also in the New World. Having adapted itself to various natural conditions and changing itself under their influence, as a result of natural and artificial selection along centuries, the honey bee has first developed into many primitive races, and subsequently into other races, which differ in point of external appearance, biological characteristics useful from the economic points of view.

COMPOSITION OF THE COLONY

In the active period, the colony is usually made up of a fully developed female — the queen, several hundred (sometime thousands) males — the drones, and many thousands underdeveloped females —

worker bees (the colour plate ; II). In the meanwhile, in the nest of the colony there are thousands of eggs laid by the queen, thousands of larvae and pupae developing from the former, and a certain amount of honey and bee bread as food stores. The existence, simultaneously with the female and the male, of a third form — the worker bees, a characteristic feature of the honey bees and of other social insects (bumble bees, ants, termites and others) is called polymorphism (a multitude of forms). Sexual dimorphism (two forms — females and males) is characteristic of the overwhelming majority of animals. The polymorphism of honey bees is the result of an evolutive process, linked to the distribution of functions among the individuals of a colony. In the bee colony, the queen is „specialized" only in egg-laying and it does not fulfil any other function. All activities of foraging, food processing, building of the nest and brood rearing are accomplished by worker bees, which, in a normal colony are free from the reproduction functions, since their sexual system is atrophied. Neither do the drones fulfil any activity. Their only attribution is to fertilize the queen.

The queen. In a normal colony there is only one fertilized queen. The development and productivity of the colony depend to a large extent on the prolificity and the hereditary qualities transmitted to the descendants through the laid fertilized eggs. That is why, ensuring young and productive queens is of a decisive importance for increasing honey yields and efficient pollination of entomophilous honey plant crops by bees.

In terms of size and weight the queen exceeds the other members of the colony. The length of its body, according to race and season, varies from 20 to 25 mm and its weight from 150 mg to 300 mg. Non-mated queens as a rule do not exceed 200 mg — 220 mg. while a good mated queen weighs, at the height of egg-laying 300 mg. and even more. Generally, the larger the queen the better its ovaries are developed and more prolific it is. The queen lives 4—5 years but the greatest prolificness is registered in the first year of life, when it lays the greatest number of fertilized eggs. Starting the second year, its prolificity decreases, the percentage of unfertilized eggs from which drones develop increases. Therefore it is not advisable to keep queens more than two years old. If in the colony, for different reasons, two or several queens appear, they start a fierce battle which designates only one winner, the most powerful. With some southern races (the African and partially the Caucasian) one may sometimes notice cases of survival in the colony of two or several queens, which shows a relatively low level of development.

Drones are temporary members of the bee colony, a fact which is linked to the limitation of their function only to mating with the queen. The drones usually appear in the colony in mid spring, when mating of young queens starts. Worker bees feed and take care of drones until the end of the nectar flow. When the nectar flow is over, the drones are mercilessly driven away from the normal colony and they die. Concurrently with driving drones away, worker bees eliminate drone brood from cells. Such an attitude of the colony towards drones after mating queens and ending of nectar flow is linked to the necessity of saving food stores for the flowless periods and for wintertime. During this period drones become useless parasites of the bee colony. Normal colonies prepare for wintering and winter without drones. Nevertheless, if a queen remained unmated or the colony has no queen at all, drones are not driven away. If late in autumn, after the nectar flow is over, the colony allows for drones to live, this is a sign of abnormal condition of the colony.

Life expectancy of drone which does not mate with queens is under 5—6 months in the central zone, while in the southern districts it may be a little longer. After mating with the queen the drones die. In point of external appearance the drones are easily distinguished from queens and worker bees. They have a flatter body, as if shortened, 15 mm—17 mm. long. Unlike the queen, whose wings do not reach the extremity of the abdomen, in drones they exceed the tip of the abdominal segments by 3—4 mm. Drones differ from queens by their more developed compound eyes. Drones' weight reaches 250—260 mg. Their sexual glands and annex organs are well developed accounting for more than half of the abdominal cavity.

Worker bees are the major part of the colony population. A strong colony early in spring owns 20,000—25,000 worker bees. Then their number gradually increases standing at the beginning of the nectar flow, at 60,000—80,000 and even more; in autumn, it drops down to 20,000—25,000.

In medium or weak colonies there are less worker bees and that is why the respective colonies are less productive and less resistant to unfavourable environmental conditions and diseases. The body of a worker bee is about 12 mm — 14 mm. long and weighs approximately 100 mg. The general weight of the bee depends on the degree of filling of the honey sac with nectar or honey and of intestines with faeces, on the rearing conditions, age, race, etc. With swarm bees, the load of the honey sac may reach 50—60 mg., i.e. half of their total weight. During an abundant nectar flow, the weight of the nectar carried in the honey sac of a worker bee is usually of 35—40 mg. The amount of faeces in the posterior intestine is 45 mg — 50 mg. in Middle Russian bees, by the end of winter.

The southern, yellow Caucasian bees as well as the Ukrainean bees are slightly smaller than the northern ones. One kilogram of bees averages 10,000 Middle Russian bees and about 11,000 southern bees (without their sac and posterior intestine being loaded). The determination of the weight and number of bees of the colony, auxiliary colonies, nuclei and of package bee is of great practical importance. The weight of the colony is most precisely established by weighing, during experimental operations. In practice, the number of bees in a colony is determined after the number of frames completely covered by them and the occupied bee ways. Generally, the bees on a standard frame compactly covered by them, weigh 250 g, their number standing at 2,500 ; on the frame of a multiple-storey hive they weigh about 200 g.

The duration of life of worker bees depends on the intensity of their activity and metabolism. In summer time, during the nectar flow, their life lasts for only 5—6 weeks, and in autumn when the activity is less intense — for 7—8 weeks. The duration of life of bees suddenly declines when a great amount of brood is reared. The bees which emerged in autumn, which did not participate in the main flow and in rearing brood, overwinter well ; they live for 8—9 months, preserving their capacity of rearing brood. The bees reared in strong colonies live longer than the weaker ones. Intense activity leads to intensification of metabolism in bees' bodies. Part of the products of metabolism is deposited in the fat cells. The complete filling of these cells is conducive to wearing out the bee's body. The intense activity also induces changes into the nervous cells, especially in the fungiform lobe cells in bees' brain and as a consequence their activity is disturbed. The disturbance of the metabolic process and of the function of the nervous system results in bee's death. In spite of the short life of individual bees, the colony, as an integral biological unity, lives for a long time, because it is permanently infused with young bees which renew the componence of the colony.

STRUCTURE OF THE BEE'S BODY

The external structure of the queens, worker bees and drones has many common traits and differs only in point of details. Knowledge of the external structure of bees and of some internal peculiarities is not important only as such. Many external and internal peculiarities are closely related to the productivity of the bee colony (weight and the size of the queen, size and number of oviducts and ovaries, length of proboscis, the capacity of the honey sac and of posterior intestine, the dimensions of wax plate). Therefore, the study of these peculiarities is interesting also for the correct solving a number of practical problems of beekeeping.

The body of the bee is made up of segments which can be very clearly seen in larvae. During the process of ontogenesis (individual development) the segments of the thorax and of the head join with each other and they can no longer be seen in adult bees. In adults, the segmentary structure is well defined on abdomens and legs.

The body of an adult bee is made up of head, thorax, and abdomen. A pair of antennae, a pair of composed eyes, three simple eyes and buccal annexes are to be found on the head. Two pairs of membranous wings are attached to the fore part of the thorax, and three pairs of articulated legs are attached to its hind part.

The external skeleton of the bee. The body of the bee is covered by a hard layer — the exoskeleton, which protects the interior organs from traumatisms, temperature oscillations, attack of enemies, being at the same time a support for attaching muscles and some internal organs. Thus it fulfils the function of both the epidermis and internal skeleton in vertebrate animals. The exoskeleton consists of three layers : the external one — the cuticle, the layer of hypodermic cells under it, and the internal one — the basement membrane.

The cuticle in its turn is made up of three layers. The outer layer of cells (epicuticle) is very thin and contains lipids, which protects the bee's body from humidity. The cells of the medium, thicker and hardened layer (exocuticle) contain the pigments on which depends the external colour of the bee. The inner layer, the thickest and laminated (endocuticle), which adheres to the hypoderm cells, consists of chitin — a very resistant substance which endures high temperatures and alkaline action.

Between the segments of the abdomen and of the legs as well as on other regions on bee's body, the cuticle is thin, elastic and soft, which ensures their mobility. The cells of the cuticle contain different pigments in various regions of the body. As a rule, the bees populating the southern countries are yellow (Italian, Persian, Yellow, Armenian, North Caucasian, etc.), while those in the northern districts are darker (for instance the bees in Central Russia, the mountain Caucasian, and Carniolan bees). This attests to the capacity of adaptation of the bee pigment ; it also plays an important part in the heat exchange.

On the outside, the body of the bee is covered by hairs. Some of them protect the body from dust and dirt. The bees remove the filth from their body with the brushes on its hind legs. The hairs of the bee play an important part in pollinating plants : when visiting flowers pollen adheres to them, and the bees carry it to other flowers, thus ensuring the selectivity of pollination and fertilization. Nervous endings draw nearer to some hairs and in this case they serve as sense organs. The body of the young bees is completely covered with flexible hairs. Getting older the hairs gradually wear off and the old bees almost completely lose their hairs on the abdomen and thorax: their body becomes dark and glossy

The hypodermis is made up of a layer of cells. Some of them (the chitinous ones) secret chitin or their external part turns into cuticle : some hypodermic cells, united with nervous fibres, play the part of sensory cells. They are always linked to external cuticle excrescences (plates-hairs) together with which they form sense organs.

The basement membrane is a thin layer lining internally the hypodermis and all organs deriving from the latter's cells.

The head of the bee is covered by a very thick layer of chitin, which makes up a hard shield protecting the brain. The shape of the queen's head is rounded out by the simple eyes. The head of the worker bee is triangular, and the three ocelli are placed at head top. The drone head is almost circular because the compound eyes form a semicircle on the head top. The simple eyes are placed to the upper part of the face.

From the centre of the face, above the upper labium arise the flexible antennae close together. Each of them is made up of a basal stalk and a distal part. In drones, the latter is subdivided in 12 small sections whereas in worker bees and queens — in 11. These flagellar sections are connected by a narrow membranous neck which ensures the mobility of the antennae. The cavity of the antenna is passed through by the nerve of the olfactory lobe of the brain and on its surface there are to be found numerous sense organs (hairs) and olfactory organs *(Sensilla placodea).*

The thorax of the bee is made up of four parts (three segments and an intermediary segment — propodeum) each of them made up of two halves of ring — the dorsal and the abdominal one. The first of them (the prothorax) — the smaller, is articulated by a thin chitinous membrane with the head and thus the bee can move the head during nectar and pollen collection and comb building. The second segment (the mesothorax) — is the most developed. Its posterior part is called scutellum and it is here that the bees are marked with paint. The third segment (the metathorax) is linked to the mesothorax by a thin ring. The fourth segment (the intermediary one) covers the posterior part of the thorax with its dorsal curved half-ring while the abdominal half ring, not too large in size, makes up the anterior part of the abdominal surface of the petiole joining the thorax with the abdomen. Three thoracic stigmata are attached on either side of the thorax, which facilitate the exchange of gases between the tracheal sacs and the exterior atmosphere.

The abdomen of the working bee appears to consist of six segments, while that of the drone of seven. Every segment is made up of two halves of a ring : the bigger dorsal one (tergite) and the smaller abdominal one (sternite). The tergites make up the dorsal and lateral wall of the abdomen while the sternite — the lower one. The first segment of the abdomen differs by its structure from the others, its anterior end narrows and turns into abdominal trunk, with whose help the abdomen is articulated with the thorax. All the segments of the abdomen are connected to each other by a thin chitinous membrane, which render the abdomen easily movable making it apt to change its volume. This is necessary for ensuring the normal functioning of the organs in the abdomen, since their activity implies changing of the volume (filling of the honey sac with nectar, of the large intestine with faeces, breathing, etc.). The size of the bee is difficult to be determined after external appearance. When the honey sac or the large intestine are full the bee looks much larger than when its abdomen is empty, when the latter's segments are withdrawn into each other.

The pair wax plates (mirrors) are to be found on the four halves of abdominal rings of the worker bee. The queen and drone do not have such plates and therefore they do not secrete wax.

The legs of the bee serve as support, as a means of locomotion, as well as organs for cleaning the body. They are also adapted for pollen collection, making up pollen pellets and their transport to the hive. The bee has three pairs of legs, attached to the thorax. Each of them is made up of five segments : coxa, trochanter, femur, tibia and tarsus. In its turn, the tarsus is made up of five segments. All segments are united

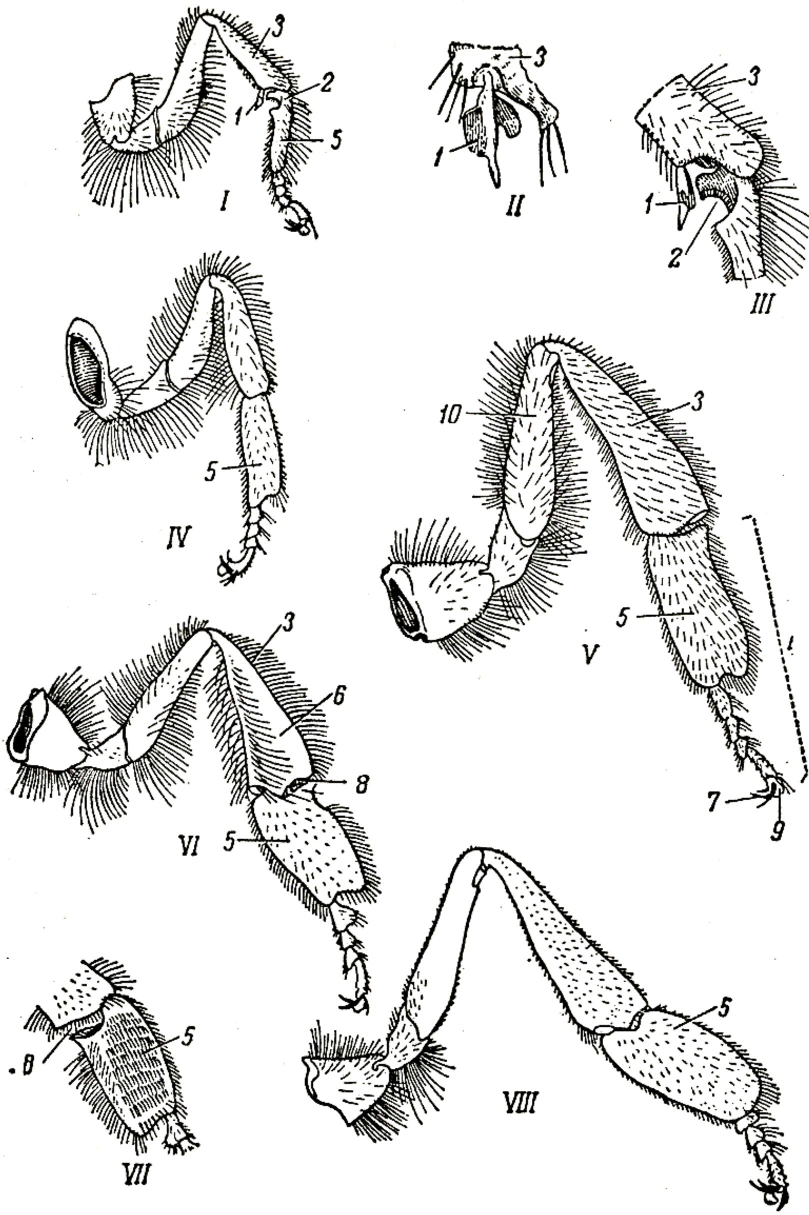


Fig. 3.
The structure of the bee legs

I — the fore leg of the worker bee; II and III — antenna cleaner on the fore leg; IV — the middle leg of the worker bee; V — the hind leg of the queen; VI — the hind leg of the worker bee with pollen basket (corbicula) on the outer side of the tibia; VII — inside view of the basic joint of the hind leg of the worker bee, with brushes and bristles for pollen collection; VIII — the hind leg of the drone; 1. — antenna cleaner at the end of the tibia; 2. — the hollow on the first segment of the fore tarsus for antenna cleaning; 3 — the tibia; 4 — the tarsus; 5 — the first segment of the tarsus; 6 — the pollen corbicula; 7 — the claw; 8 — wax shears; 9 — adhesive cushion for advancing on smooth surface; 10 — the femur.

by a thin chitinous membrane, which ensures a high mobility to the legs.

The fore legs of the bees are shorter but more mobile than the others. Small brushes for cleaning the compound eyes are to be found on their tibias. Such brushes also exist on the first segments of the tarsus; they serve for collecting the pollen from the fore part of the body and cleaning the mouth parts. On the inner part of the same tarsus there is a hollow with hairs. In front of the hollow there is the mobile excrescence of tibia. Placing the antenna into the hollow and covering it with the excrescence, the bee moves the antenna to and fro, thus cleaning the filth and the dust grains stuck on it. The regular cleaning of the antennae is highly important for bees, since numerous sense organs are to be found on the antennae.

The middle legs are less mobile. On the large internal surfaces of the tibia there are to be found many small hairs with which the bee brushes the pollen from the body. In the lower part of the tibia there is a small excrescence — the spur with whose help the bees throw into cells the pollen pellets which they bring into the hive.

The hind legs are more mobile than the middle ones and they are provided with a number of parts for collecting and transporting the pollen from the flowers to the hives. On the external part of the tibia there is the pollen basket, in which the bee makes up the pellet for carrying the pollen into the hive, in the inside part of the first segment of the tarsus — the brush for gathering the pollen grains on the bee's body. Finally, the pollen spur, between the tibia and the first segment of the tarsus, which serves for making up pellets. All these parts are well developed in worker bees and do not exist in queens and drones, since they do not collect pollen.

The wings of the bee are attached at their basis to the edges of the half dorsal ring of the thorax. The bee has two pairs of wings, the fore wings being much larger. When the wings are at rest, they are folded over the back, the fore wing covering the hind one. When extended preparatory to flight, the front wing is drawn over the upper surface of the hind wing beneath it, and the hooks of the latter engage in the fold of the front wing.

The organs of locomotion of the bees are the muscles. With their help the bee walks, flies, performs various operations. As a consequence of the successive contractions of the muscles the bee regurgitates the nectar from the honey sac, the food advances into the intestines, etc. The

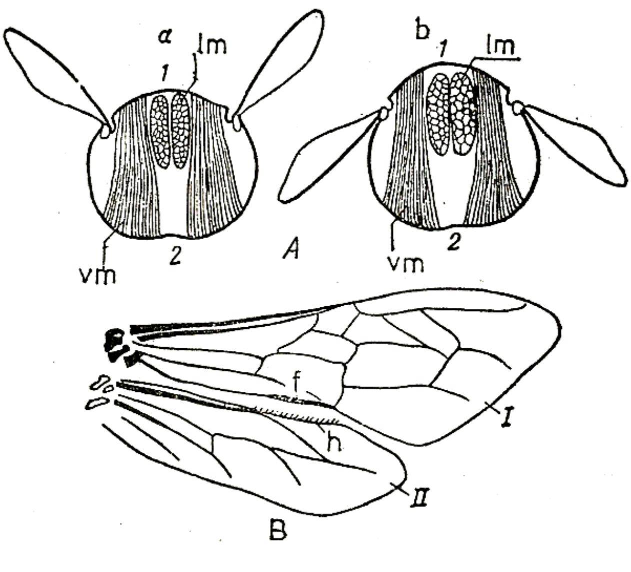


Fig. 4 The wings of the honey bee

A. Wing movements during flight ; a — the wings in upright position and b — the wings let down ; 1 — the dorsal segment and 2 — the abdominal segment; vm — vertical muscles and lm — longitudinal muscles; B — bee's wings hooked together. I — the fore wing and II — the hind wing ; f — fold ; h — wing hook.

relative force of the bee's muscles is remarkable. On a rough surface the bee may carry 2 grams (20 times as much as its own weight).

The bee's locomotion and flight. The legs of a bee in stationary position are directed a little forward and laterally which ensures its stability. In walking and rushing the equilibrium is maintained, since the bee raises concomitantly three legs, and leans itself upon the other three — on the middle one on one side, and on the fore and hind one on the other. The bee can move along a vertical rough surface (along the walls of the hive) as well as on an absolutely smooth one, thanks to the devices on the last segments of the tarsus : there are two split claws with their tips curved downwards on every segment as well as the „clutching organ". The bee clutches itself with its claws at rough surfaces and it can move even in up-side-down position. With its arolium (sometimes called suckers) the legs of the bee clutch at the smooth surface of the things (for instance the petals of the flower) and the bee can move on their surface.

The wings of the bee have no muscles although the number of rhythmical strokes per second stands at 400—450. The movement of the wings is produced with the help of the well-developed muscles of the thorax. When contracting the vertical thorax muscles the borders of the wing-bearing segments of the thorax draw nearer to one another and raise the wings. When the muscles relax, the segments are compressed and the wings descend. During flight the bee can carry up to 75 mg. of load, but the practical load of the honey sac does not surpass 45—50 mg. The weight of the pollen pellets is twice smaller. The bee with a full load flies at a speed of 20—25 km per hour. Without any load its flying speed reaches 60—65 km./hour. During flight the bee consumes nearly 1.5 mg. food per minute.

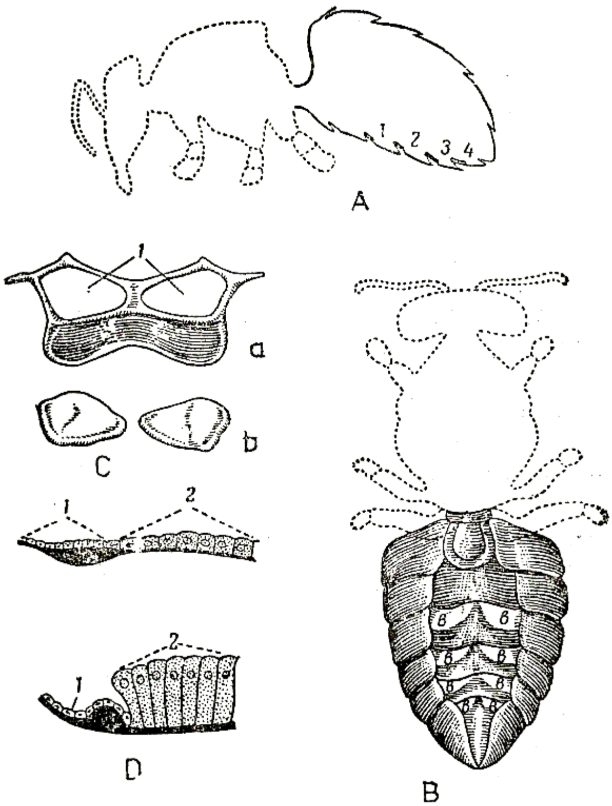
The flight range of bees depends on the relief of the place, the distribution of honey plants, the presence of marks of orientation (trees, thickets and other things). In plain regions, where orientation landmarks are less frequent, the bees fly only within a 4—5 km radius. In a place having many dingles and numerous land-marks easily noticeable, the bees' flight range may be of 10—12 km, to reach the large areas under farm crops which need bees for pollination. The farther from the apiary are the massive melliferous crops the more time and food is needed by bees for collecting nectar and for pollinating flowers. Therefore, the apiaries must be located as close as possible to the sources which need bee pollination. Such plants must be sited within bees radius of flight, not farther than 1.5—2.0 km. At a greater distance it is necessary to bring the bee-hives to the honey crops.

WAX GLANDS AND THE BUILDINGS OF THE BEES

The wax glands of the bee are modified cells of hypodermis, which during the process of evolution have become specialized in secreting wax. As it was already shown, they are situated on the last four abdominal segments of the worker bee above the wax plates (mirrors).

Fig. 5.
The bee's wax glands

A — Position of wax glands in bees (1—4) ; B — ventral part of abdomen ; wax plates are seen protruding from under the abdominal segments ; C — the abdominal segment with a pair of wax mirrors (a) ; under it wax film is seen (b); D — wax glands; I — in newly emerged bees ; II — in 2-week old bees; 1 — hypodermis cells ; 2 — cells of the wax gland.



Studying transversal sections with the microscope one can see how the cells of the hypoderm, gradually separating, turn into cells of the wax gland and the limit between them is difficult to be established. The tracheas reach every cell of the wax gland, and thus the cell is supplied the necessary oxygen for the intensive metabolic processes entailed by wax secretion.

The development of the wax glands starts in the first days of life of the young bees, though they do not secrete wax yet. Only in the 4 th—5 th day of life one can notice a thin wax layer on the wax plates. Under favourable conditions the wax glands attain maximum development when bees are 12—18 days old. In this case the cells of the glands reach their utmost height, vacuole filled with liquid wax may be perceived, the wax being discharged through the microscopic orifices of the mirror to the outside. On the surface of the mirror, the wax hardens under the action of the atmosphere under the form of a plate. Since the bee has four pairs of wax plates it secretes 8 plates (weighing 2 mg.) at the same time. For one kg. of wax, about 4 million wax plates are necessary. After the age of 2—3 weeks the function of wax glands diminishes and the cells of the gland shrink (especially in height) and wax secretion ceases.

Wax secretion is highly influenced — in addition to the age of the bee — by the food and nectar flow conditions, the strength of the colony, the room available in the nest, etc. The most abundant wax secretion occurs in spring and summer, when many young bees and brood exist in the hive and the nectar flow is good. By the end of summer and in autumn the wax secretion decreases abruptly. During winter time, the wax glands are at rest, secreting no wax.

The combs. The natural combs of honey bees are made up of wax. It is also out of natural wax that foundation is made, which constitute the basis for drawing out combs by the bees. In the bee nest the combs are vertically placed, parallel with one another. Each comb consists of a midrib; on its both sides, hexagonal cells in horizontal rows. When building the comb the bee takes off her abdomen the wax plates with its fore and hind legs, softens it with its maxillas and out of the wax pellets it builds cell bottoms and walls. That is why close to the building areas bees usually flock very much like clusters. As a rule the combs are built vertically — from the upper side downward. The newly built combs are white, but gradually their colour gets darker.

Bees draw out combs only in queenright colonies. In queenless colonies and in those which prepare for swarming building of combs ceases. The weak colonies build a few combs only, and of poor quality, it is only the strong colonies — which have abundant food stores — that build many and good combs, and produce much wax.

The cells of the combs are of three kinds : for worker bees, for drones, and for queens. The cells for worker bees and drones are hexagonal, the cells on either side of the comb being built so as the bottom of a cell is a component part of the bottoms of another three cells on the opposite side. The walls of the cells are slightly thicker at the upper end. Such a structure of the cells confers them maximum capacity and resistance, with a minimum amount of wax being necessary. The horizontal diameter of the worker bee's cell is between 5.3 and 5.7 mm, and that of the drone cell — about 7 mm. The depth of worker cells is 12—13 mm. whereas the volume is of 0.25 cu cm — 0.28 cu cm. Four worker bee cells or three drone cells exist on an average in 1 cu cm of comb. In step with latitude — from south to north — the size of the cells are greater as the bees are. As bees emerge, the volume of the cells decreases, because every emerged bee leaves behind its pupal cover and faeces.

The thickness of combs with worker cells is 22—25 mm., the distance between the midribs of the neighbouring combs in the nest being 35—37 mm. The distance between two combs is called bee space, which is usually of about 12 mm.

For queens, worker bees build solitary, large cells — *the queen-cells.* There are two kinds of queen-cells: swarming queen-cells and emergency queen-cells. The swarming queen cells are built when the colony prepares for natural swarming. They are built at the peripheral areas of the comb. The starter of a swarming queen cell is called queen-cell cup, and it really has the shape of a cup or a jug with a round bottom. Here the queen lays the egg out of which will emerge the young queen. The bees build emergency queen cells when a new queen must be obtained in stead of a failing one. The bottom of the emergency queen cells is no longer a cup but a worker bee's cell, in which there is a young larva. The bees enlarge this cell on the account of the neighbouring ones and turn it into a queen-cell (see the colour plate, II, 9). The volume of the swarming queen cell is more than three times larger than that of a worker bee cell — 0.8—0.9 cu cm. The emergency queen cells are usually smaller. Smaller and less productive queens emerge from smaller queen-cells. Better queens are obtained through the artificial method of rearing them in highly productive colonies, supplied with plenty of food.

Besides the worker bee, drone and queen cells, the bees also build honey cells, transition cells and connection cells. The honey cells are common cells of worker bee or drone, a little deeper, with oblong walls and curved upwards. The capacity of honey cells is 1.5—2 times greater. The nectar does not leak out of them. Bees build such combs when frames are situated at a greater distance from one another than the usual one. This method is used when comb honey or section honey is produced in honey supers. The queen does not lay eggs in the honey cells. The transition cells are built by bees between worker bee cells and the drone cells, the connection cells — in the places where the comb is attached to the frame.

In modern hives the combs are perpendicular set to the hive entrance (cold way) or are parallel to it (warm way). The former method is more widely used. In traditional hives as well as in wild bee nests the cold and warm way occur, and even combs across the nest.

For closing up all orifices in the nest when it is cold, for narrowing the hive entrance, impregnating the crown board or cloth, reinforcing frames and for other purposes, the bees use propolis. They gather it from the buds of certain trees, under the form of resinuous secretions, which are processed before being used. The tendency for collecting and using propolis is unequally manifest with bees of different races. For example, it is highly developed with Caucasian bees, while Middle Russian bees and especially the Carpathian ones collect and use small amounts of propolis.

The fact has a practical importance : a nest less glued with propolis, as that of the Carpathian bees, is cleaner and easier to inspect ; an abundance of propolis is undesirable in comb honey production. On the other hand, from the Caucasian bees' nests, more propolis can be collected and marketed.

The sting. Only the worker bees and the queen have it. It is an elaborated ovopositor, its parts being readily identified with those of the ovipositor of many hymenoptera ; during the process of evolution it has got new functions. With worker bees the sting is an organ of active defence. The queen also uses it in the process of laying eggs. The drones do not have any sting. It is situated at the end of the abdomen and, when at rest, it is concealed by its last segments. It is made up of chitinous parts (two unpaired fixed stylets, and two paired mobile elements — the lancets, the poison glands and the poison sac, muscle tissue and two palps — sense organs (fig. 10). At the underside of the stylet there are two longitudinal arms. The lancets are slender rods armed distally on their lateral surfaces with barb-like teeth pointed anteriorly, and having longitudinal grooves anteriorly. The lancets are held close against the undersurface of the stylet by grooves that fit over tracklike ridges of the latter, making up an interlocking device which allow the lancets to slide freely back and forth. Between the stylet and the lancets is the poison canal of the sting which expands into the cavity of the bulb where it receives the liquid poison from the great poison sac.

Three glands are linked to the sting : the large poison gland (made up of a long and ramified tube at the end, where the poison is secreted and the poison sac which stores it), the small poison gland (under the form of a short tube, at the basis of the stylet and the so-called Kozhevnikov gland (a mass of glandular cells whose secretion lubricates the stylet and the lancets).

Bee venom is a mixture of secretions of the large and small poison glands. It is transparent and acid, it has a specific smell and bacteriolytic properties. Its chemical composition is complex. It contains a relatively small amount of water, dry matter — 41% on the average. Its ash has been found to include copper and magnesium: among the micromolecular compound substances hystamine was recorded in a proportion of 1%, as well as organic acids. The venom is mainly made up of complex aluminium compounds with molecular weight close to 35 000, on whose

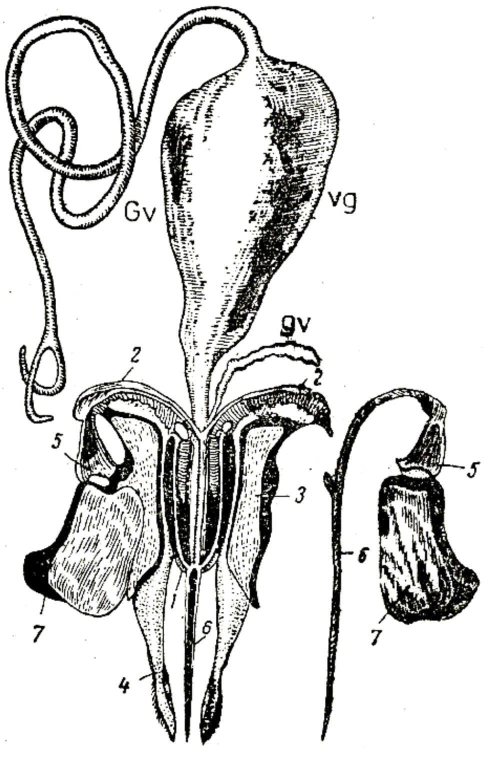


Fig. 6. The sting of the bee :
Gv — large venom gland ; gv — small venom gland; Vg — venom sac of sting; 1 — lancets; 2 — barbs of the lancets; 3 — the oblong plate; 4 — palp ; 5 — triangular plate ; 6 — stylet ; 7 — quadrate plate

biologically active fraction depends the basical pharmacological action of the bee venom.

The bee venom — very much like the phytocides and antibiotics, — is used for its good effect on the vital functions of other organisms.

The fact is known that the evolution of bees and of other mammals took place in the conditions of a close inter-play, and that they even competed in occupying the nests (in hollow trees). That is why the sting of the bees is better adapted for an efficient attack against mammals; the bees are strongly irritated by the smell of the epithelial secretions, by the dark spots in motion, and when reaching surfaces covered with thick fur. The fact has also been proved by comparative toxicological investigations made (N. M. Artemov), according to which the minimum lethal doses of bee venom for caterpillars and reptiles are 8—10 times higher than for the mammals. The bee's venom is twice stronger in its effect on mammals; on the one hand it affects the body's vital systems, and on the other it stimulates the latter's defence forces. This combined action underlies the therapeutical qualities of the bee venom.

When stinging a man or an animal, they first thrust the tips of the lancets into the skin, then the sliding of the lancets along the longitudinal grooves accomplish the penetration of the tip into the wound and the barb-like teeth fix the sting into the wound of the victim.

The bee, trying to fly tears itself away from the sting and after a while it dies. But the sting will penetrate deeper and deeper into the victim's body, while bee venom accumulates in the wound. The longer the sting remains in the human body the greater the amount of venom penetrates into the wound. To lessen the pain, one must take out the sting as soon as possible, without pressing the poison sac. Therefore the sting must be extracted obliquely, with the help of the finger nail or with the spike of the knife not with fingers.

THE DIGESTIVE ORGANS OF THE BEE

The digestive organs include the alimentary canal, the organs of feeding and the system of glands.

The mouth-parts-organs of feeding of worker bees, queens and drones identical in general, being of the licking and sucking type. They include the labium, the paired upper maxillae and the proboscis.

The upper labium under the form of a mobile plate hangs from the lower part of the fore wall of the head and covers the access into the buccal cavity.

The upper maxillae are to be found on the edges of the labium and they are able to perform only side movements. With its maxillae endowed with strong muscles, the bee can gnaw the cap of the cell before emerging from it, bite bee bread and propolis, chew wax for building cells, and take the dirt out of the nest.

The proboscis is used for collecting nectar, honey and water. It is made up of the paired lower maxillae and the labium which includes the triangular basis of the mentum, the mentum in the shape of a groove, and a long and flexible glossa, ending with a labellum. Where the glossa joins the mentum there are two palpi made up of four segments. The glossa is covered on its external side with hairs. When not in use, the proboscis is folded back behind the head. When the bee collects liquid food, it stretches out, the component parts, being brought together in such a way as to form tube through which the liquid nectar from flower corollas can be drawn up to the mouth. When the nectar is not in large quantities, the bee licks it with the tip of its glossa, and the nectar reaches the pharynx through the narrow tube of the proboscis very much like a capillary vessel. The proboscis is best developed with worker bees, which perform all operations of collection and carrying of the food stores to the hive. Since the queen and drones do not perform such functions, their proboscis is less developed.

The length of the proboscis is highly important for collecting nectar and plant pollination, especially those plants in which nectar is to be found at the end of the long tube of the corolla (e.g. red clover). It is taken into consideration when classifying bees. The average length of the proboscis is determined at the microscope by means of an occular micrometer and is made up of the sum of the length of the mentum base, that of the mentum and that of the glossa. The length of the proboscis of worker bees increases gradually from the northern to the southern regions. In bees living in northern regions the proboscis is 5.7—5.8 mm. long, in the bees of central zone it is 6—6.2 mm long, while in those in the southern regions it reaches 7 mm. The longest

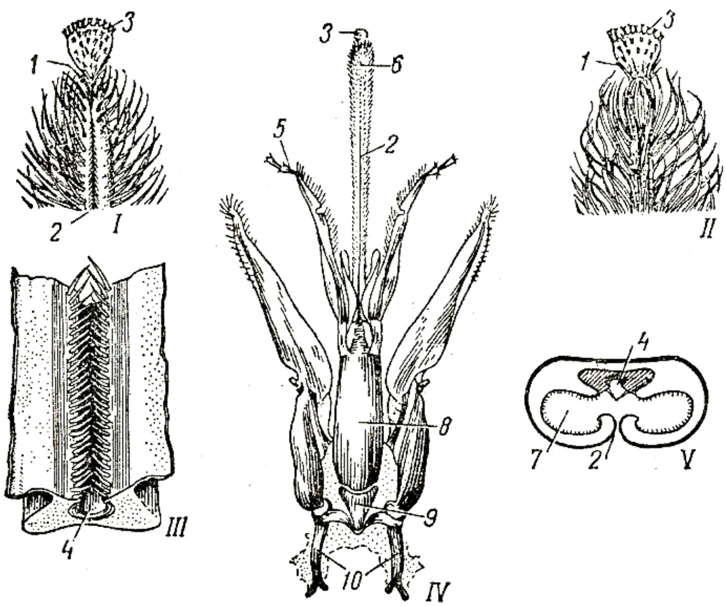


Fig. 7. The mouth parts of the worker bee:
I — the tip of the glossa (seen from the underside); II — the tip of the glossa (seen from above); III — the tip of the glossal rod with groove; IV — the stretched proboscis; V — cross section of the glossa; 1 — the hairs on the tip of the glossa; 2 — the groove on the underside of the glossa; 3 — labellum; 4 — the groove on the underside of the glossa; 5 — the labial palpus; 6 — the glossa; 7 — the canal inside the glossa; 8 — the mentum; 9 — the basis of the mentum; 10 — the maxillary suspensoria

proboscis is recorded in the mountain grey Caucasian bees, and especially in the Georgian ones (over 7 mm.).

The alimentary canal starts with the mouth parts and ends with the rectum. It is made up of three parts: the fore-gut, which receives and keeps the food for a while ; the mid-gut where the food is digested, and the hind-gut where the remains of the undigested food are stored (colour plate III, 1 and 6).

The fore-gut is made up of pharynx, oesophagus, the honey sac with intermediary valve. The *pharynx* starts with mouth parts continues along the anterior wall of the head, turns back and passes into the *oesophagus*, which is a slender tube passing through thorax into the fore part of the abdomen where it expands into the honey sac. The muscles of the pharynx alternatively contracting, distent and shrinks its lumen, and the pharynx acts like a pump absorbing the liquid food from the proboscis.

The honey sac is well developed in worker bees. It serves as a sac for storing the nectar and honey, and it is in it that nectar is partially processed. In drones and queens, which do not collect nectar, the honey sac is atrophied. The honey sac continues into the mid-gut by a valve which regulates the entrance of the food from the honey sac into the mid-gut and retains in it the nectar to be taken to the hive. When muscular fibres covering the honey sac in the exterior contract, the food in it may be regurgitated through oesophagus or let to pass into the mid-gut (if the valve of the honey sac is open).

The intermediary valve ensures the removal of the pollen grains from the liquid food reaching the honey sac ; this is of an essential importance for the feeding of bees in wintertime, preventing the overloading of the hind-gut with remains of undigested food.

The mid-gut, unlike the foregut and hindgut has numerous deep internal folds which increase the digestive area. At the bottom of these folds the multiplication of the gland cells takes place, which secrete the necessary enzymes for food processing. In the anterior parts of the mid-gut, the peritrophic membranes exist, which enclose the food mass. These membranes are very permeable in one direction for the digestive secretions and in the other to the digested food, and protect the epitelial cells from being harmed by pollen grains, and hampers the penetration of the pathogen agents. By contracting the external layer of muscular fibres (peristaltism), the food mass is pressed from the anterior part of the mid-gut to the end part. According to the latest research results of the Bee Research Institute, the anterior and posterior parts of the mid-gut fulfil the following functions : the anterior one — pre-eminently the secretory function, and the posterior one — the absorption one.

The hind-gut is made up of the small intestine and the large intestine. The first is a slender tube, covered with muscles in the exterior. Inside it, there are dents oriented to the posterior part thanks to which faeces are pressed quicker into the large intestine, with peristaltic movements.

The large intestine is a large thin-walled and chitinous sac, covered with a muscular layer on its outer surface. When it is empty it is

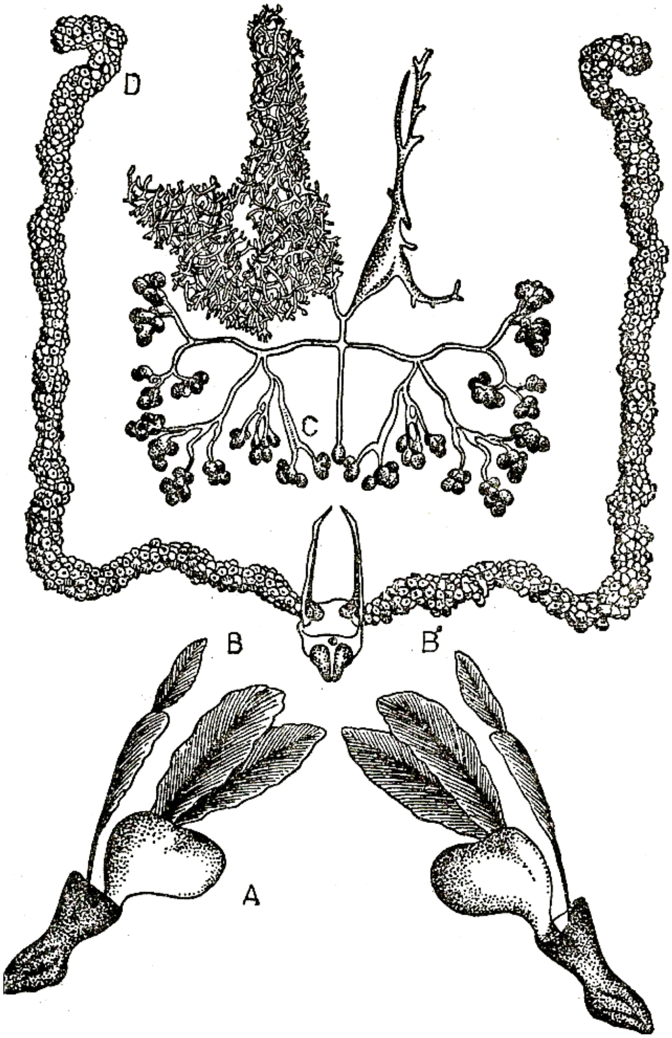


Fig. 8. The salivary glands of the worker bee :
A — the supramandibular gland; B — the pharyngeal gland ; (B1 — the pharyngeal plate) ; C — the post cerebral gland ; D — the thoracic gland

a flabby pouch ; when full it becomes so expanded as to hold 40—50 mg. of faeces, i.e. half of bee's own weight. This has a great importance from the point of view of adaptation, as it enables the honey bee to resist to the long winter in the north.

On the walls of the anterior part of the hind-gut are six long, regularly spaced thickenings of the epithelial wall. The secretion of these glands penetrates into the inner cavity of the hind-gut preventing fermentation and putrefaction of faeces.

Salivary glands. The activity of the salivary glands is closely linked to the digestion organs. There are four pairs of salivary glands in bees — supramandibular, pharyngeal, post-cerebral and thoracic ones.

The mandibular glands are sac-like glands attached at the basis of the upper maxilla. The secretion of the glands with worker bees is the basic component of the royal jelly used by them to feed the young larvae. They are well developed in worker bees and queens, but vestigial in drones. According to latest reports (Orösi Pal) in worker bees these glands secrete a substance dissolving wax. The mandibular glands of the queens produce the queen substance (ectohormone). This substance is licked from the surface of the queen's body by the worker bees which — according to Butler et al. — incites the bees to start building queen cells.

The pharyngeal glands are to be found in the head of the bee under the form of two long channels, united with numerous spheric ramifications of the glandular cells. These glands lie in the front part of the head and open into outlet ducts leading to the pharynx. They release a secretion containing the enzymes necessary for processing nectar and pollen. In addition to that the worker bees' secretion of these glands is a component of the royal jelly. The pharyngeal glands of the newly emerged bees are under-developed and they do not produce any secretion. They attain maximum development in 9—12 day-old bees when they are busy with brood rearing. Then their secretory activity declines. Although in the old foraging bees the pharyngeal glands are less developed, the activity of invertase and phosphatase is higher. These glands attain utmost development in worker bees in spring and summer when much unsealed brood exists in the colony.

When bees consume pollen and bee bread their activity intensifies.

The post-cerebral gland lies against the posterior walls of the cranium in the upper part. It consists of a loosely arranged mass of small pear-shaped bodies with individual ducts which unite irregularly with each other and eventually come together in a single duct that joins the common median duct from the thoracic glands. The secretion of the post-cerebral glands serves for lubricating the chitinous parts of the proboscis.

Each *thoracic gland* consists of a mass of many-branched glandular tubules lying in the anterior part of the thoracic cavity. The several short collecting ducts which unite in several major ducts end in a sac-like reservoir on the labium. Its secretion contains the enzymes necessary for food digestion.

Of the bees salivary glands, a great part is played in digestion by the pharyngeal and thoracic glands.

DIGESTION AND METABOLISM IN BEES

The food of the bee consists of complex chemical compound substances. They cannot be assimilated by the bee's body without being previously processed, by using the enzymes secreted by the specific cells of the salivary glands, the glands in the mid-gut, etc. The following enzymes are involved in the process of digestion: invertase which splits sucrose ; in glucose and fructose ; amylase, which breaks down starch ; glycogenase which splits glycogen ; lipase which acts on fats ; protease, pepsin and tripsin which break down albumins. Besides them, there are a number of enzymes which reach the digestive tract of the bee together with the pollen. The micro-organisms in the intestine are also likely to play a part in developing enzymes.

When liquid food is ingested, the secretion containing invertase and amylase comes from the pharyngeal and thoracic glands, starting to act upon food in the first part of the intestine. But the essential processes of food digestion and absorption take place in the mid-gut.

The monosaccharides are readily absorbed through the walls of the mid-gut, without any previous processing. The disaccharides are split by invertase into glucose and fructose ; starch is turned by amylase into dissacharides, then by other enzymes into monosaccharides. In the same segment of bee's intestine take place the saponification of the lipids by lipase and splitting of albumins by the enzymes protease, pepsin and tripsin into aminoacids. The hind gut does not play a too great part in the digestion since no enzymes are secreted here. The processes of decomposition of food under the action of the enzymes secreted in the fore-gut and mid-gut are completed into the hind-gut.

The absorption of the extra amount of water from the non-digested food takes place in the large intestine where faeces are accumulated. Rectal glands inside the large intestine produce a secretion (the enzyme catalase included) which prevents putrefaction, thus making it possible for the bees to retain much intestinal waste during the winter period. The duration of the digestion process depends on the food consistency, on the physiological condition of bees and on their living conditions. The liquid food reaches the honey sac after being sucked. It may stay here for several hours. When the bees' metabolism is reduced, as for example in the natural swarm cluster or during experiments with combless package bees, honey may stay in their honey sac up to 4—5 days. The first food intake reaches the mid-gut 15 minutes after ingurgitation, and after 24 hours it is already in the hind-gut.

The products which result following digestion, penetrate into the epitelial cells of the mid-gut, wherefrom they reach the blood and are carried to the cells of various organs and tissues of the bee.

Within the process of metabolism, the potential energy of the food is turned into thermal, mechanical, and into other kinds of energy ; also formation processes take place — regeneration of the destroyed substances of cells, development and increase in number of cells.

The metabolism is a characteristic feature of the live organism distinguishing it from dead ones. A live organism cannot exist without certain environmental conditions and it is only in close unity with it that life is possible.

The formation processes are highly important during the period of embryonic and post-embryonic development of the bee, and during heavy egglaying by the queen. With adult bees, the energetic processes are the most important, as during building of cells less food is consumed. The metabolic intensity depends on several factors : the physiological condition and age of bees, the functions fulfilled by them, the condition of the colony, the temperature condition, etc. Indicators of the intensity of metabolism include the quantity of oxygen inhaled and the quantity of carbon dioxide liberated by the body. The oxidation processes result in release of energy. That is why one of the indicators of the food quality is the amount of calories resulting following their oxidation in the body. 1 g. of carbohydrates or of albumin produces 4.1 calories, whereas 1 g. of lipids — 9.3 calories.

Unlike in mammals, the body temperature of insects is variable. It primarily depends on the environmental temperature and within certain limits it rises with the latter. This dependence is also characteristic of an isolated bee (living outside the colony); the higher the temperature of the environment, the higher the temperature of the body and the intensity of the metabolism. However the bee colony, a biological entity as it is, made up of a great number of individuals is capable of maintaining a relatively constant temperature in the nest, irrespective of the environmental temperature. Accordingly, in the conditions of a low environmental temperature, the intensity of the metabolism for covering the great loss of heat increases; the metabolism also accelerates at higher environmental temperatures, to enable the bees to recover the energy consumed by them for reducing the temperature in the colony.

The intensity of metabolism and the bees' need for oxygen readily changes according to the bees' condition and the functions fulfilled by them. According to prof. V. V. Alpatov, the consumption of oxygen by a bee, in one minute at 180°C is (in mm^3) : 0.9 — when inactive ; 8 — when moving slowly, and 520 — during flight. There is the consumption of food calculated in sugar /hour (mg.) : immobile bee — 0.07, moving bee — 0.61, and flying bee — 39.7. Such a large range of intensity of metabolism is characteristic not only of individual bees but also of the entire bee colony. According to R. Reidenback, the total average consumption of oxygen by immobile bees at 20°C is 457 cu cm/1 g weight/hour, while that of active bees up to 297,000 cubic centimetres. That is why measures must be taken for bees not to consume supplementary food and energy for flying to distant honey sources for away from apiaries ; bees should be moved to the forage source. It is necessary to reduce to the minimum the inspections in colonies in order to avoid disturbances of bees, especially in winter time.

In the long run of the process of evolution the bee colonies have adapted themselves to maximum reduction of metabolism in the periods when they have no possibility of obtaining food. During winter time, the clustered colony consume 4—5 times less food than in the periods of intense activity in spring and summer.

BEE FOOD

Food containing albumins, lipids and glucids is necessary for the bees to grow and the bee colony to develop as well as for their normal activity. In addition bees also need water, mineral salts and vitamins. Bees obtain these substances from the nectar and pollen they collect.

Unlike other domesticated animals, bees not only gather the necessary food for the colony, but they process and preserve it as honey and bee bread stores. Honey and bee bread is used by adult bees and for feeding worker bee and drone larvae older than three days. Young larvae and queens are fed with the jelly secreted by the special glands of worker bees. During its development and egg-laying, the queen feeds on royal jelly but it also consumes honey, especially during diapause, which it takes by itself from the cells. Worker bee and drone larvae are fed on royal jelly only in the first three days. Then bees feed them on a mixture of honey and bee bread. The queen larvae are fed on royal jelly all the time. The jelly on which they feed from the very first day differs from the jelly fed to worker bee and drone larvae, a fact which must be taken into account when rearing queens artificially.

Honey is the main source of sugars for bees and the major bee product. The main raw material of honey is the nectar — a sweet liquid secreted by special part of the flower — the nectaries. Other sources of honey include honeydew — a sweet secretion of plant lice and of other insects, and manna proper — a sweet exudation of leaves. The nectar consists mainly of water (from 40 to 80%) and sugar especially sucrose, fructose and glucose. The water content and that of various sugars in nectar vary greatly depending on climate and other conditions, and on the plant species and variety.

When the nectar collected from flowers reaches the honey sac, it mixes there with a secretion containing the enzyme invertase, which comes from the pharyngeal gland.Under the action of this enzyme, sucrose is being broken down into the monosaccharides fructose and glucose. The processing of nectar is completed in the hive, where it is matured into honey. The fresh droplets of nectar brought into the hive and stored into cells is immature honey, since the biochemical processes taking place in it are not yet finished. Bees deposit the nectar droplets brought by them on the upper cell walls; the large surface of these droplets provides for rapid evaporation of the excess water. Then the young bees suck the nectar from the cells into their honey sac, pump it out into a flat drop on the underside of the proboscis, and draw it up again; and thus evaporation of excess moisture and honey ripening go faster. This process is repeated many times, for 15—20 minutes, and then the nectar is stored into cells. When honey ripens and its water content decreases down to 18—21% bees cap the honey cells with wax which is moisture proof. During the process of turning nectar into honey, the gluconic acid develops (under the action of a glucose-oxidizing enzyme). That is why, unlike nectar, the ripe flower honey has an active acidity.

The honey obtained from honeydew secreted by insects, or from manna differs from blossom honey by the higher content of indigestible substances toxic to bees (dextrins, protein substances, minerals, etc). Honey dew honey is highly noxious during wintering; it causes paralysis and a high death rate of bees. Therefore bees must be left blossom honey in store for wintering; honeydew honey must be replaced by flower honey or sugar syrup.

In the conditions of the central zone a bee colony consumes 70—90 kg honey yearly (maintenance food) 10—12 kg of which during rest period and the remaining during the active periods.

Bee bread is the basic source of protein for bees. It contains many vitamins and various mineral substances necessary for bees normal development. The source of bee bread is pollen. When collecting pollen, bees add to it a small quantity of nectar and honey, moulding it into small flat spheres in the corbiculla at their hind legs, where it is retained by small hairs. These spheres of pollen in corbiculla are called pollen pellets. The weight of the right and left pellets is practically the same an important fact for preserving the equilibrium of flying bee. The bees deposit these pellets into cells from which worker bees have already emerged. The inner shape of such cells looks like a cylinder because the skin of the pupae, which remains after bees emerge, rounds off the corners of the pellets in the cells, with their head which they use as a pestle. The pellets which form now a compact mass do not occupy the cells entirely and the bees fill up the cell with honey. The pollen imbued at the surface with honey makes up an air-tight layer on top. Under the action of bacteria, in the mass of pollen containing sugar, takes place a lactic-acid fermentation which results into lactic acid which preserves the contents of the cell.

The colour of the pollen differs from one plant to another. Different in point of colour are also the pollen pellets and the fresh bee bread. A bee colony consumes yearly according to strength and development stage about 16—20 kg. of bee bread. Bees consume very much bee bread in the period of heavy build-up in spring. If during this period there is no nectar flow or bee-bread stores, brood rearing may slow-down or even stop.

Table 3

Chemical composition of pollen and bee-bread
(after data supplied by A. Mitropoliskyi)

	content (%)					
	sugars	proteins	fats	ash	lactic acid	pH
Pollen	34.80	24.06	3.33	2.55	0.56	6.3
Bee-bread	18.50	21.74	1.58	2.43	3.06	4.3

Royal jelly is the most nourishing and complete food of bees. This secretion of the salivary glands of worker bees is fed to young worker bee and drone larvae up to the age of four days, and throughout the larval stage to the queen larvae. Royal jelly is rich in proteins, fats, sugars, vitamins and minerals necessary for the development of larvae and adult bees. It has bacteriolytic properties, which prevents young larvae from getting diseased. Fresh royal jelly looks like fresh cream and has a sour taste. It contains substances contributing to speed-ing up sexual maturity of queens, and to developing eggs in their reproductive organs.

Water and minerals are also component parts of the bee's body. The bee blood contains almost 90% water, while other tissues 75—80%. Water is necessary to the bee colony for preparing the food for larvae and of bee bread and honey. Bees usually satisfy their need for water from the fresh nectar collected by them. When conditions are not favourable for flight or no nectar flow is available many bees would leave the hive in search for water and would die. That is why a special watering place must be provided for in the apiary. Bees find sufficient amounts of mineral substances in bee-bread and honey. Therefore, as a rule, bee colonies need no supplementary mineral substances.

RESPIRATORY SYSTEM AND BLOOD CIRCULATION

The products of combustion of nutritive substances which are brought to the cells of the body through the circulation system, may release their energy by oxidation. The necessary oxygen is ensured by the respiratory organs, which at the same time remove from the body the air reaches all organs and cells of the body directly through the vertebrates in which the access of oxygen to the tissues and cells is made by the agency of the closed circulation system which is provided with oxygen through the lungs, in bees very much like in other insects, the air reacnes all organs and cells of the body directly through the complex closed system of tracheas. The entire body of the bee is criss-crossed by a well-developed system made up of the tracheal tubes, the tracheal sacs, the trachea and tracheoles (see the colour plate III, 2). The air penetrates into the bee's body through spiracles — some special apertures, reaching large air sacs, wherefrom by thin and numerous tracheas permeates the entire body.

The spiracles or stigmata are on each sides of the thorax and abdomen : all individuals of the colony have three pairs of stigmata on the thorax ; on the abdomen of the working bee and of the queen there are six pairs, while on that of the drone — seven pairs. The air penetrates through the stigmata into the respiratory chamber whose walls are covered by small hairs protecting tracheas from dust. The air chamber is connected with the trachea by a valve regulating the penetration of the air and the removal of water vapours from bee's body.

The air sacs lie on the abdomen (a pair of very large sacs) on the thorax (ante-thoracic and post-thoracic), and on the head (three pairs), some of them fulfil the part of air reservoires, decreasing the bee's specific weight during the flight, favour the ventilation of the tracheal system. The tracheas consist of very many tubes with thin walls. The interior chitinous walls form spiral thickenings which make them resistant and prevent the fall or flattening of the lumen. The tracheas branch to all organs and tissues of the bee and in their final part they turn into very thin tracheal capillary vessels (tracheoles), with no chitinous spirals. *The tracheoles* branch to the cells of bee's tissues, delivering them oxygen and removing carbon dioxide.

The exchange of air in the air sacs and large tracheas takes place by means of the respiratory movements performed by the abdomen. At the contraction of the abdomen the dorsal and ventral plates overlap each other and at its extension they are pulled together again. Movement of the air in the thin tracheas and tracheoles takes place on the account of gas difusion.

The air flow depends on the bee's physiological condition, temperature, and other factors. Inactive bees have 40—50 respiratory contractions of the abdomen per minute while active bees, with an intense metabolism, up to 120—150 contractions.

The circulatory system of the bee essentially differs from that in vertebrates. Bees do not have special blood vessels for blood circulation as the vertebrates do. Unlike the latter, bees have an open circulatory system (see colour plate III). No red blood corpuscles containing haemoglobin exist in the bee's blood called haemolymph and that is why it does not fulfil such „respiratory" functions as the blood of vertebrates does.

The haemolymph makes up the internal medium of bees body. By bathing all organs, tissues and cells, it brings them nutritive substances and absorbs the combustion residues (uric acid and urates) which are removed from haemolymph through the excretion organs. In addition thanks to the permanent osmotic pressure and the active aciditv, the haemolymph ensures the relative stability of many physiological and biochemical processes in the tissues and organs which come in touch with it and ensures the interaction between them. Finally, the haemolymph plays the role of protecting bee's body from microorganisms and noxious substances, the bee's haemolymph is a clear, colourless or slightly yellowish liquid. It is made up of a liquid part — plasma and cells called haemocytes. Cell elements hold almost 20—25% of the total volume of haemolymph. *The plasma* of bee's haemolymph has a slightly acid reaction more or less permanent (pH 6.2 — 6.6). It contains albumins (6—7%), aminoacids (up to 10%), fats (up to 5%), glucose (up to 4.4%), mineral substances, various enzymes and hormones. With bees, much like with the majority of insects, the haemolymph does not coagulate because it does not contain fibrinogene.

Haemocytes are apt of active displacement. In adult bees they are represented by three forms: platocytes, oenocytes, and spherulocytes. The most important are the platocytes which according to B. A. Siskin account for 80% of the total number of bee's haemocytes (with some authors platocytes are called proleucocytes while the mature forms — white cells). Haemocytes are highly important in phagocytosis. They contain grains of albumin and crystals of uric acid, which demonstrates that in these cells stores of nutritive substances and residues of combustion are to be found.

Elimination of these residues is the condition necessary for bees to be active. The carbonic acid and partially water are removed from the bee's body by the respiratory organs while part of the residues of combustion and the remnants of undigested food — by the intestine. The water-soluble residues of combustion are eliminated by the Malpighian tubes, while part of them are accumulated in the evacuation cells of the fat body of the bee.

The Malpighian tubules, according to their functions, correspond to kidneys in vertebrates. They are thin and oblong tubes (about 80—100) and they penetrate into the lumen of the small intestine (colour plate III, 1—M.C.) Then vessels collect from haemolymph the uric acid, calcium oxalate uric acid, calcium oxalate, calcium carbonate and other substances toxic to the bee's body and eliminate them into the hind gut. A certain part in collecting and eliminating the residues of combustion is played by the *fat body;* under the form of soft tissue it lines the internal cavity of the bee and the outer walls of the intestines. Its main function is the accumulation and storage to the nutritive substances: fats, glycogen and albumins. The fat body is made up of fat cells proper, excretory cells, and oenocytes. The longer the bee lives, the more residues of combustion are accumulated in its cells. The colour of the excretory cells may show the physiological age of bees and queens. These cells acquire a darker colour in step with bee's getting older.

Blood circulation in bees. Although it has not a closed circulatory system the blood circulation takes place in several directions, thanks to the action of the dorsal vessel and of the ventral and dorsal diaphragms (colour plate III, 1). The diaphragms separate horizontally the abdomen into two cavities — the dorsal and the ventral one which are usually called blood sinuses. The special vessel skirting the whole body is to be found in the dorsal sinus. In the enlarged part of the dorsal vessel which is in the abdomen and plays the part of the heart, there are five chambers. In the side walls of each compartment there are several apertures (ostia) for the admission of blood to the heart. The dorsal vessel meanders when passing through the thorax; these sinuses are to be found in the vaginal sac. The fact protects the vessel from sudden shocks during the bee's flight. In the sac the blood partially enriches with oxygen. Farther on, the dorsal vessel passes between the thoracic muscles and goes into the head of the bee, where it ends openly beneath the brain. The narrow anterior tube of the dorsal vessel is called aorta.

The heart acts like a pump forcing the blood from the abdomen tc the head. The ventral diaphragm forces the blood from the abdominal sinus to the end of the abdomen, by wavelike movements running posteriorly. At the same time, the vertical movements of the diaphragm pump part of the blood in the general abdominal cavity where the blood, bathing the mid-gut, gets richer in nutritive substances and releases the residues combustion. The latter are collected by the evacuation organs, along the way where the blood flows. By rhythmical movements of the dorsal diaphragm the blood enriched with nutritive substances and purified is pumped from the general abdominal cavitiy into the dorsal sinus wherefrom it flows into the dorsal vessel and then into the head cavity. Thus, the purest and richest in nutritive substances blood first irrigates major organs such as the brain, sense organs, the salivary glands in the head, then the organs and the tissues in the thorax and abdomen. The penetration of the haemolymph into the antennae, legs and wings is ensured by special pulsating organs, at their base, which contract independently from the dorsal vessel. With inactive adult bees, dorsal vessel (the heart) contracts 60—70 times/minute, about 100 times when moving, and 140—150 times when flying.

REPRODUCTION, GROWTH AND DEVELOPMENT OF BEES

The reproduction of organisms is a very important process, necessary for maintaining the species. With honey bees one must distinguish the multiplication of separate individuals (worker bees, queens, and drones) and the extension of the bee colony as a biological and economical unit (natural multiplication — swarming, and the artificial multiplication). The multiplication of the number of bees and of colonies are closely linked to one another and they depend on the environment conditions, hereditary patterns, and on the feeding and management methods.

In sexed multiplication, the ovule cell may as a rule develop after its fertilization by the spermatozoon which is conducive to the formation of the germ cell (zygote) out of which the new organism develops. Still there are exceptions from this rule when the new organism develops from an unfertilized egg. This phenomenon was called parthenogenesis or virgin reproduction. It occurs with social and other insects, including the bee colony whose drones would commonly develop from unfertilized eggs.

The reproductive organs of the queen and of the worker bee have generally similar structures but they are atrophied with the latter. In queens they include a pair of very well developed ovaries, the paired lateral oviducts, a median common oviduct, a spermatheca and a vagina (Fig. 13). Every ovary of the queen consists of 120—200 ovarioles in which eggs develop and grow mature. The ovarioles of each and every ovary reach the corresponding lateral oviduct and both pass into the median common oviduct. The last ends into the vagina with two lateral prominences called *bursa copulatrix*.

The thin canal of the spermatheca, with an ostium functioning like a pump, reaches the lumen of the oviduct. The spermatheca looks like a globular, not too large sac with a volume of 1.2—1.5 cu. mm., with thick walls, no muscles, and wrapped in tracheas. Two accessory glands are closely applied to the surface of the spermatheca. Although the worker bee also develops from a fertilized egg just as the queen, because of the poor food supplied to its larva, the worker bee's reproduction organs are atrophied.

The ovaries of the worker bee are small and they usually contain 2—3 (never more than 20) ovarioles; the spermatheca is represented by a small vestigial organ, the copulative organs are not developed, so that the bee cannot mate with the drone. Under certain conditions, of heavy feeding, the ovaries of the worker bee may function and the bee is able to lay a small number of unfertilized eggs. Such a bee is called an egg-laying bee. One may distinguish the anatomical egg-laying bees i.e. bees in whose ovaries more ovarioles (up to 20) have developed under the influence of abundant food, but they do not lay eggs. It is rather difficult to recognize them in the colony after their external characteristic features; they can be discovered only by dissecting the abdomen (after the swollen ovarioles). When a colony becomes queenless anatomical egg-laying bees start to lay eggs. These bees are called *physiological* egg-laying bees. Their presence in the colony is easy to be discovered because they lay a few eggs not only on the bottom of cells but also on their walls. The queenless colony in which no physiological egg-laying bees occur is a drone-rearing colony. Their existence in the apiary shows careless work by the beekeeper.

The reproductive organs of the drone include a pair testes, the seminal ducts, the seminal vesicles and the mucous accessory glands, the ejaculatory duct, and the organ of copulation. The tests consist of 150—200 small seminal tubules in which spermatozoa develop. The ends of these small tubules open into a common chamber at the end of vas deferens linked to the seminal vesicle in which mature spermatozoa accumulate. The ejaculatory duct enlarges as it reaches the organ of copulation in which one may distinguish the bulb and the cornua. When mating with the queen, the organ of copulation everses to the outside and the plates of the bulb enter the vestibule of the vagina, the spermatozoa are forced into the bulb wherefrom they penetrate into the queen's paired oviducts. Following the spermatozoa, into the reproductive organs of the queen is the secretion of the accessory (mucous) glands which under the action of air hardens very fast, acting as a stopper, not letting the spermatozoa out. At the end of the process, the plates of the bulb, filled up with the secretion of the drone's accessory glands remain in the queen's reproductive organs, — the socalled mating sign which shows that the queen has mated with the drone.

Mating of queen with the drone takes place outside the hive, on the wing, when sexual maturity is attained. The queen reaches sexual maturity on the 7th—10th day after emerging from the queen cell, while the drone — on the 10th—14th day. On the second or third day after emerging from the queen cell the queen performs its first, orientation flight, during which it learns to recognize the location of the hive of its colony. The mating flight takes place on warm and clear days, as a rule from 12.00 a.m. to 5.00 p.m. After a successful mating she comes back with "the mating sign" and the drone with which she had mated dies. Not until long ago it was believed that the queen would mate with only one drone. Now it has been established that she mates with several drones (V. V. Tryasko). The circumstance in which the female receives sperm not only from one male but from several males is called polyandry. The sperm passes from the oviducts into the spermatheca which, in spite of its reduced capacity (1.2—1.5 cu mm) can hold up to 8—10 million spermatozoa. In the queen's spermatheca, they may live several years, assimilating nutritive substances from the queen's body.

The young queen, which has not mated with a drone and does not lay eggs is called virgin queen. In some cases, in unfavourable contions, when the young queen cannot mate with the drone, she lays unfertilized eggs out of which drones develop. Such a queen is called drone-laying queen, while a queen which mated with a drone and lays fertilized eggs is a mated queen. A mated queen with exhausted semen stores, which lays unfertilized eggs is also called drone-laying queen. During the active period of the colony the mated queen lays 1,200—1,500 eggs daily; some queens attained the record figure of over 3,000. One egg weighs 0.1 mg. and all eggs laid in 24 hours by a prolific queen—300 mg.—i.e. more than its own weight. During a season, depending on local conditions and stregth of the colony, the queen lays about 150—200 thousand eggs. Such a heavy egglaying of a queen is possible only when her ovaries are well developed and with abundant food supplied to her during egg-laying, a complex food with a high energy value—royal jelly.

The eggs, larvae and pupae which are in the nest of the bee colony make up the *brood*. The unsealed brood consists of the eggs and young larvae in open cells, while the sealed brood — of the larvae, prepupae and pupae in sealed cells. In addition, these are also fertilized eggs — laid in worker cells, and unfertilized eggs laid in drone cells. The amount and quality of the brood are the most important indices of the economic efficiency of the queen and of the bee colony in the active period. It was found (I. Avetisyan) that the bigger the queen and her ovaries, the more numerous ovarioles she has and the greatest the queen's prolificness and the productivity of the bee colony. In the second year of her life the prolificness of the queen starts to decrease. Therefore, strong and well-developed, not older than 2 years, queens must be provided to bee colonies. The queen's egglaying depends on the force of the colony, on the nectar flow, on the food stores, on the number of free combs in the hive, on temperature, a.s.o. During egglaying the queen is attended to by a group of bees, with periodically supply it with royal jelly. This group is the *queen's retinue*. When the queen ceases to lay eggs the suite dissipates and the queen feeds on the honey in the cells by herself.

The development of bees. The successive growth and development, from the stage of the egg up to the adult individual and the natural death of the organism is called individual development or *ontogenesis*. During their individual development, all members of the bee colony traverse several main stages: egg, larva and pupa. Such a necessary modification of the forms of bee's organism has been called *metamorphosis*.

The development of bee's embryon inside the egg on the account of the nutritive substances in it is called the *embryonic* development, while the development of the larva after emerging from the egg up to stage of adult insect — the *postembryonic* development. According to hereditary requirements, the bee's body needs certain external conditions (food, temperature, humidity, a.s.o.) for its growth and development.

The embryonic development of all individuals of bee colony takes place in three days. The egg laid by the queen attaches itself with one end against the bottom of the cell so that it is parallel with the lateral walls. In step with its development, the egg gets gradually inclined sideways and on the third day it lies on the bottom of the cell. In the meantime, an intense division of cells and the formation of the offspring of the future tissues and organs of the bee take place in the egg.

A few hours before emergence of the larva the egg becomes light grey, more or less translucid, through which the larva may be seen. In the meantime the nurse bees put close to the egg the first abundant portion of royal jelly, which exceeds 3—4 times, the weight of the egg. In touch with the food, the cover of the egg splits, the larva gets out of it and starts to feed on royal jelly, mixing it up by rotative movements while bathing in it.

The post embryonic development of the bee starts after the emergence of the larva. At the beginning the length of the larva is almost 1.6 mm. and it weighs 0.1 mg. In the first 24 hours it becomes 2.6 mm. long and 0.6 mg. in weight by the end of the second day it has 6 mm. and it weighs 4.7 mg ; by the end of the third day the larva covers the entire bottom of the cell and weighs 24.6 mg. Thus, in the first three days of the post-embryonic development, the weight of the larva increases over 240 times, due to its being constantly supplied with royal jelly, a high-energy food. After the three days, the nurse bees start to feed the larvae of worker bees and drones with a mixture of bee-bread and honey. With this food they are fed all the rest of the period of their development, until the cells are sealed.

The queen larva is fed by bees with plenty of royal jelly throughout its development, until the queen cell is sealed. As a result, during three days (from the age of three days up to that of six days) the queen larva increases 26 times in weight, the worker bee — 6 times, and the drone — 3 times. The quality and quantity of the food supplied to them is of outstanding importance for the rate of their growth and for the performance of the resulting adults alike. Under identical hereditary conditions of the egg, a young larva in a queen cell, abundantly fed on royal jelly with specific composition, develops into a normal female — the queen. The direction of its development is determined by the hormones in the royal jelly. Thanks to the different character of the ontogenesis, the queen differs from the worker bee not only by the fact that it becomes mature fast and has a greater live weight, but also by a number of external and internal characteristic features and instincts (a developed reproductive system, atrophied proboscis and honey sac, no organs for secreting wax and for collecting pollen).

In terms of structure, the bee larva entirely differs from the adult individual (colour plate II, 8). It has a very well developed mid gut occupying almost the entire cavity of the body, and is not linked to the last part of the intestine. That is why the undigested food amasses in the dorsal part (the larva does not excrete during the development period). It is only by the end of the larval stage that the mass of undigested food breaks through the wall separating the mid gut from the hind gut and is deposited on the bottom of the cell. The larva has a silk gland with whose secretion it weaves its cocoon. The fat body is well developed with larva, in which plastic substances are accumulated. The other organs are slightly developed, and some of them (wings, legs and others) are represented by a group of rudimentary cells — *imaginal discs*. During the process of development, the larva comes out the old cover, which becomes too narrow, casting its coat. Four such processes take place until the cell is sealed. By the end of the sixth day of the larval stage the nurse bees supply it for the last time with food and seal the cell with a cap wax mixed with flower pollen. Inside the sealed cell, for two weeks, the larva secretes from its silk glands a liquid which hardens into threads and with which it weaves a cocoon around the pupa. The organism of the larva goes through complicated transformations — a hystolisis takes place — and all the organs except the reproductive and nervous systems as well as the imaginal discs are destroyed. Concomitantly, new tissues and organs develop (muscles, salivary glands), and the intestine, the fat body and other organs characteristic of the adult bee are restructured. During these changes, the larva turns first into prepupa, then into pupa, casting its coat when passing from a stage to another. In step with pupa's growth, the organs of the future adult bee are formed, and the external cover of the body gets darker. After casting the last coat, the adult bee gnaws the cap of the cell and comes out.

The entire development of the worker bee, from the egg up to its emergence from the cell, takes 21 days.

After bee's emerging from the cell, the pupal cover and excrements of the larva remain in the cell. Because a cell is used for breeding several generations of larvae, the comb becomes darker and the cell diminishes in size. Small, insufficiently developed bees emerge out of such old cells.

The development of the queen in the embryonic period and the first two days of the post-embryonic period is absolutely the same as that of the worker bee. During its entire larval stage the future queen receives so much royal jelly that its level in the queen cell attains 8—10 mm. As the larva develops, the bees finish the building of the queen cell walls and on the fifth day of the larval stage they seal it. Twenty four hours before queen's emergence, the bees gnaw the outer wax layer of the cap facilitating the queen's emerging. The adult queens cuts with its maxillas the caps of the queen cell and comes out of it. The entire development of the queen — from the egg to its emergence from the cell — takes about 16 days. As a rule, the larger the cell and the more food exists in it, the better developed and bigger is the queen in it. Therefore, when rearing queens, it is necessary to discard the smaller queen cells and the *sterile* queens.

The development of the drone lasts more than that of the queen and of the worker bee. The drone cell is sealed by bees on the seventh day of the larval stage ; the full development of the drone takes 24 days.

THE NERVOUS SYSTEM, THE SENSE ORGANS, AND BEHAVIOUR PATTERNS

The complex and varied behaviour of bees and of bee colonies as a whole, and their inter action with the environment are controlled by the well-developed nervous system and the sense organs.

The nervous system consists of nerve cells with nerve fibres extending from them. In some parts of this system the nerve cells, and nerve ganglia amass.

The nervous system of the bee consists of three sectors (central, peripheral and sympathetic) (colour plate III, 1).

The central nervous system includes the hyperpharyngeal ganglion (the brain), the hypopharyngeal ganglion and the ventral nerve chord.

The brain lies under the oesaphagus, and is linked by two nerve fibres to the hypopharyngeal ganglion and the latter is connected by fibres to the ventral nerve chord. By its function, the brain — as the centre of the nervous system — is similar to the brain of vertebrates. On the cerebral lobes exists the large optic lobes — of the compound eyes. It is also from the brain that nerves extend to the eyes and antenna on which there are many sense and olfactory organs, and to the labium. The hypopharyngeal ganglion is linked to the upper and lower maxillas and to the labium of the bee. In the hyperpharyngeal nerve ganglion of the bee there are masses of special nerve tissue — the mushroom-shaped bodies which are considered to be the principal centres of the bee's higher nervous activities.

The ventral nerve chord includes two ganglia situated in the thorax and five ganglia in the abdomen. The thoracic ganglia innervate the legs and the wings, while those in the abdomen — the corresponding segments of the abdomen.

The totality of nerves linked to the sense organs is *the peripheral nervous system*. In addition there is a special system of nerves, *the sympathetic nervous system,* which controls the activity of the digestive organs, of the heart, of tracheae stigmata, and of the reproductive organs of the bee.

The sense organs are directly linked to the nervous system which — according to I. P. Pavlov — are an inbetween between the environmental factors and the organism. The bee has a series of separate morphologic formations whose activity is controlled by the nervous system, which are sense organs — optic, auditive, tactile, gustatory and olfactory. Although the bees possess the sense of equilibrium, of pressure, cold and warmth, the formations which control themsenses have not been identified yet.

Sight. The eyes are highly important for the activity of bees and of the bee colony. The bee has five eyes — three simple —, ocelli and two compound eyes. The bee larva has no eye. The ocellus is made up of a lens surrounded by pigment cells to which adhere the optic cells connected by nerve cells to the brain. The compound eye consists of many six-sided facets, each corresponding with the outer ends of the ocular units — ommatidia. The central area of each facet constitutes the lens of the ommatidium, to which a crystalline cone is also attached. Under the cone there is the transparent rhabdome surrounded by long optic cells, connected my nerve fibres to the optic lobes of the bee's brain. Each ommatidium is a thin tube separated from the neighbouring ommatidium by a layer of pigment cells.

According to A. N. Melnichenko, the number of ommatidia in the compound eye of the drone is over 9,000, in that of the worker and the queen — 3,000 — 4,000. With the decrease of the solar radiation from the south northward, the number of facets increases, in all castes of bees.

The primary colours for the bee are ultraviolet, yellow, and light blue, whereas for man they are violet blue, red and green. The intermediary colours are obtained by combination of two primary colours. The figures indicate the wave length in millimicrons. Unlike man, the bee can see the colours in the short-wave range of the spectrum.

Unlike the simple eyes, each ommatidium does not reflect the entire image but only part of it. In the compound eye, the general image of the entire object is made up of its component parts, sensed by ommatidia. This type of sight is called "mosaical".

By the compound eyes, the bee can very well distinguish the moving objects, and determine the shape of immobile objects during its flight. The simple eyes can slightly distinguish objects. By them, the bee probably distinguishes only the degree of light intensity.

The process underlying the registering of light by animals, the bee included, is turning the photoenergy into electric power following chemical reactions taking place in the receptor cells. The perception of the light colours depends on the peculiarities of the chemical reactions depending on the different wave length ranges of the spectrum. The ranges of the solar spectrum visible to bees, were for the first time determined by the investigations of Karl von Frisch.

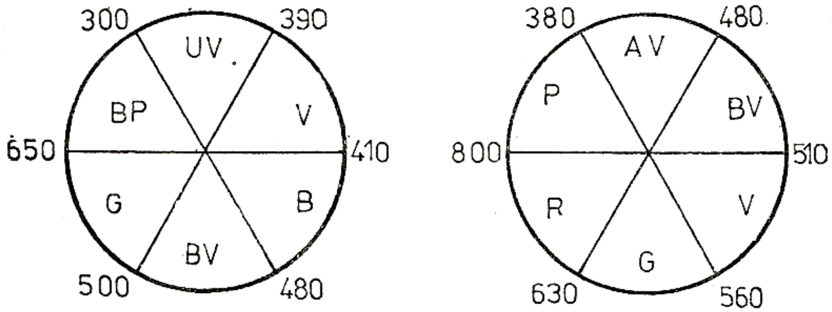
The range of solar spectrum "seen" by bees is that of short waves. Unlike man, the bees perceive the ultraviolet rays (wave length 300—390 mm) but they do no perceive the red ones (630—800 mm). It is frequently asserted that bees will see pure yellow and blue ; they distinguish bluish green, violet and purple (of bees) resulting from the intersection of ultraviolet, blue and yellow ranges.

The investigations conducted in the last few years, by recording the nervous impulses in individual ommatidia of the compound eye of insects, have shown that bees have a very acute sight and that they can distinguish the slightest details.

The characteristics of bees in perceiving colours are of a high practical importance. Painting hives and nuclei in colours easily perceivable by bees — blue, yellow and white — facilitates their finding the hives and prevents drifting.

The painting of nuclei, when in great number in the apiary, is highly important in queen breeding, when a few small colonies are in one hive. With adequate painting of nuclei, drifting declines substantially, both in terms of bees mistaking their nucleus, and of queens when flying back after the mating flight.

The sense of smell in bees, very much like in many other insects, is well developed and it is one of the important means of finding a source of food. The bees' olfactory organs are the numerous *porous plates* covering the small orifices in the chitin, linked to the sensitive excrescences of nervous cells. The porous plates (the tegulas) are located on the last



VV — ultraviolet
BP — „bee“ purple
G — yellow
BV — green-blue
B — blue
V — violet

AV — violet-blue
P — purple
R — red
G — yellow
V — green
BV — green-blue

Fig. 9. The circular diagram of colour sight in bee and man :

Primary colours for bees are ultraviolet, yellow and blue ; for man are violet blue, red and green. Intermediary colours are obtained by combining two primary colours. Figures show wave length in mμ. Unlike man, bees may see colours in the part of the spectrum with the shortest wave length.

eight segments of the antennae and their number stands at 6,000 ; therefore the bee with antennae removed cannot perceive smells. A specific odor is characteristic of the bees of each and every colony, and it is precisely by this smell that they distinguish their hive-mates from the strange ones. Bees have a special olfactory organ — the Nasonov's gland, which produces a secretion with a special smell. The "smelling" organ lies between the fifth and the sixth tergites of the worker bee. When the end of the abdomen moves the scent gland comes out and the evaporation of the gland secretion takes place.

The intensity of most smells is perceived very much like by man. Some smells, which are of a high biological importance for bees, are however much better perceived by them than by people. For instance, the smell of the aromatic substance geraniol, which is a component of the secretion of the scent gland is perceived by bees in a dilution of 0.000001%. Bees are keen in perceiving the smell of the venom, which strongly irritates them. They feel the smell of the queen and distinguish an unmated from a mated queen. The "queen substance" secreted by the queen indicates to the bees her presence in the colony and brakes up the instinct of building queen cells. The odor of the queen draws the drones during the mating flight. Bees distinguish mixtures of odors; they perceive the specific odor, characteristic of all individuals of their own colony, from that of the bees in other colonies.

The taste of food is perceived by bees through special formations — small rods located in the pharynx and at the base of the tongue. The food passing through the proboscis reaches the sensitive ends of these rods and causes chemical excitation. The bees easily distinguish various concentrations of sugar syrup. A solution of 2—4% of cane sugar does not induce the sensation of sweet taste and they are indifferent to it. The higher the sugar concentration (however, not exceeding 60—70%) of the solution, the more readily the bees consume it and the fuller their honey sac. Neither the saccharine solution causes the sensation of sweet taste in bees, nor the quinine solution the taste of bitter. Addition of acids and salts in the syrup are detected by bees in concentrations comparable to those perceived by man.

The touch is performed through numerous sense cones and small hairs, located on the antennae and on other parts of the bee's body. The bee does not have specialized hearing organs for perceiving sounds. The oscillations of the objects on which the bees stay or of the air are perceived by means of the tactile organs — sense hairs and cones. There are probably the same organs which perceive the piping of queens and of other sounds emitted by the bees.

The bees *perceive* and *make sounds*. This is highly important in the bee colony's life. The bee which prepares to sting emits a particular sound which excites the other bees. Also, the piping of queens can be heard on the eve of the second swarming : thin and long sounds are emitted by the young queen which emerges from the cell ; her fellows in the other queen cells answer in a muffled voice. Special sounds are emitted by the colony preparing for swarming as well as by the queenless colony. Finally, the bees which find an abundant source of food emit characteristic sounds during their "dance". Without these sounds "the dance" does not mobilize the other individuals.

The sounds of the bees reproduced by special organs, located on the tarsus of the forelegs (the chordotonal organs) and on the second segment of antennae (the organ of Johnston).

Time sense is well developed with bees and the apiarists have since long known it. The bees visit the sources of food often, especially when they are abundant. The most frequent visits to the buckwheat fields are noticed at the hours when this plant secretes much nectar and, on the contrary, they do not visit the buckwheat fields when the nectar secretion decreases. The capacity of the bee colony to control bees so as to have them collecting nectar and pollen at the most favourable hours of the day has a great biological and practical importance. This provides for gathering a maximum amount of nectar and pollen in the shortest possible time and with minimum energy consumption.

Conditioned and unconditioned reflexes of the bees. The stimuli perceived by some sense organs induce the corresponding response from the body. These responses of the body to external stimuli have been called reflexes (from the Latin word *"reflexus"*). They are either conditioned or unconditioned. The *unconditioned reflexes* are innate responses of the body to external stimuli, for instance withdrawing bee's leg at mechanical stimuli, extension of the proboscis at chemical excitation with honey, filling the sac with honey at smoking, a.s.o. The *conditioned reflexes* are temporary links appearing at certain individuals of the basis of unconditioned reflexes. The bees trained to find food on a yellow — or blue-painted square go on intensily visiting them after removing the food. If food is placed in a certain place at fixed hours (for instance from 10.00 a.m. to 12.00 a.m.), several days running, bees would come to the respective place at the above-mentioned hours even if the food was removed. The conditioned reflex (for place and time) develops after certain time on the basis of the unconditioned reflex (the food).

The great Russian physiologist I. P. Pavlov has the merit of having thoroughly investigated scientifically grounded the conditioned reflexes and their use in the objective study of the superior nervous activity. Although Pavlov has carried out his research on mammals with a highly developed nervous system, he pointed out the importance of analogous investigation of insects, especially of honey bees. In the preface of Shvanvich's book "The Insects and the Flowers" describing the experiments determining the conditioned reflexes in bees, I. P. Pavlov wrote: „These experiments refer not only to stereotypical, in-born activity — the instinctive activity, but also to the activity based on individual experience.

These animals manifest two kinds of behaviour: superior and inferior, individual and specific. It goes without saying that the mechanism of the former is the most important problem for the human mind and further relevant research in various regions of the world is essential for elucidating it. The study of the bees' conditioned reflexes has not only a theoretical importance, but is also of a great practical interest. The conditioned reflexes are of great importance for the activity of the bee colony extending and deepening its links with the environment, diversifying the range of its behavioural patterns according to the variable environment conditions. When undertaking orientation flights the bees remember the location of their hive, and when flying for collecting nectar and pollen — the way to the respective place and back to the apiary.

The memorization of the colour of the food source, of the smell and the hour of the most abundant secretion of nectar enable the bees to obtain food in the most efficient way, with minimum time and energy consumption. Finally, on the basis of conditioned reflexes, man can control the bees' behaviour toward increasing efficiency of the pollination of farm crops and the production of honey.

Communication ("bees' language"). In the process of evolution of the bee colony as a biological unit various forms of connections have developed among the members of the colony. With bees, the connections between individuals include contacts for feeding, chemical, taste, sound, and tactile excitations and special communication movements — "bee dances". The latter has been the object of many investigations by researchers in the Soviet Union and in other countries. An essential contribution to the study of bees' behaviour was made by F. von Frisch, who was awarded the Nobel Prize in 1973 for his relevant investigations. Most researchers consider that by means of dances the scout bees indicate the source of food and the direction to it.

The foraging bees of the colony find the source of food following the information communicated to them. When visiting flowers, bees first develop the conditioned reflex for place and circumstances in relation to the source of food.

During the collection of food, conditioned reflexes for time, odor, colour and shape are established. When the source of food is exhausted, the conditioning stimuli gradually lose their meaning and the conditional reflexes extinguish. First disappears their response to colour, then to odor and finally (on the fourth or the fifth day) that to time and to the general aspect of the area. Lasting relations with the source of food or with a certain species of honey plants are established only

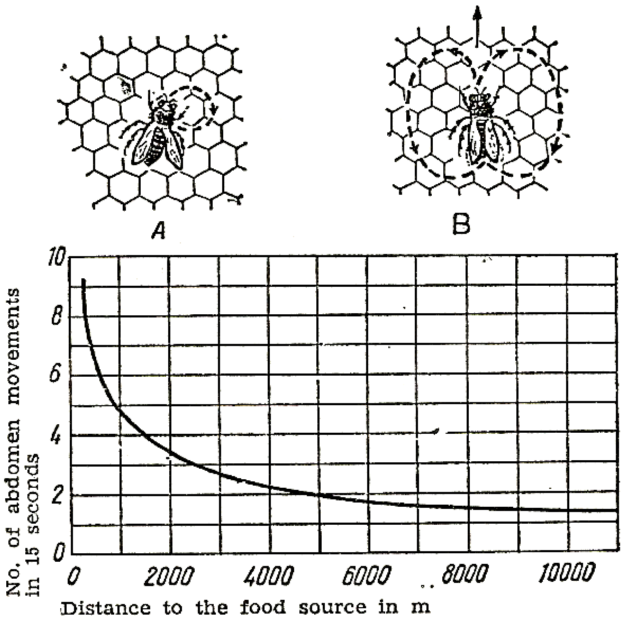


Fig. 10. Communication by bees of the distance to the food source:
A — round dance ; B — wagtail dance

when the food source is abundant. A number of experiments have shown that during the bee's flight back from the food source, the reflex conditioned by a number of successive stimuli appears (for example that for the yellow, blue and white colours). Changing the order of colour stimuli was conducive to inhibiting the acquired conditioned reflex and to ceasing flights.

The larger the amount of food with a certain odor brought into the hive, the more actively and the greater the number of bees are mobilized to look for it and collect it. Finally, the group of bees mobilized for collecting nectar from plants with a certain odor, do not visit other plants until the nectar secretion of the former ceases. Thus, there are different groups of bees in the hive, each collecting nectar from different species of plants. When the conditioned reflex ceases to be maintained (ceasing of the nectar flow or plants' withering) the main mass of bees stop foraging the respective plant species, while a few of them — the scout — continue to periodically visit these plants; when nectar flow on the previous place starts again or new sources are discovered, the scout bees which have come back to the hive with their honey sac replete, would transfer this food with a certain odor to their mates, performing at the same time the dance, thus mobilizing them to fly and forage the food source.

The importance of the communication dances was experimentally demonstrated by K. von Frisch which called them the bees' "language". Two main types of bees' dances (the round and the wagtail) are distinguished. When the distance between the source of food and hive does not exceed one hundred metres, the scout bee performs a *round dance;* it moves in not too large a circle first into one direction then into the opposite direction (Fig. 16 A). Circling round again and again the bee passes to another part of the comb, where it performs another series of round dances. When finishing the dance, the bee quickly walks out of the hive and flies to the source of food discovered by it. The bees close to the „dancer" become animated, and follow it trying to reach its abdomen with their antennas, sometimes they make the same movements and after the end of the dance they also leave the hive for collecting food. When performing the *wagtail dance*, the scout bee starts moving in a semicircle then passes straight over 2—3 cells towards the initial point, and wherefrom it starts moving in a semicircle into the opposite side (fig. 16 B). Its movement is relatively slow while when moving straight forward its body moves quite briskly on both sides, especially the end of the abdomen, and therefore it is called „wagtail" dance. By this dance the scout bee indicates the distance from the hive to the source of food and the direction to

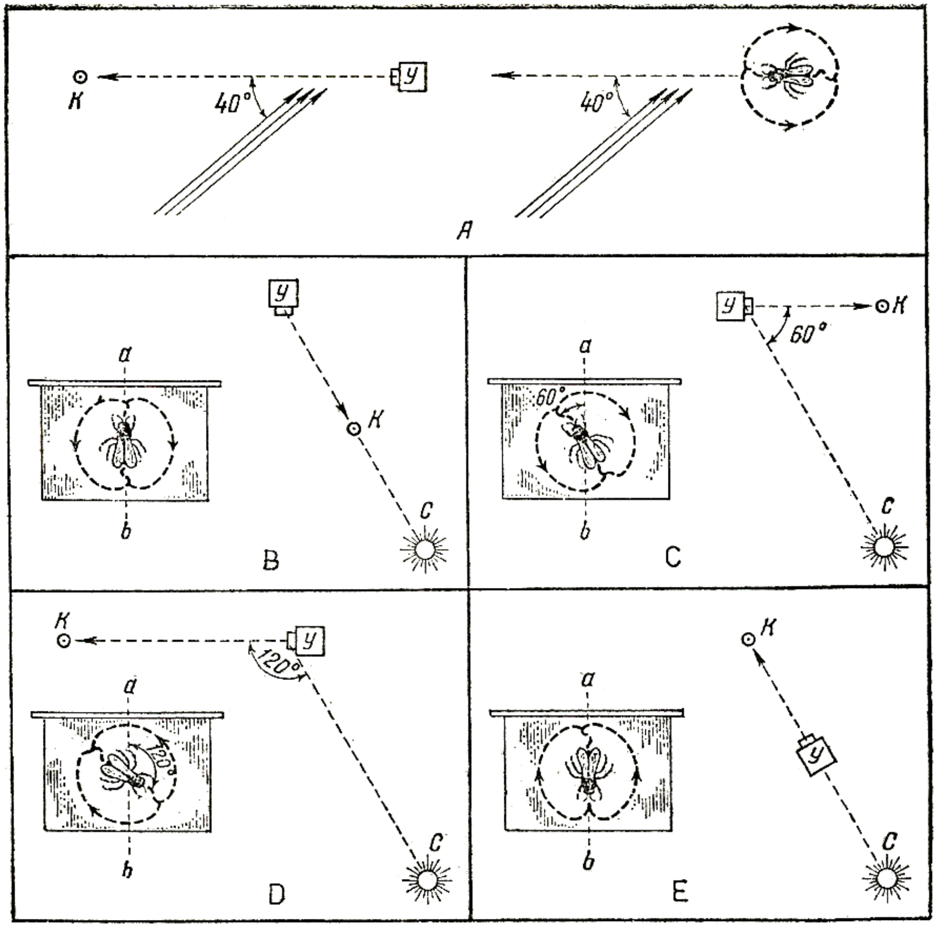


Fig. 11. Communication by bees of the direction to the source of food :

A wagtail dance on the flight board (orizontal plane); B, C, D and E — on combs (on the vertical plane). Straightward movements on combs with the head upright show the direction of flight under a certain angle against the sun ; the straightward movements with head down means the direction of flight from the sun under a certain angle ; K — source of food ; Y — the hive ; C — the sun ; a — b — direction of the action of the gravity force

it. Function of the distance between the source of food and hive, the general duration of the cycle of the dance as well as the number of movements increase accordingly. When the straight forward movement with abdominal oscillations is oriented vertically and upwards, then the bees fly from the hive to the sun ; on the contrary, when the movement is oriented vertically and downwards they fly to the opposite direction. When moving straight forward, under an angle to the vertical plane, they fly under the respective angle to the sun. Special experiments carried out and filmed by I. A. Levchenko showed that the further the source from the hive the more precisely is indicated the direction of flight towards it by means of the wagtail dance (Table 4).

Table 4

Communication by bees of various distances to the source of food (according to I. A. Levchenko)

Distance to nectar flow (in metres)	Average number oscillating movements during the cycle of the dance	Duration of the dance (in seconds)	Duration of the oscillating movement of the abdomen (in seconds)
0	2	1.84	0.16
100	4.3	1.92	0.34
200	5.6	2.11	0.45
500	10.4	2.56	0.83
1000	18.9	3.15	1.51
2000	95.1	4.78	2.81

DISTRIBUTION OF ACTIVITIES IN THE BEE COLONY

Function distribution in a bee colony. Fulfilment by the bee of one or another function depends on its physiological condition, on the condition and necessities of the colony, as well as on the complex environment condition. The entire cycle of bee's activities may be divided into two main categories; that of activity inside the hive, and the activity of collecting nectar, pollen, propolis and water, outside the hive. The bees working in the hive are the house bees, and the others the foragers.

In a normal colony, an individual performs a succession of various activities.

The young bee gnaws the cap of the cell, comes out, is supplied with food by the older bees and trims itself: it cleans its eyes, wings and body with its legs. During the first 3—4 days, the young bee is relatively inactive and more often than not it introduces itself into the cell and rests. In the meantime its body gets stronger, the outside chitinous cover hardens and its glands develop. It begins to participate in cleaning the cells. As a rule, at the age of 3—6 days the young bees start to feed mature larvas with a mixture of honey and bee bread also feeding abundantly themselves. Later on, when the glands secreting royal jelly develop, the bees start to feed the young 1—3 day old larvae with royal jelly. In the meantime, the wax glands of the bees start to develop and they help in drawing out combs. Under favourable conditions, the bees secrete more wax and draw out combs when they are 12—18 days old.

The bees which feed the brood are called *nurse bees,* while those which build combs — wax-making bees. Nevertheless this classification is conventional, since most of the young bees which feed themselves on a great amount of protein food, perform both the function of rearing brood and of drawing out combs. Therefore they are nurse and wax-making bees alike.

The nurse bees are always on the brood combs; they warm it up visiting them about 10,000 times during the development period. Part of them also seal larva cells, clean the hive and guard the hive entrance. The young bees periodically leave the hive on orientation flights nearby, to get to know the colour and shape of the hive, the location of the hive entrance, and later on — the location of the hive and of the apiary.

Separate groups of bees fulfil various functions during the nectar flow. There are scout, foraging and "receiving" bees. The scout bees look for new sources of food. After finding the source of nectar and collecting it, they return to the hive and by means of „dances" they convey the information to most foragers, i.e. they mobilize them for collecting the food discovered. Receiving the information about the nectar source (direction, distance, odor), the foragers bring in food throughout the flow period.

If the nectar flow ceases the foragers do not fly any more. The scout bees go on flying — looking for sources of food. When finding a new source of food, they again mobilize the field bees for collecting nectar.

When bringing the nectar from the field, into the hive, the foragers do not deposit it into cells; they transfer it to 2—5 house bees which usually stay on combs close to the entrance. The „receiving" bees carry the nectar transferred to them to the honey combs, process it and deposit it into the cells. With a limited number of empty combs in the hive or an insufficient number of house bees, the intake of nectar during an abundant and long nectar flow may suddenly cease. By specific movements, the bees communicate that the nest is full up with honey or that the amount of nectar brought into the hive during the day is impossible to be processed and the foraging activity ends.

The distribution of the activities among various groups of bees and the communication of information have a high biological and practical importance. The activity of the scout bees in search for food sources saves the energy of the colony during flowless periods preventing improductive flights of the mass of foragers. When nectar flow starts, the foragers mobilized by the scout bees start their activity. On the other hand, thanks to the system of communication the foragers bring into the hive as much food as the house bees can process, which prevents fermentation in the combs of the unprocessed, liquid nectar.

Depending on type of honey flow and foraging conditions, the field bees bring into the hive only nectar or only pollen, sometimes both of them at the same time. On fine weather, the foragers make 9—10 flights a day, bringing in 30—40 gr. nectar or 10—15 mg of pollen every time. According to I. I. Perepelova, under these conditions during the main nectar flow each flight takes about an hour, while the stopover in the hive lasts for 15 minutes. About 35,000 foragers of a strong colony of 60,000—70,000 bees fly to field daily during an abundant main nectar flow, thus by making 10 flights each, they collect 10—12 kg nectar.

The fact should be mentioned that when the condition of the colony or the environment conditions change, the succession and duration of various activities performed by bees may also change. In a strong colony, in the conditions of an abundant nectar flow, the bees can start to collect nectar at the age of one week. The 6—7 month old bees, which were born late in autumn can also rear brood at the end of winter and build combs early in spring, because there was need for their glands to function during autumn and winter. In spite of their old age, these bees are physiologically young. The more heavily are bees foraging and processing food and rearing bees, the sooner they become physiologically old.

III. LIFE IN THE BEE COLONY ROUND THE YEAR

The activity of the bee colony and of its individuals is very closely related to the environment conditions all the year round. In the tropical zone, where plants grow all the year round, bee colonies have the possibility to collect nectar and pollen any time of the year having no seasonally specific activities. But under the conditions of the temperate climate, the character of the bee colony's activity changes according to the variable environment conditions. Under these conditions, two main stages are distinguished : the period of heavy activity, when the colony collect and process the food, store the food, rear brood and multiply themselves, and the period of relative autumn and winter rest, when the colony, deprived of the possibility of gathering food, no longer rear brood, or multiply themselves, living on the account of the stores accumulated during the active period. Although brood rearing starts at the end of wintering, in the temperate climate, the first spring flight is considered to be the beginning of the active period of bees ; this usually corresponds with the start of nectar and pollen flow. After the first cleansing flight in spring, queens begin egg-laying and the amount of brood in the nest increases substantially, because the fresh food (proteins and glucides) stimulates egg-laying and brood rearing.

In the first 3—4 weeks of the active period the overwintered old bees die being replaced by the younger ones, not only in terms of age but also of physiological condition. In the meantime, the number of bees in the colony does not increase as a rule but important changes take place in the pattern of the colony.

After replacing the overwintered bees, the number of bees in the colony increases fast. While in the first month of the active period old bees prevailed — each of them rearing one larva, later on, the physiologically young bees, with well developed glands rear three or four times more larvae. As a result, more bees are born daily in the colony than die.

When the weather gets warmer being more favourable for foraging, the number of eggs laid by the queen increases as well as the amount of brood reared by the young bees ; the bee population in the hive grows at a rapid rate. Whereas in the first month of the active period a normal colony weighs 1.5—2.0 Kg, after a month, under good conditions of development, their number may double and the number of young bees, able for work may reach 35,000—40,000. A good queen lays up to 1,500——2,000 eggs daily ; even with such a number, the brood rearing capacity of the bee colony is not used to the full. And, when under such a condition there is also a poor nectar flow — in whose foraging the bees not rearing brood are commonly involved — several groups of these inactive bees of various ages are formed, and because the activity of the colony is slow the swarming impulse appears. In a colony which prepares for swarming there is a great amount of drone brood but the surest indication of the swarming impulse are the cups built by worker bees — the bottoms of queen cells. The old queen lays eggs in these cells, the bees supply the larva emerging from them with plenty of royal jelly, and in step with the development of larva they continue building them to become queen cells when part of the queen cells are sealed by bees, the colony is ready to swarm.

During the period of preparation for swarming the colony's activity gets less intensive ; bees' foraging activity declines substantially as well as comb building, queen's egg-laying and brood rearing ; the inactive bees cluster on frames and under them, and all this is conducive to a decreased productivity of the colony. The substantial reduction of the number of eggs laid by the queen during the preparation of the colony for swarming causes reduction in queen's weight and in the size of her ovaries ; the abdominal tracheal sacs deflate. Thanks to this, the queen becomes able to fly, which she cannot do during egglaying. During the preparation of the colony for swarming, bees' wax secretion ceases as well as comb building. All these peculiarities have been developed during bees' evolution, for maintaining the species survive. They enable the swarming colony to build combs in the new nest fast, to gather the necessary amount of food stores, and to rear the young bees for winter.

3—5 days before emerging of the young queens, almost half of the bees, with their honey sacs full, leave the hive together with the old fertilized queen and cluster on the branches or the trunk of a tree. under the overhanging eaves of houses, or on fences. The swarming bees are a compact crowd around the queen. It is a temporary halt of the swarm, for concentrating in only one place the bees which had flown from the hive. If the swarming bees would not form the cluster in due time, the swarm would soon fly to a new place, sometimes far away from the apiary, to a new nesting place, previously found by scout bees. According to M. Lindauer, already before the swarm leaves the hive scout bees would fly in search for a new nesting place.

After the swarm stops, the scout bees perform mobilizing dances indicating the distance and direction to the new nesting place. As a rule, after 2—3 hours (sometimes after 24 hours) the swarm, would fly to the place indicated by the scout bees, occupy it, and start building combs heavily ; the queen starts lay eggs, foragers bring in nectar and pollen, and the new colony starts normal activity. Under favourable conditions, they also gather food stores necessary for their good wintering.

A few days after the first swarm — *the prime swarm* — issues, a second swarm issues from the parent colony — *the secondary swarm* —, with virgin queen emerged from the queen cell ; and a few days after it, — *the third swarm.*

Sometimes, from the colony at the height of swarming fever a fourth swarm may issue, and also other swarm given off by the previous swarms. Before the secondary swarm and the following ones issue, one can hear the queens piping in the parent colony.

Swarming is the natural method of multiplying bee colonies. It was highly important for preservation of the species with wild bees. Under the present-day conditions, of beekeeping practice, swarming is undesirable since it entails great unproductive expenses as a rule, bees' productivity decreases and this is a drawback in selection work. That is why measures must te taken in beekeeping farms for preventing swarming, and for replacing it by various other methods of multiplying colonies.

During the active period of bee colonies the main nectar flow is of paramount importance as it is the major source for the colony to collect important food stores for winter and to also yield marketable honey. In various districts of this country, the main flow occurs in different periods, depending on the type of honey plants, on climatic conditions and on other (especially agrotechnical) factors. In some districts, the main flow starts in June, — flowering of meadows ; in others — in July when lime trees are in blossom, and a little later, buckwheat and fireweed. In a number of districts several abundant nectar flows may exist, in different periods. As a rule, during the main nectar flow the number of bees in colonies is the greatest. The main task of the beekeeper is to prepare strong colonies for the main flow — able to work, with a great amount of drawn out combs necessary for storing the nectar processed into honey. It is very important to control the swarming instinct of bees in colonies is the greatest. The main task of the beekeeper is to their foraging impulse. During the main flow, a strong colony may gather up to 10—12 kg nectar on a favourable summer day ; cases are known when the daily intake in the scale hive reached 24 kg (in the Far East). A strong colony (6—8 kg), availing an abundant main flow, may gather 100—150 kg. honey. The foraging and processing of such a great amount of food require much and hard work by the bees, as well as huge consumption of energy which means an intensive metabolism. Consequently, worker bees wear out soon and die, so that by the end of the main flow the number of bees declines substantially.

By the end of the flow bees take steps for an economical consumption of the food stored : they drive away the drones, which are useless now, egg-laying and brood rearing slow down and they can even cease. When cold weather comes in autumn, bees cluster preparing themselves for the winter. The period of autumn-winter rest comes. While during the active period the temperature in the nest is almost permanently quite high 34—35°C, during the inactive period, it drops down to 15°—20°C in the cluster, and it is only by the end of wintering, when brood appears, that the temperature rises again to 34°—35°. During the inactive period, the content of carbon dioxide in the winter cluster goes up to 3—4% while the content of oxygen decreases accordingly (down to 17—18%). During this period, with Northern bees (middle Russian and Bashkirian) the carbon dioxide content in the cluster is much higher than with southern bees (of Kuban region or Italian bees). The high content of carbon dioxide and the low temperature in the winter cluster result in a slow rate of metabolism in bees and a more economical consumption of the stores, also preventing overloading of the intestine with faeces, which has a great importance for the survival of the colony during their wintering. The stronger the bee colony, the higher the carbon dioxide content in the cluster, and therefore the temperature in the nest is more homogenous, and the consumption of warmth and food per kg of live bees is lower.

Alongside with the strength of the colony, its viability also greatly depends on the physiological condition of bees. A long winter can only be overcome by a colony with physiologically-young bees, emerged in autumn, not exhausted by the heavy foraging activity, nectar processing and brood rearing. That is why strong colonies only should be overwintered, with young bees (especially in the Northern districts), and with abundant good-quality food stores ; such colonies overwinter well, develop better in spring, and yield high honey crops.

During wintering, bees have no opportunity to relieve faeces which accumulate in the large intestine. Being fed on low-quality food, especially honeydew honey — which contains many indigestible and toxic substances, the hind gut would be filled fast with faeces. Then diarrhoea appears which is conducive to a high death-rate, more often than not to the disappearance of the entire colony. That is why only blossom honey stores must be left in the hive for wintering, the honeydew honey collected by them having to be replaced in due time by sugar syrup.

By the end of the wintering period, usually 1.5—2 months before, the temperature in the cluster begins to rise and bees to be active, the queen lays a few eggs and then, with the spring drawing nearer, more and more. Then brood appears, and in order to be able to rear it, bees feed themselves abundantly. The metabolism and energy of bees also increase and after the cleansing flight the colony begins working heavily — i.e. the active season starts.

BEE-HIVES, BEE SUPPLIES AND BEEKEEPING EQUIPMENT AND ANNEX BUILDINGS IN THE APIARY

Bee-hives, bee supplies and beekeeping equipment as well as the annex buildings are a major factor of beekeeping management. They must provide optimum conditions for extending and increasing the productivity of bee colonies, as well as for saving the beekeepers' work and raising their labour productivity.

BEE-HIVES

Wild bees nested in hollow trees or cavities in rocks. When passing from hunting the honey and wax from bee nests to their rearing by man, the latter began to make hives for them. The first step was to make hollows in trees (Fig. 1). Then, with the development of the forest beekeeping, people started to use parts of tree trunk with a bee nest in them which were located close to their dwellings. In the districts without forests, they used baskets of wicker, coated with clay, or straw hives. In some southern countries, bees were kept in clay hives. The main drawback with all these primitive hives is the fact that combs are fixed and the beekeeper has no possibility to inspect the nest and to control the bee colony. Such hives are called fixed-comb hives (Fig. 18). Such hives still exist in countries with primitive beekeeping. In the Soviet Union bees are kept in movable-frame hives which enables control of the bee colony and increase of their productivity.

The inventor of the first movable-frame hive in the world was a famous beekeeper of this country, P. I. Prokopovich. In 1814 he devised his hive which was made up of brood chamber and super, with movable frames, which could be taken out.

Later on, both in this country and in others, many movable-frame type hives have been devised but the basic principle remained the same :

combs in movable frames, which allowed for inspecting the brood nest. No matter what type the hive is, it must meet the following basic requirements :

1. The hive must meet the biological requirements of the bee colony and protect it from unfavourable environment conditions ; provide for much room, which can be readily restricted or extended depending on season and the colony's strength and productivity.

2. The sizes necessary for meeting the biological requirements of bees must be observed : the distance between the side walls of the hive and the side bars of the frames — 7.5—8 mm ; the distance between the *midribs* of neighbour combs = 37—38 mm. ; the interval between combs — 12 mm.

3. Hive parts must have standard sizes so that brood chambers, supers, covers, bottom boards, frames, and division boards should be interchangeable.

4. The hive must be easy to handle by the beekeeper and labour-saving, simple, and light, suitable for migratory beekeeping.

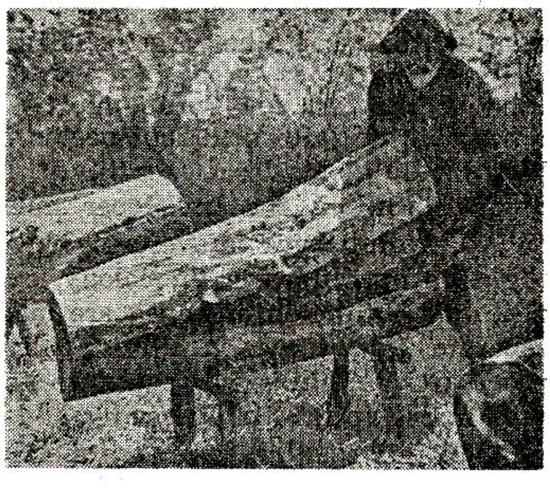


Fig. 12. Fixed comb hives : horizontal hollowed tree trunk in Caucasus area

The movable-frame hives in use in the USSR are both vertical and horizontal.

The *vertical* — multiple-storey hives, are extended upward, by adding hive-bodies and supers. Such are the 12-frame hive with 2 supers, and the two — and multiple-storey hives.

The *long* hives are extended horizontally, on both sides of the brood chamber. Such hives are broader, and therefore are called horizontal. To this group belong the 12-frame horizontal hive, the Ukrainean long hive, and others.

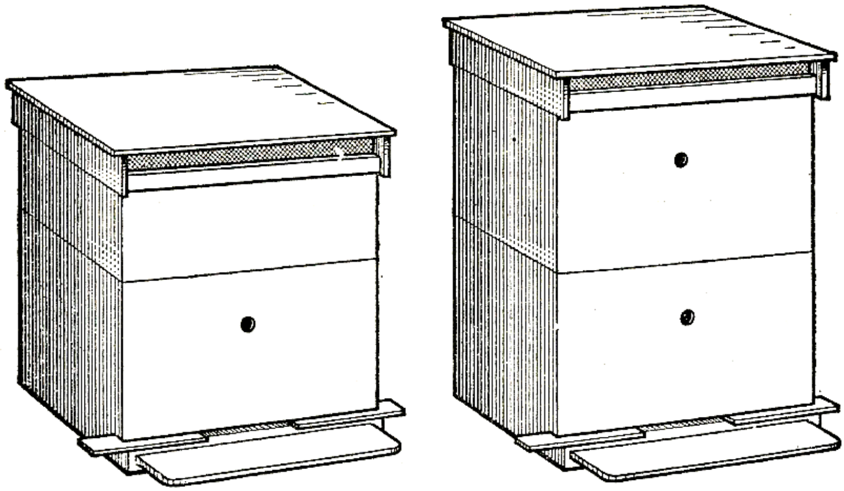


Fig. 13. 12-frame hive with super (left), and hive with two equal bodies (right)

In this country, more than half of bee colonies are kept in standard 12-frame hives with 2 hive bodies. Next comes the long hive, used mostly in steppe and forest-steppe areas in the Ukraine, North Caucasus, Central Asia, and other regions. Because of the little room available for the nest in the 12-frame hive, the two-storey hives have been widely used in the last few years, mostly in the Far East, South Ural and other districts with abundant nectar flow. Many beekeeping farms obtain high honey yields from such hives. To keep bees in such hives requires much labour as the beekeeper must handle the frames individually.

This drawback is overcome with multiple-storey hives, with which the main operations in the colony, extension of the volume of the brood nest, and extraction of honey are made by handling hive bodies and not separate frames, which substantially increases the beekeeper's labour productivity. That is why multiple-storey hives have become most widely used in the apiaries of kolkhozes and sovkhozes in various zones.

In this country, hives are mostly manufactured at industrial entreprises or in the workshops of kolkhozes and sovkhozes, in keeping with the relevant standards. Hives must be made of dry timber — pine, fir and cedar or lime, as well as of other soft essences with 15% moisture content at the most. In order to assure interchangeability of hive parts, their standard sizes must be strictly observed. For the longest possible use of hives, the walls and the roof are painted at the outside, in light colours (white, blue, yellow) which can be easily distinguished by bees.

Each hive consists of the following main parts :

a) a removable or fixed bottom board, with flight board ;

b) one or several bodies with brood frames ; certain type hives have supers.

The main entrance of the hive is in the lower part of the front wall, while the upper entrance in the upper part;

c) a flat top, covered with thin iron sheet or tarred board, with holes for ventilation;

d) brood and shallow frames (for 12-comb and hives), wood inner covers or cover of thick cloth.

e) devices used during migratory beekeeping (for fixing various parts of the hive and for ventilation during transportation), and for keeping the nest warm (side of top cushions).

In the Soviet Union, standard frames are used: *brood frames* for 12-comb, twin, and long hives — of 435×300 mm. at the outside, *shallow frames for supers* — of 435×145 mm., and frames for *multiple-storey* hives — of 435×230 mm.

The 12 frame hive consists of a brood chamber with single walls, holding 12 standard frames, one or several supers holding 10—11 shallow frames each, a bottom board and a cover. Such hives are the most widely used although they have several essential disadvantages — small volume, and two types of frames. They can be overcome by using two or more supers.

The twin hive consists of two similar bodies, bottom board and cover. The interior sizes of the bodies are 450×450×310 mm. Each of them holds 12 standard frames. The thickness of the walls is 40 mm, while that of the bottom board — 30 mm. The cover is flat, made of

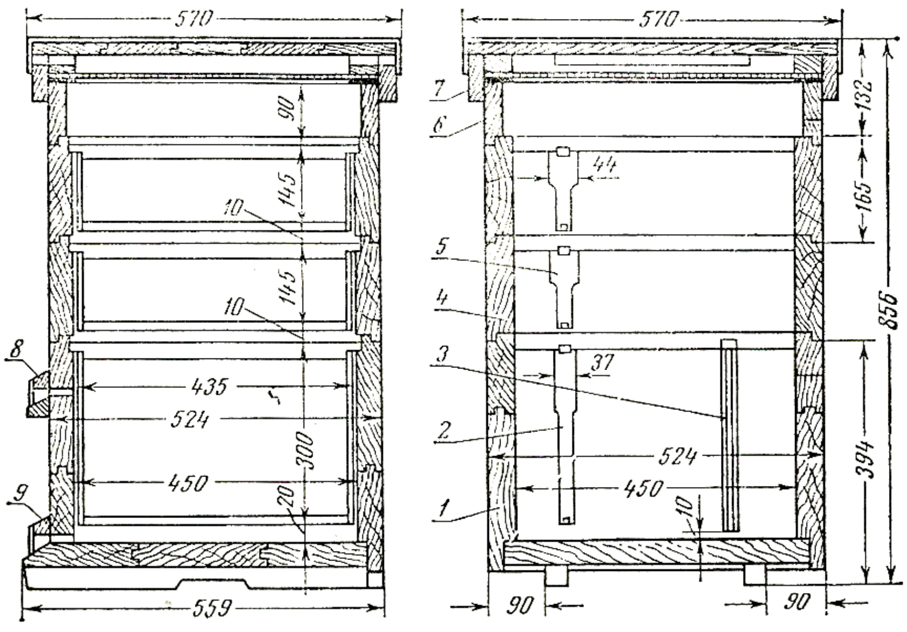


Fig. 14. Hive with one brood chamber and two supers:

1 — brood chamber; 2 — brood frame; 3 — division board; 4 — super; 5 — shallow frame; 6 — wood inner cover frame; 7 — cover; 8 — block of the upper entrance; 9 — block of the bottom entrance

15 mm. — thick boards and coated with thin iron sheet on tarred board. In the front and rear walls of the cover there are holes for ventilation, covered with wired cloth. The hive has a 15 mm. high bottom entrance all along the wall, and a round upper entrance with a diameter of 25 mm. Twin hives are more efficient than single-body hives especially in the districts with abundant nectar flows. But keeping bees in such hives requires much labour, especially for adding and taking off a second body, which is heavy. One beekeeper can hardly perform such a work; he needs an assistant. Attempts to mechanize this operation have already been made but no satisfactory loading devices have yet been developed for being produced industrially.

The long hive is a long hive body, holding 20 combs, one super, a fixed bottom board, and a flat cover. Here are the interior sizes of the body : 810×450×400 mm. The walls of the body overlap the brood nest up. In the free space above the nest a straw cushion may be laid for keeping the brood warm. The long hive has two 12 mm high bottom entrances and two round upper entrances with a 25 mm diametre. The cover, with holes in it for ventilation, as well as the flight board are similar to those in twin hives.

The long hive is more adequate than the multiple-storey hive for the biological requirements of southern bees (especially Caucasian), since these bees would hardly go to the upper bodies for expanding the brood nest and for depositing food stores. The long hives are good for keeping colonies, for strengthening other colonies and nuclei close to the brood nest, separated by a blind division board.

Such hives are pre-eminently used in the southern districts of the USSR — the Ukrainean SSR, Northern Caucasus, and the Trans-Caucasian republics.

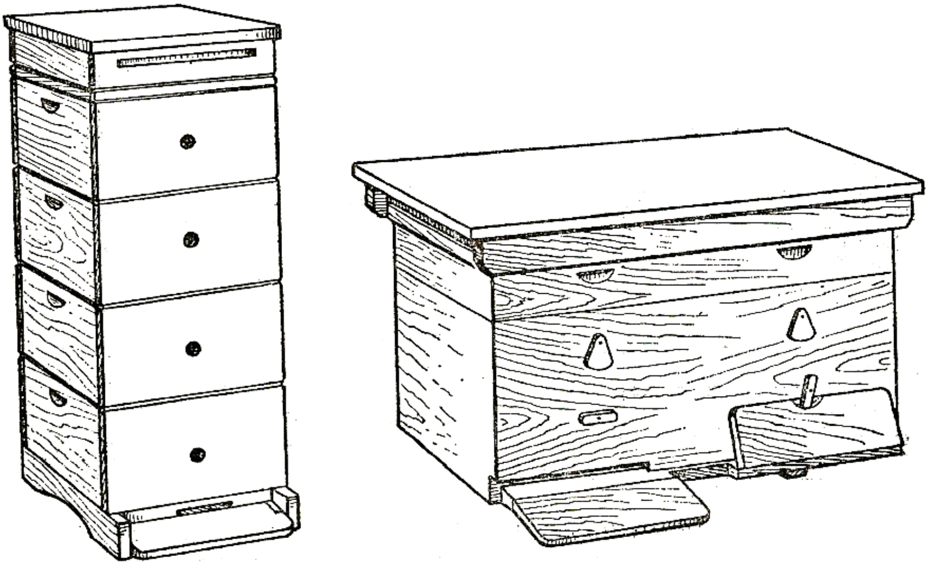


Fig. 15. Long hive (right) and multiple-storey hive (left)

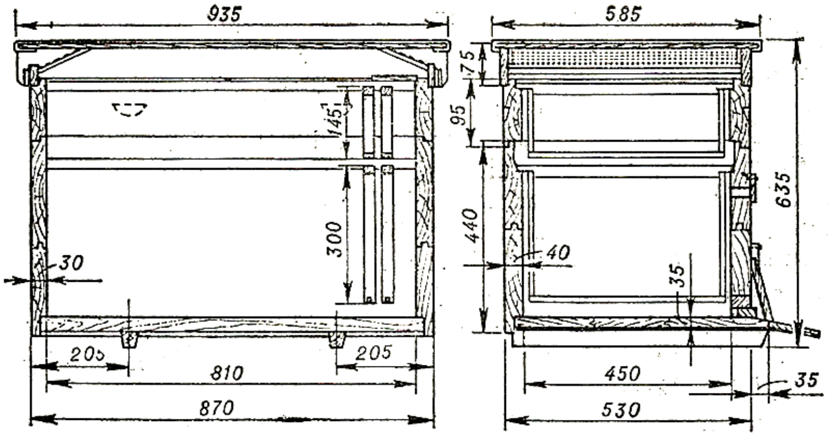


Fig. 16. Long hive; details

Double-walled hives are used in the Northern and Siberian districts with severe climate. They hold 12, 14 or 16 brood frames, and have one or two supers for the same number of shallow frames. The walls of these hives (all of them, or at least the front and the rear) are double and are made of 15—20 mm. thick boards. The space between the walls is filled with dry, insulating material (moss, shavings, boon, tow). The double-walled hives, although they better preserve warmth are too large and therefore unfit for transportation.

The multiple storey hive is widely used in the USA, Canada, Central and Latin American countries, New Zealand and Australia, where its use

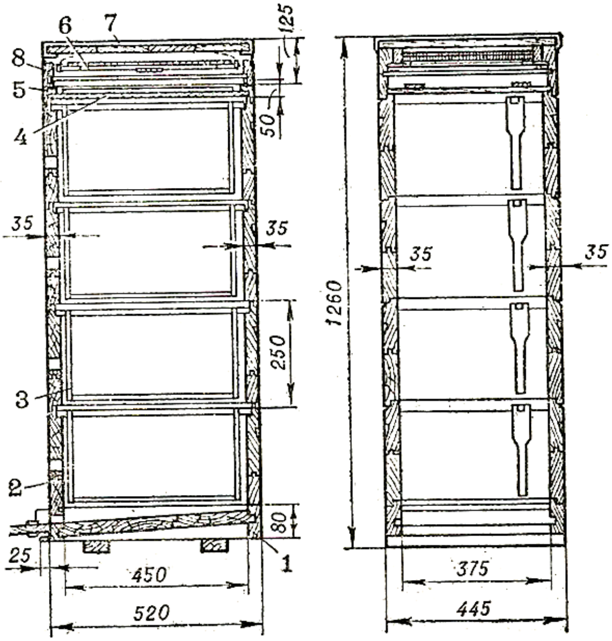


Fig. 17. Multiple-storey hive; details:

1 — bottom board; 2 — hive body; 3 — frame; 4 — crown board; 5 — the frame under the cover; 6 — the ventilation frame; 7 — cover; 8 — the frame of the cover.

together with mechanized labour-consuming operations provide for utmost labour productivity and high honey yields. Mass production of such hives is going to start in this country too. The multiple storey hive consists up of two, three or more bodies, each holding 10 frames (435×230 mm). Four or five supers are used in the districts with abundant nectar flow. Also, supers holding 8—9 shallow frames (145 mm high) are used for honey production. This hive has a movable bottom board, flat cover, a crown board, and a block for the entrance. The hive is placed on stand, and is provided with a queen excluder.

Here are the interior sizes of the body : width — 375 mm, length — 450 mm. and height — 240 mm. According to climatic conditions, it is made of 25—35 mm — thick boards. Such a body is much lighter than the body of the 12-comb hive.

The beekeeper can easily raise the super with combs full of honey by himself and put instead a new super, with comb foundation. The small volume of each body allows for easily modifiying the room of the brood nest, not by handling frames, — as in a common hive — but by handling whole hive bodies, which saves a considerable amount of labour.

Hand holds are made on the outside of the walls of the hive. The hive is covered by a crown board and a flat cover. The bottom board is movable which allows for either extending or restricting the space under the frames (10 and 20 mm.) according to the season. The bottom entrance is adjusted by a cleat. In the multiplestorey hives frame spacers are used, which facilitates the preparation of the colonies for transportation. Unlike standard frames, the side laths of the multiplestorey hive are at their upper third 37 mm-wide, while at the lower part — 25 mm.

Permanent frame spacers are recommended to be used with other hive types.

The Observation Hive. The observation hive is important for knowing and investigating the life of bee colony. Such hives commonly hold 4—6 frames, in the same plane. The lateral walls of the observation hive are broad and made of glass. The other walls are narrow and made of wood.

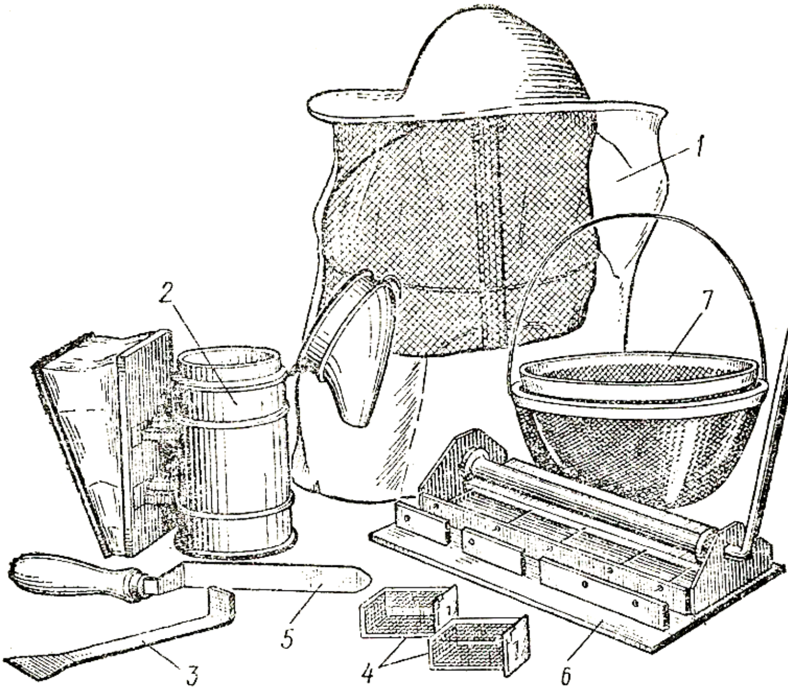
In these hives all cells of the brood nest are under glass. Wood shutters exist on the outside, which are opened during observations.

The scale hive must exist at any apiary, for registering the results of the nectar intake. It is a usual hive, with a strong bee colony in it ; it is put on scale under shelter. It is advisable to use decimal scales with a bottom lever for 100—150 kg.

BEE SUPPLIES AND BEEKEEPING EQUIPMENT

Endowment of apiaries with bee supplies and beekeeping equipment and modern outfit has been fully demonstrated as highly important for increasing the beekeepers' labour productivity. Adequate sup-

Fig. 18. Bee supplies used in the apiary:
1 — bee veil; 2 — smoker; 3 — hive tool; 4 — queen cages; 5 — uncapping knife; 6 — frame perforator; 7 — honey strainer



plies and equipment are necessary for attending to bee colonies, for fixing wired foundation in frames, taking out, uncapping and extracting honey, for processing crude wax, etc.

The following bee tools are used when inspecting bee colonies:

The smoker for subduing bees made of a double metal body (the inside body has holes on the bottom) and bellows. Inside the smoker rotten wood, peat or another materials are put which burn without flame releasing a great amount of smoke. The smoke is forced out with the bellows.

The bee veil, made of black tulle and light materials protects the face from bee stings. Just like the smoker, it is highly necessary when inspecting the middle Russian bees which are more aggressive. The Caucasian, Carpathian, and of other Southern races may be handled during nectar flow without smoker or bee veil.

The hive tool is used for separating frames, bodies, for removing wax and propolis from the frame as well as for other operations.

Portable working kit used for various tools and rotten wood for the smoker. It is also used as a stool when working in the apiary.

The tent for protecting bee colonies during flowless periods, for preventing robbing. It is made of light sticks, covered by a metallic network (or better by a kapron sheet) which prevents bees' access.

Carts for transporting hive bodies, hives, frames and other light items; lifting and transport functions may be combined. Thus simplifying the taking out and lifting of hive bodies, their loading into trucks for transport to the field, their arrangement on shelves in the wintering room, etc.

Bee Supplies for Special Purposes

They include *cages for queens* for isolation of queens and queen cells ; *cages* for introducing queens on combs and their isolation ; queen excluder with appertures of 4.3—4.5 mm. through which queens and drones cannot pass, but worker bees can.

Tools for fixing wired foundation on frames : a frame perforator a templet for sizing the wired foundation to be fixed on frames, *a roller* for pressing wired foundations against upper bars of the frames, and the *spur* for embedding the wire of the frame into the wired foundation. Fixing of the wired foundation in the frame is very difficult. It is more efficient to use electric power, from an accumulator (4—6 Volts), or from the network (reducing tension by a transformer down to 6 volts).

Equipment for processing wax in the apiary. First is the *solar wax* extractor which consists of a wooden box whose rear wall is higher than the front one. The box is covered by glass. Inside it there is a tray with crude wax and a pipe through which flows the wax melted by the sun. The solar wax extractor is used for melting light-coloured combs, a good-quality wax being obtained. Rendering wax from dark-coloured combs is made by the *wax press*. The wax waste slumgum is processed in special wax extraction factories.

Tools for uncapping combs and honey extraction. They include special knives, forks and outfits for uncapping combs, tables and other devices, as well as centrifugal honey extractors and equipment for its purification and packing.

The uncapping knife is two-edged, sharp, with wooden handle. It is heated in boiling water, uncapping being thus easily made. Also used

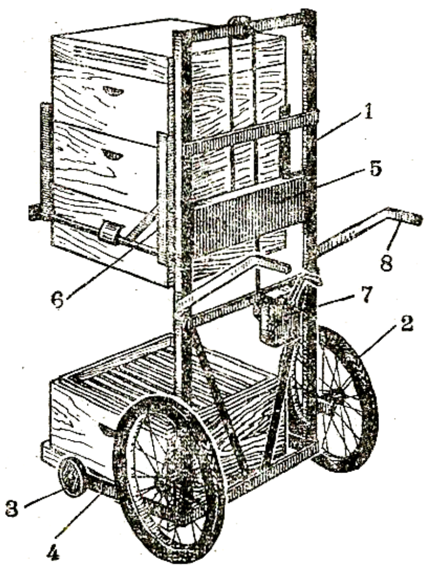


Fig. 19. Truck with lifting device built at the Bee Research Institute :

1 — frame ; 2 — motor-cycle wheel ; 3 — a wheel with a smaller diameter ; 4 — bracket ; 5 — truck displaceable on the frame ; 6 — fastening device ; 7 — hand pulley ; 8 — handles is another type of knife, with one edge slightly curved. The *steam heated* knife is heated by the steam comming to theblade through a pipe — from a small generator. Its use enhances labour productivity. Electrically heated knives are also used ; the electric power heats the coil inside the blade.

A number of firms in the USA manufacture *special automatic uncapping machines* with mechanical handling of frames. They are used at large commercial apiaries, and can ensure the uncapping of frames for three electrically-driven centrifuged extractors holding 45 frames each.

Centrifugal honey extractors are used for extracting honey from frames. They are of different types but the principle of operation is the same : under the action of the centrifugal force honey flows out the uncapped combs revolving at a high speed round the axis of the drum, and down into the tank below. The centrifugal extractor consists of a metallic tank, a rotor, a driving device and a tap.

There are also *tangential* centrifugal extractors, in which framed combs are placed vertically in the „basket“, being tangential to the vertical spinning axis ; *radial* ones, with combs supported radially like spokes of a wheel and *universal* ones. Of the latter, highly interesting is the M 3/27, hand operated centrifugal extractor, which can be used both as a tangential centrifugal extractor for 3 standard frames and as a radial extractor for 27 shallow frames. Tangential extractors are either hand, or mechanically, or electrically driven ; radial extractors are electrically driven. With tangential extractors, framed combs can be reversed either by hand or automatically. The combs to be extracted are supported into "baskets". In extracting honey in tangential extractors, the relevant requirements must be observed. In radial centrifugal extractors, combs need not being reversed. Such extractors are actuated by an electric motor, which facilitates the beekeper's work and increases the productivity of his labour. Our industry turns out tangential centrifugal extractors for 2 and 4 frames, radial extractors for 20 and 50 frames, and universal extractors for 3/27 frames.

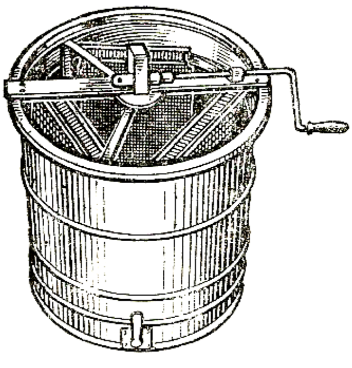


Fig. 20. The tangential universal extractor M 3/27

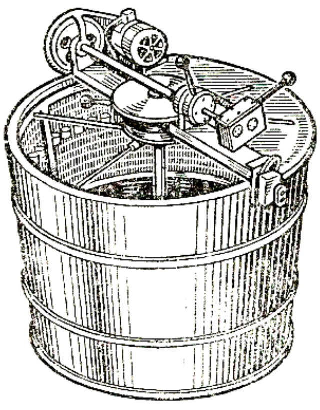


Fig. 21. The electrically driven radial centrifugal extractor for 50 frames

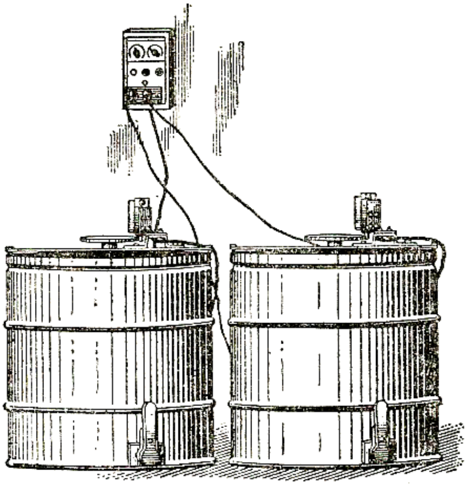


Fig. 22. The UPP-1 electrical centrifugal extractor with automatic switcher

During an 8-hour shift, according to the degree of comb filling and honey consistence, the 4-frame tangential extractors can produce 500—600 Kg honey ; the 20-frame combs centrifugal extractor — 1,000 — 1,200 kg., while the radial centrifugal one for 50 frames — over 3,000 kg.

For heightening the output of the 5-frame reversible centrifugal extractors, the Institute of Apicultural Research suggested use of coupled, electrically-driven centrifugal extractors and the UPP-1 universal extractor with automatic decoupling of motor after the extraction of honey. This installation gives the possibility of successive coupling and discoupling of the engines of centrifugal extractors : while the rotor of the first centrifugal extractor revolves, the second is loaded with uncapped frames ; after the honey from the frames in the first extractor is extracted, it is stopped for loading and the motor of the second extractor is automatically connected. This alows for a 2—3 times higher labour productivity.

Honey extraction at large apiaries is an important and difficult process, and the mechanization of this process is very important for increasing the honey production, for reducing its cost price, and for more efficient labour. Use of highly-productive machines for uncapping, of automatic loading and unloading devices, concomitantly with small mechanization (fixing of wired foundation, transport in apiaries, etc.) provides for further constant extension of beekeeping and for ever higher efficiency of the work of beekeepers.

ANNEX BUILDINGS IN THE APIARY

The buildings in the apiary include the wintering shelters, the bee house — where combs are uncapped and honey is extracted and packed, the rooms for storing combs, workshops, folding cabins for migratory beekeeping, covers for scale hives, and storage rooms.

The nomenclature, sizes, and construction materials for annex building are established function of the local natural conditions, scale of operation, specialization of the beekeeping farms. Thus, in a number of districts, where bees can successfully winter in the open, building of wintering rooms is unrational. In the large beekeeping sovkhozes, specialized in honey production special rooms must exist, as central extraction and packing plant, which is not necessary in the farms specialized in bee and queen breeding apiaries. In the farms with up to 100—150 bee colonies, a bee house must exist in the apiary, for uncapping combs, honey extraction and bottling — with the necessary equipment, also a workshop for fixing wired foundation on frames and some joinery and repair work, as well as a wintering room.

The annex building of the large beekeeping farms or of the beekeeping section of sovkhozes with 500—600 bee colonies, include a bee house and a storage room for preserving the extra hives, the tools and equipment. The building of a dwelling (made up of one or two flats with household annexes for beekeepers) is recommended to be provided for.

Uncapping of combs, honey extraction and bees' preparation for wintering are done at the Stationary apiary. It is also here that bees spend their wintering period. After the winter is over and the spring inspection is made, about 75—120 colonies are left at the stationary apiary, the others are carried to outapiaries.

A work team attend to all colonies in the apiary. In order to obtain a high labour productivity the apiary is endowed with transportation and loading means (the UAZ — 450 D truck, the 4031 automatic loading-device), with modern equipment for fixing foundation into frames, and for uncapping combs and honey extraction, etc.

The central apiary of a large specialized sovkhoze is provided with a properly equipped honey where combs are heated and uncapped, a honey extraction and packing room, a carpenter's workshop, a drying appliance shed for lumber, a garage, storehouses, an office and rooms for beekeepers to dwell in.

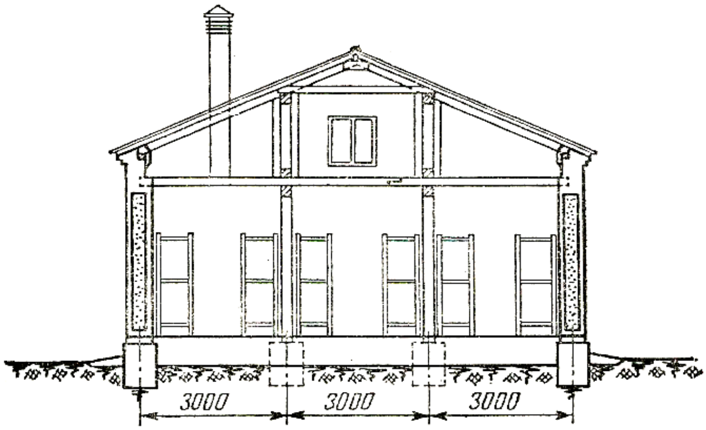


Fig. 23. Cross section of a bee house at ground level, for 300 bee colonies (brick walls, sizes are in mm)

The wintering rooms are intended for keeping bee colonies in the autumn-winter period. Wintering in bee houses is practised in most forest and forest-steppe regions in this country, having a severe climate. In the southern districts and in some Baltic Republics bee colonies are kept in the open all the year round. Depending on the local climatic conditions and the level of phreatic waters, the wintering bee houses are underground, half in the ground, or at ground level. The *underground* wintering bee houses are entirely under the earth, so that their ceiling is at the ground level ; the *exterior* ones are built on the ground level while these in the half ground are at mid way.

When choosing the type of bee houses one must take into account the level of the phreatic waters, which must be 1.0—1.5 m. below the floor of the bee house. During the entire wintering period, the temperature in the bee house must be around 0°C, with oscillations not greater than 1°—2°C. Such an average temperature is best maintained in underground bee houses. The air humidity is also highly important for bees' wintering in good conditions. A relative air humidity of 75—80% is optimum. The more humid shelters are definitely not recommended for bees' wintering.

For removing excessive humidity and ensuring optimum wintering conditions for bee colonies bee houses are equipped with a ventilation system, preferably with exhauster. In this case the aspiration pipe starts in the *tambour* in the bee house and passes through the floor. The evacuation pipe begins at the ceiling and comes out through the roof. The influx and evacuation of the air is regulated by means of small flaps. The section of the ventilation pipes is calculated so as to provide for at least 7—10 sq. cm for every bee colony.

For bee houses, the best location is a higher place, protected from cold winds. For letting out rain water and that resulting from thawing snow, an evacuation channel is built around the bee house.

In 1970 the USSR Ministry of Agriculture approved the standard designs for bee houses for 110, 150, 250, 300, 500 and 800 bee colonies.

The walls of bee houses are built of brick, and of wood filled in with insulating material. The floors are 10 cm. layers of sand, spread on a clay layer of 30 cm. The good insulation of the roof is very important. Boards are laid on wood beams, which are covered on top with a layer of clay, on which a sand layer is laid, and on it a mixture of clay and organic substances, and finally a layer of dry earth. The brick and stone walls are plastered with a lime — and cement mixture, while the wood walls, the division boards and the ceiling — with a mixture of clay and straw. All the interior surfaces of the bee house are whitewashed, and the doors are dyed with oil paint.

Three shelves are made for placing the hives in each bee house. In large bee houses for 500 and more colonies a rope way is used for introducing hives in the bee house and for taking them out in spring.

Folding honey houses for migratory beekeeping are intended for some operations in the apiary (preparation of frames, honey extrac-

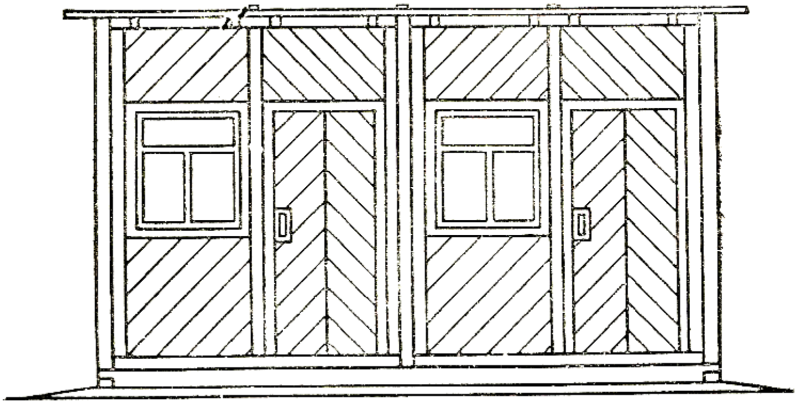


Fig. 24. Folding honey house for migratory beekeeping

tion, etc.), as well as for temporary dwelling for beekeepers in case of distant apiaries or of migratory beekeeping. They must be light, of simple design, and easy to be transported rapidly assembled. A standard of such a honey house is 4.24 m × 2.0 m. It is provided with a small room for the beekeeper and a shop with separate entrance doors. It is made of panels which are easily assembled by means of screws. The floors are of 37 mm-thick panels, while for walls and roof 20 mm-thick boards are used. They may be loaded in a truck. The cost of such a honey house is 260 roubles.

Simpler honey houses for migratory beekeeping may be used, out of plywood panels (5 mm.-thick) with no ceiling and floor. It is both lighter and cheaper. For protecting the plywood, it is covered with an oil paint. The roof is covered with thin metal sheet.

BEE FORAGE

THE BEE FORAGE PECULARITIES

An efficient use of the bee forage in beekeeping depends less on the land under plants of the beekeeping farm than on the honey plants available within a 2—3 km radius from the apiary location. This distance is usually called the radius of productive flight of bees. This land area („the pasture area") is of 1,250 ha at a fligth radius of 2 km and or 2,800 ha for a 3 km radius.

Bees consume much energy and food for collecting nectar and pollen and for their transport to the hive. In order to collect 1 kg of honey they must visit about 2—3 million lime-tree flowers, or 1 million fireweed flowers, or 4—5 million buckwheat flowers, depending on the nectar secretion. As much energy is required for pollen collection. The nearer the bee pastures are to the apiaries, the less energy bees consume for collecting nectar and pollen, and the greater the productivity of the bee colony.

Proper planning and use of the bee forage are of a decisive importance for the development of beekeeping operation and for increasing the productivity of the bee colonies. The honey plants available in this country are very abundant and varied. In the forest areas and alpine regions — mostly wild plants ; in the forest-steppe and steppe zones predominant are the nectar-yielding farms crops.

The most important wild honey plants include different varieties of willow, maple and lime-trees, fireweed, white clover, sweet chestnut tree, acacia, raspberry, berries, heather, dandelion, most of the wild legumes, compositae and labiatae. Of the farm crops the most important as nectar flow are the buckwheat, sunflower, esparcet, cotton, white mustard, corriander, alfalfa, fruit trees, etc.

One must take into account the fact that the nectar secretion of plants differs according to natural conditions, variety characteristics, and the farming methods.

There are huge honey sources still unexploited in Siberia, the Far East, Kazakhstan, the mountain areas in Altai, Central Asia and Caucasus. In many districts with advanced beekeeping special measures are necessary to be taken for improving the bee pasture and for providing for successive nectar flows, such as cultivation of honey plants in crop rotations on stubble fields, of herbaceous plants for improving pastures and meadows, plantation of trees and shrubs which provide for an abundant nectar flow as protective belts and for fixing up land, in recreational parks in inhabited areas and along roads, etc. In order to efficiently use the bee pasture, it is necessary to assess nectar flow conditions on each and every beekeeping farm, to take into account the area under honey plants, the nectar yield and the dates on which the main honey plants flower, and to move bee colonies to the wild honey plants and to farm crops in step with their successive flowering.

FACTORS WHICH INFLUENCE NECTAR SECRETION IN PLANTS

The nectar is an aqueous sugar-containing secretion released by the nectaries or by other parts of plants. The nectar consists of water, sucrose, fructose, and glucose. The nectar may also include small amounts of dextrin, organic acids, aromatic substances, yeasts, nitrogen compounds and minerals.

Sugar content in nectar ranges from a few percentage units up to 70% and more, but most often it stands at 40—50%. The concentration of nectar is variable (differing much even within 24 hours). In the morning the nectar is more fluid than at noon as a rule. On rainy and humid days it becomes more aqueous, while on hot or windy weather it becomes thicker. The sugar content of nectar depends on the plant species and variety.

If nectar contains less than 5% sugar, bees do not collect it. The bees hardly collect the nectar with a less than 15% sugar content. When collecting nectar with a high water content bees consume much energy for evaporating the extra amount of water. Likewise, bees would hardly collect the too thick nectar too (containing over 85% sugar). Before passing it into the honey sac, bees must dilute it with saliva. The bees collect best and fastest the nectar and sugar syrup with a 50—55% sugar content.

In most honey plants nectar is secreted by special glands — the nectaries, consisting of small parenchyma cells with thin and delicate walls, covered by epidermis. The nectaries are to be found on various parts of the flower (floral nectaries). Some plants have extrafloral nectaries.

The floral nectars can be found on various parts of the plant; at the base of sepals (lime tree), at the base of stamens (white mustard), on the receptacle (gooseberry), between the staminal tube and the ovary (leguminous plants), above the receptacle (morello tree), etc. There is a variable number of nectaries of various shapes in the flowers of different plant varieties. The shape, place and number of nectaries are permanent characters of honey plants of different kinds and are used for plant classification. The larger the flower the bigger the nectaries. The top flowers of inflorescences or of plants are smaller, their nectaries are also smaller and secrete less nectar. At the beginning of the flowering period the nectaries are bigger and they secrete more nectar than at the end of the period.

The extrafloral nectaries are to be found on different parts of plants. In cotton they are on the main nervure of the leaf, on the bracts and on the exterior part o fthe calix. The extrafloral nectaries of morello-, bird-cherry and cherry-tree are at the base of the leaf limb; in vetch — on stipules. The extrafloral nectaries of most plants secret relatively little nectar and they almost do not have any importance for bees. An exception is the irrigated cotton from whose extrafloral nectaries the bees gather more nectar than from the floral ones.

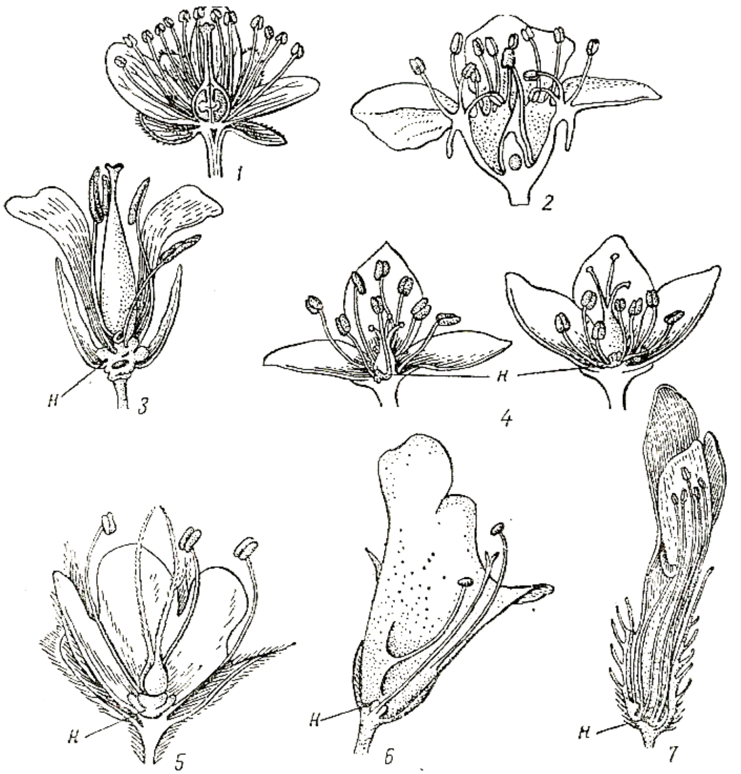


Fig. 25. Structure of flower, nectaries and their location in the main honey plants:

1 — lime tree flowers with no nectaries; 2 — morello tree; 3 — the flowers with open nectaries of white mustard; 4 — of buckwheat; 5 — flower of phacelia with semi-open nectaries; 6 — flower of blueweed with hidden nectaries; 7 — flower of red clover with very hidden nectaries (H — the nectaries)

Factors influencing nectar secretion. The nectar secretion of honey plants depends on latitude and altitude, on weather condition during the flowering period of the honey plants, on the farming methods used, on variety particularities and on many other conditions.

Geographical conditions. According to data recorded for several years by the Chair of Apiculture of the "K. A. Timiriazev" Academy of Agricultural Sciences, the nectar secretion of the same honey plants is higher in northern regions. The nectar secretion of fireweed for example is higher the farther in the north it grows, attaining maximum value in the Krasnogorsk region and in the Yacut/ASSR, beyond the 60° latitude north. The same is true with a number of other honey plants.

The average amount of nectar in a flower of white clover *(Trifolium repens)* is of 0.013 mg. in Adler district, Krasnodar region, of 0.022 mg in the Kiev zone, of 0.025 mg in the Moscow zone, of 0.033 in the Vologda region, and of 0.051 mg in the Murmansk region.

At the same latitude, in the eastern districts with a severer climate nectar yield is higher ; in the Moscow zone for example it is by far higher than in Estonia ; in the Yacut ASSR and in Krasnoyarsk region it is larger than in the A.S.S.R. of Karelia. The nectar secretion also increases with altitude.

Thus the sugar content on flowers of sweet chestnut *(Castanea sativa)*, azalea *(Azalia pontica)*, germander *(Tencrium* sp.) increases in step with their being cultivated at higher altitudes.

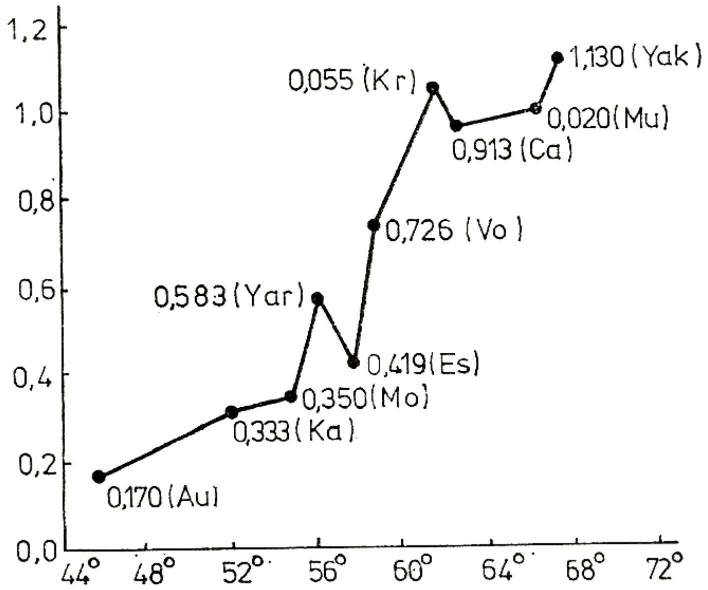


Fig. 26. Nectar secretion of fireweed according to latitude

Yak-Yakutia ; Mu — Murmansk ; Ca — Karelia ; Kr — Krasnoyarsk ; Vo — Vologda ; Es — Estonia ; Yar — Yaroslavl; Mo — Moscow; Ka — Khazakhstan ; Au — Austria

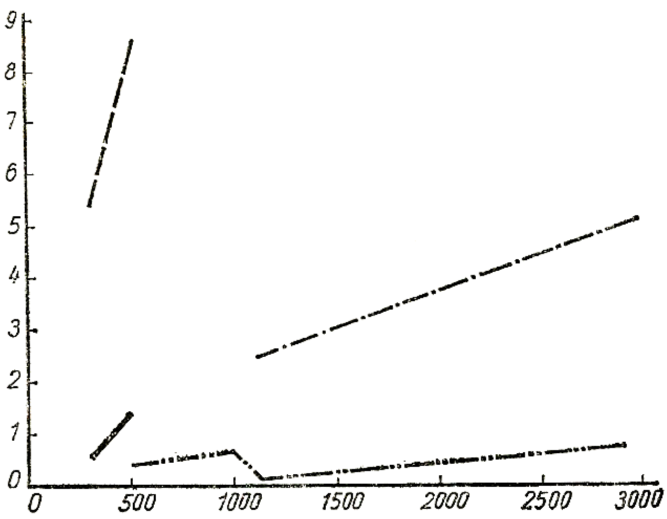


Fig. 27. Variation of nectar secretion according to altitude: ——— *Castanea sativa* ; — — — *Azalea pontica* ; —.—.— *Teucrium* sp. ; —..—..— *Trifolium repens*. *On the ordinate — mg sugar/flower ; on the abscissa — m — above sea level*

Investigation of the nectar yield in over 20 red clover *(Trifolium pratense* varieties at the greenhouse of the Institute of Fodder Plants (Moscow region), cultivated in identical conditions, showed that the varieties from the Northern and alpine districts had richer nectar secretion.

The average sugar content in a red clover flower of Canada was 0.253 mg, of Igava (Krasnoyarsk region) — 0.220 mg, of Armenia and North Osetia — 0.229 mg, while that of the varieties of Khutorak steppe area (Krasnodarsk region) and of Marusinsk (Tambov region) was 0.130 mg and 0.066 mg respectively.

In this respect too, the same geographical variability exists as with nectar secretion. A relatively higher nectar secretion exists in cold-resistant varieties of apple-trees and raspberries in the Northern districts.

Weather bears a considerable influence upon nectar secretion. The minimum temperature at which nectar secretion starts is of 10°—12°C. The most favourable temperature for nectar secretion is from 16° to 25°C. However the optimum temperatures are not the same for all varieties.

According to data reported by I. B. Kopelkievski and G. D. Guvari, a drop of day temperature to 18°—22°C causes sharp decrease in buckwheat nectar secretion. But the yellow melilot continues to secrete nectar at temperaures lower than +10°.

Dry wind associated with high temperature and low air humidity is conducive not only to sudden decrease of nectar secretion but also to the deformation of nectaries. Sometimes, under such conditions the sugar concentration in nectar increases so much that it becomes inaccessible for bees.

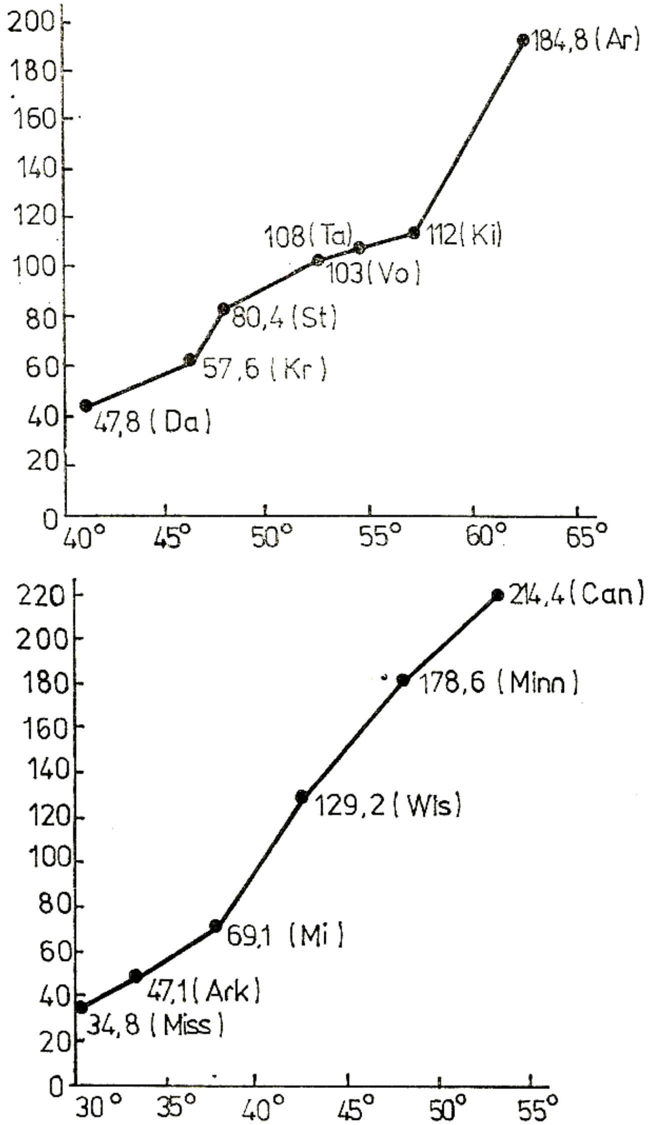


Fig. 28. Variation in nectar secretion of plants according to the latitude — the European part of the USSR and in the U.S.A.

Ar — Arkhanghelsk ; Ki — Kirov area ; Ta — Tartar ASSR ; Vo — Vologda area ; St — Stavropol ; Kr — Krasnodar ; Da — Daghestan ASSR ; Can — Canada ; Minn — Minnesota ; Wis — Wisconsin ; Mi — Missouri ; Ark — Arkansas ; Miss — Mississipi.
On the ordinate — production of bee colonies (% of the average in RSFSR and respectively USA) ; On the abscissa — latitude

The optimum air humidity for nectar secretion in most plants ranges from 60% to 80%.

Sunny weather favours nectar secretion with most plants. In one and the same plant, the flowers on the sunlit side secrete more nectar than these on the opposite side. On sunny days, the red clover for example secretes 2—3 times more nectar than on cloudy days. Still, some plants are exceptions to the rule. Thus buckwheat yields 1.5—3 times more nectar on cloudy but hot days than on a sunny day. However, sugar concentration in nectar decreases.

Influence of fertilizers on nectar secretion in plants. The agrotechnical methods contributing to raising seed and fruit crop of entomophilous plants also exert a positive influence on nectar secretion. Nectar secretion and seed production are closely linked to one another.

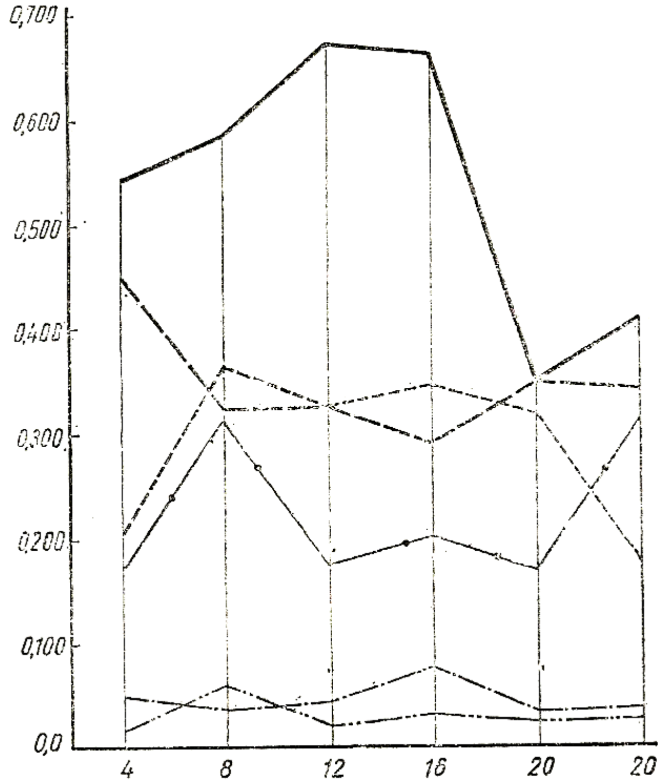


Fig. 29. Variation of nectar secretion in plants in 24 hours:

On the abscissa — hours; on the ordinate, mean quantity of sugars (mg/flower)

——— lime tree
—·— fireweed
— — — vetch
—·—— beans
— · — · buckwheat
·—··— melilot

Fertilizers are highly important for raising nectar secretion. Potassium and phosphorus fertilizers stimulate the development of flower organs and contribute to heightening their nectar secretion.

Professor P. N. Veprikov's experiments showed a 2.5 and 3 times increase in the nectar secretion of buckwheat and red clover respectively when using potassium and phosphorus fertilizers.

As a rule, nitrogen fertilizers — applied late and in large amounts — do not bear an essential influence upon the growth of nectar secretion. The same fertilizers, applied in due time on poor soils, substantially increase nectar secretion as well as seed production of most honey plants.

Microelements — boron manganese, etc. — have a positive influence upon nectar secretion. Their use in buckwheat, sunflower and esparcet crops has contributed to a considerable increase of nectar secretion and seed yield of the above crops.

The following results were reported on the influence of microelements on nectar secretion of flowers and on seed crops, by F. L. Lesik following tests made in Dnepropetrovsk region (Table 5).

Table 5

Test	Nectar/flower (mg)			Seed crop (2/ha)		
	Buck-wheat	Sun-flower	Espar-sette	Buck-wheat	Sun-flower	Espar-sette
Unfertilized	0.05	0.62	0.07	15.0	12.1	5.0
Fertilizers with manganese	0.26	0.41	0.28	17.9	14.8	7.3
Boron (10 kg boric acid/ha)	0.23	1.53	0.29	17.3	12.2	7.0

Nectar yield depends not only on application of fertilizers but also on other agrotechnical methods. Nectar secretion is positively influenced by modern agrotechnical methods which contribute to a better development of plants (sowing in check-row holes, weed control, use of organic and mineral fertilizers, the hydrogenic method of plant cultivation, etc).

According to data recorded at the Institute of Apiculture (G. A. Soloviev, E. I. Ponomariova, G. V. Kopelkievski) the nectar yield of buckwheat flowers and bees' visits on them, when sown in for apart rows, increase by 40—50%.

Nectar secretion is greatly influenced by *irrigations,* especially in the droughty areas.

T. I. Kaziev found that in the conditions of Adzerbaidzhan S.S.R. watering of cotton crops when in flower two more times than usually, results in a 42—76% rise in nectar secretion.

In Dnepropetrovsk region, one sprinkling alone (700 cu.m. of water per hectare) made sunflower production increase fourfold, while watering it twice (700 cu.m. + 700 cu.m. per hectare) was conducive to a sevenfold production. At the same time, sunflower seed production rose to 19.4 and 22.2 q as compared to 12.7 q with no extra watering.

Variability of nectar secretion according to plant variety.

Data reported by the Institute of Apiculture (G. V. Kopelkievski), show that in the Moscow region, the sugar content of nectar differed in individual buckwheat varieties as follows :

Plant Variety	Sugar content of nectar (kg/ha)	Seed output (quintals per 1 ha)
Bogatyrii	142.5	15.0
Shatilovskaia	137.5	15.0
Moskovskaia	114.0	14.0
Voznesenskaia	49.7	9.7

A great variability of nectar yield was found to exist in individual varieties of red clover, apple tree, currant and gooseberry as well as in a number of other crops, by the Apiculture department of the "K. A. Timiriazev" Academy of Agricultural Sciences. The higher the degree of self-sterility of the plant variety the greater the amount of nectar secreted by flowers for attracting insects and ensuring crossed pollination.

Cotton varieties with fine fibre (the Egyptian ones) are known to secrete 2—3 times more nectar than the common ones.

Beekeepers have reported that the new sunflower varieties, with a high oil content, developed by the well-known expert in selection Academician V. S. Pustovoit ("V. I. Lenin" USSR Academy of Agricultural Sciences) secreted less nectar than earlier varieties. Comparative data on nectar secretion of different sunflower varieties show that this is not true (Table 6).

Table 6

Sugar-content and yield of nectar in different sunflower varieties

Plant Variety	Sugar-content of nectar		Number of bees/ 100 sq m	Seed yield (q/ha)	Oil content of dry seeds %
	in 100 flowers (mg)	in kg/ha			
Saratovski 169	59.1	23.3	71	20.8	43.2
Sortandinskii 41	52.7	18.6	44	16.5	35.5
Iugovostochnii	59.7	23.2	75	81.1	43.7
VNIIMK 18 962	59.3	28.5	63	21.6	43.6
VNIIMK 8 931	60.9	31.0	101	25.2	48.3

As a rule, the higher the seed yield of an entomophilous crop, the larger the quantity of nectar secreted. This provides great possibilities for selecting and cultivating the best performing varieties, profitable both as farm crops and as honey sources.

Determination of nectar production of flowers is highly important for estimating honey potential. There are different methods of direct determination of the amount of nectar. Each has advantages as well as disadvantages.

Determining nectar sediment. This is the simplest and the most accessible method to be used in the field. It is largely used for comparative assessment, in the field, of the nectar yield of plant species and varieties, and of the influence of various agrotechnical methods on nectar secretion. Twenty four hours before taking samples, flowers are covered with gauze lest the insects should forage the nectar. The gauze is removed only for taking samples. Depending on the flowers size, nectar samples are taken from 20—25 to 100—200 flowers : from 20—25 — fruit trees and berries (apple and pear trees, strawberry), from 50—75 — fireweed and esparsette, from 100—200 — buckwheat, alfalfa, and clover. The flowers collected are put in a flask and 25—40 ml. distilled water is poured on them. The previously weighed water must cover the flowers. Then the flask is stirred gently lest the flowers should be damaged. The duration of stirring varies function of the type of nectaries. With open nectaries (buckwheat, lime-tree) five minutes are enough. For fireweed flowers 8—10 minutes are necessary, while for sunflower, esparssete and clover — about 12—15 minutes. Then the solution is strained. Then 20 ml. of the filtrate are mixed up with an equal amount of 96° alcohol. The sample can be thus preserved in glass tubes with tight caps. On each of them labels are attached describing the sample : plant species and variety, time and place, number of flowers, amount of water used for dilution and straining. The amount of sugars, of mono- and disaccharides is determined by Hagedorn-Jensen and Issckutz tests.

Determining nectar by strips of filter paper. 20—25 mm long and 1.5—2.5 mm wide strips of thin filter paper are used. One end of the strip must be triangle-shaped. The filter paper strips, previously dried up to a constant weight are put into a tightly closed test tube. The strips are taken out by pincers, and the nectaries of flowers are touched with their narrow end. The nectar of one or several flowers — depending on the amount of secreted nectar is gathered on the strip. Then the strips are put back into the test tube and weighed again. By the weight difference one can establish the amount of the nectar sample. Then strips are again dried up to a constant weight, the difference between the third and the first weighing showing the sugar content of the nectar sample.

By capillaries and micro-pipettes. About 10—15 capillaries (0.2 mm. diameter and 5—6 mm. long) are put in a micropipette and weighed. Then, nectar samples are taken, placing one end of the capillaries in the nectaries of the flowers. The capillaries with nectar in them are put into a test tube and weighed again, the amount of nectar is tantamount with the difference of weight.

The micropipette is a tube of fusible glass, having a diametre of 4 mm. and 10—15 mm length, enlarged at a given point into a sphere with a 10—15 mm. diametre. From the sphere, the tube continues with a diametre of about 2 mm., and ends into a cone of 10 mm. with a terminal orifice of 0.2 mm. diametre. The larger end of the micropipette is provided with a thin, 40—50 mm long rubber hose which ends with a glass tip. The cone of the micropipette is put closely to the nectaries and the nectar is sucked through the glass tip. Nectar samples are taken from a certain number of flowers. The difference in weight between the full and empty micropipette constitutes the quantity of nectar; by means of a refractometre the sugar content is determined.

A common drawback with the above three methods is the great amount of work. By using these methods, one can however record the rate of nectar secretion by taking successive samples throughout the blooming period of individual flowers.

Determining by one of these methods the nectar production of flowers, one can calculate the amount of nectar yielded by the flowers on a certain area counting first the flowers on one plant,then calculation for one hectare of similar crops are made. Multiplying the average number of flowers on a honey plant with the amount of nectar and the number of plants, the quantity of nectar on the respective area is obtained.

One may also calculate the amount of sugars in nectar. Adding to it 20%, the honey production per hectare is estimated.

Honeydew. Besides nectar bees also collect from certain plants honeydew — an excretion of plant lice, which live on the underside of leaves and feed themselves on the plant sap. The sweet excretions of these insects accumulate on leaves. Honeydew is especially abundant on

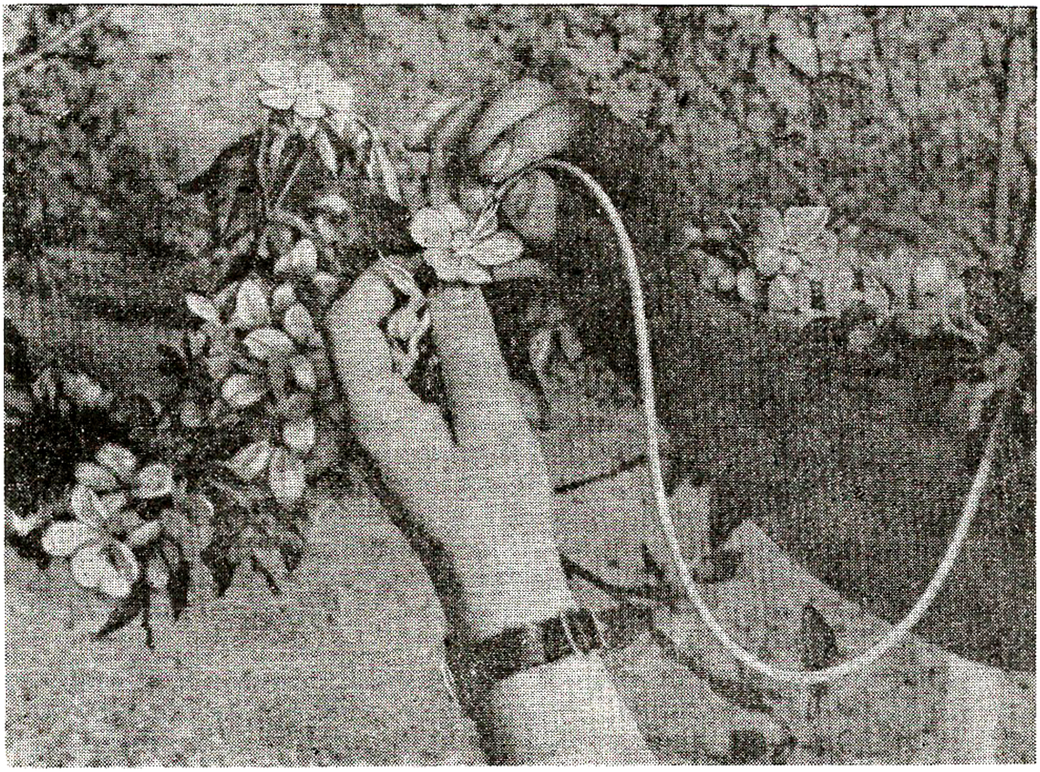


Fig. 30. Taking nectar sample by a pipette

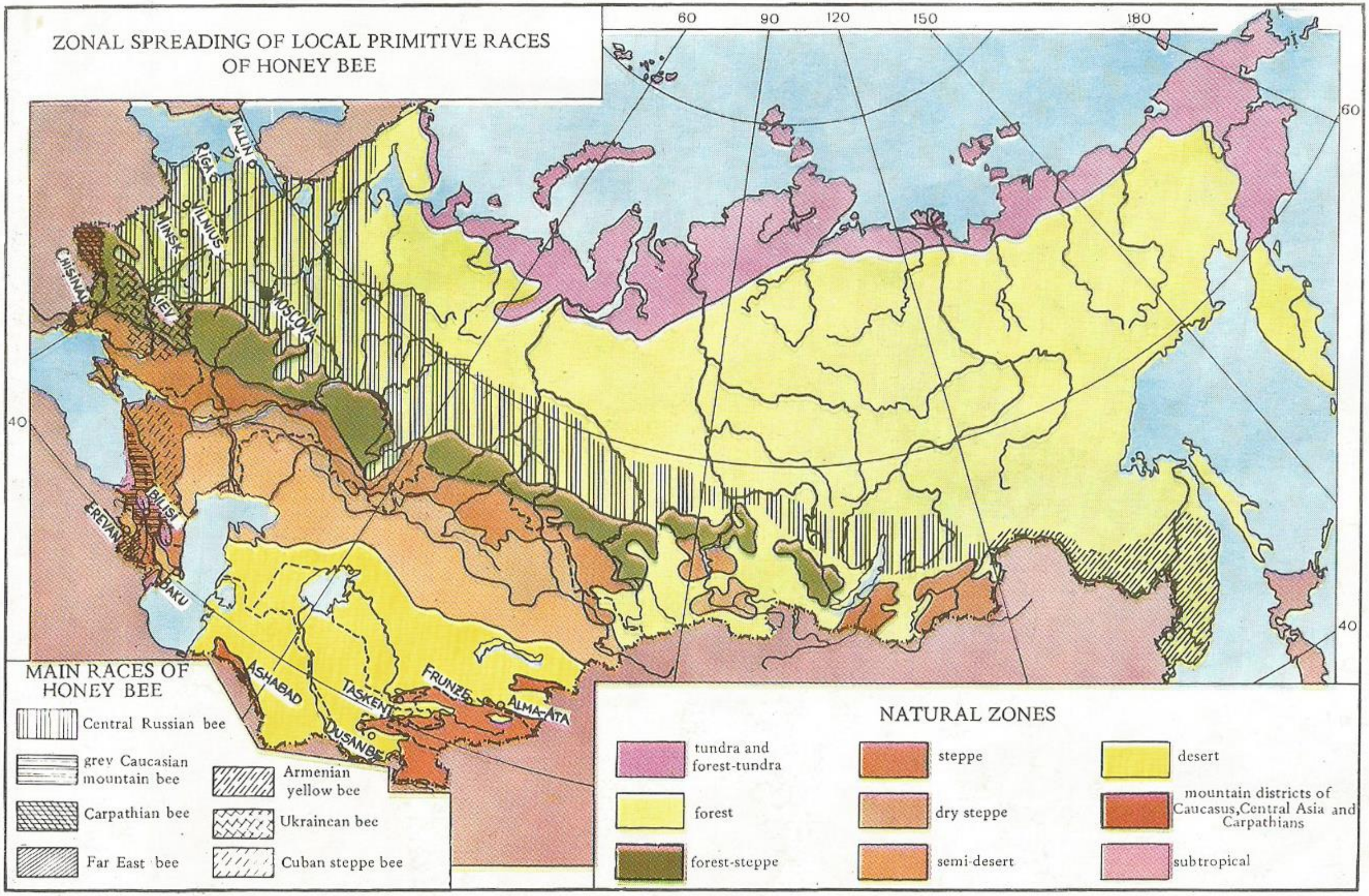


Plate I—Map of distribution of bee races in the natural zones of the USSR
1—Central Russian bee; 2—grey Caucasian mountain bee; 3—Carpathian bee; 4—Far East bee; 5—Armenian yellow bee; 6—Ukrainean bee; 7—Cuban steppe bee

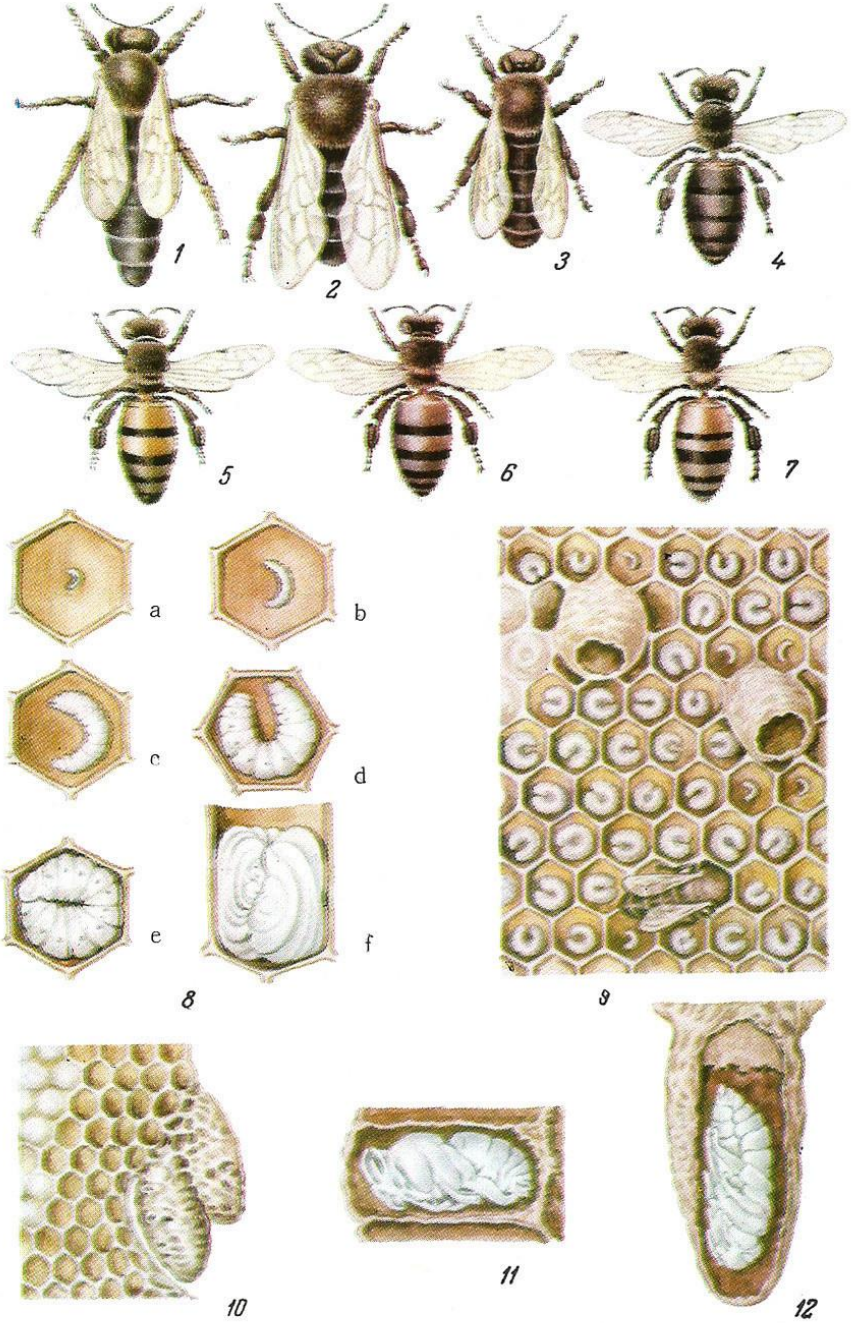


Plate II—Biology of the bee colony

1—queen bee; 2—drone; 4—worker bee (Central Russian); 4—grey Caucasian mountain bee; 5—yellow Caucasian bee; 6—Italian bee; 7—African bee (Egypt); 8—worker larva; a—recently hatched; b—one day larva; c—two day larva; d—three day larva; e—four day larva; f—a larva shortly before being capped; 9—part of an uncapped brood area in a comb and two uncapped emergency queen cells; 10—capped swarming queen cells; 11—worker pupa in capped cell; 12—queen pupa in capped queen cell

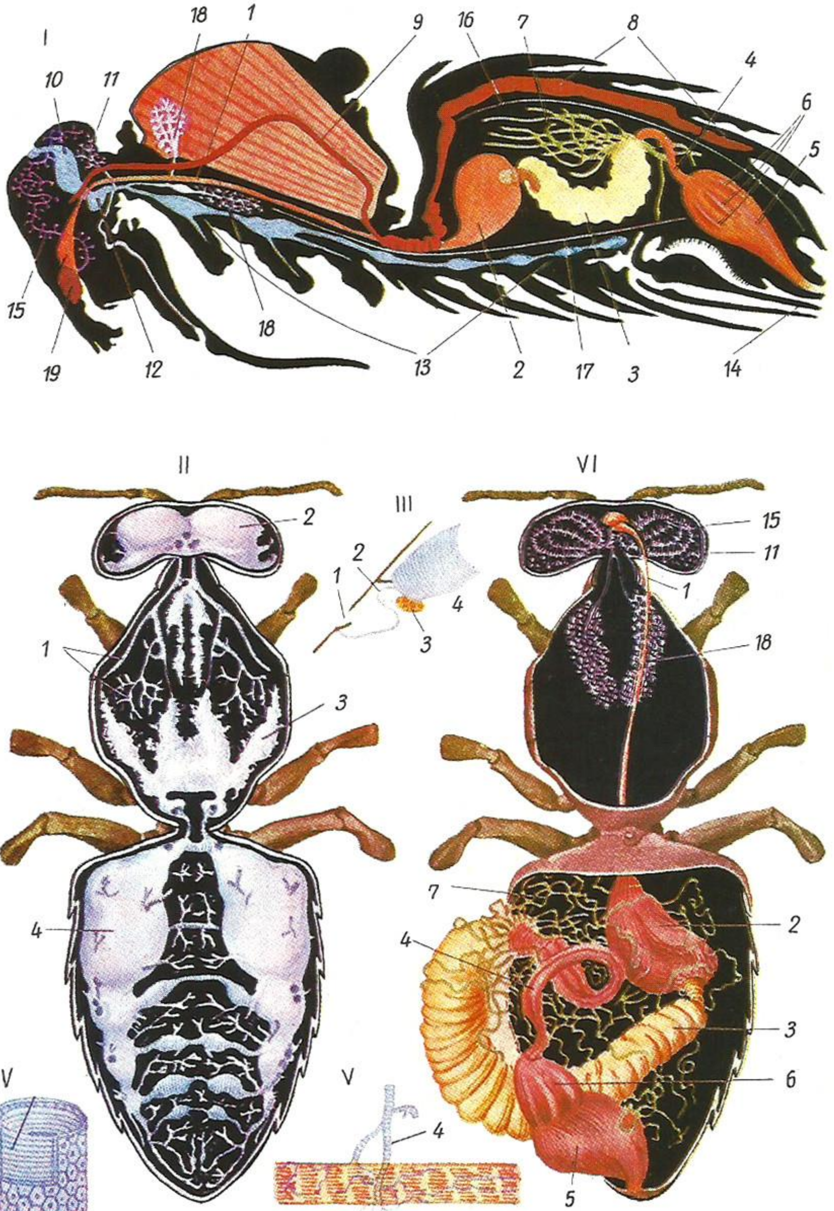


Plate III—Honey bee anatomy

I—internal organs: 1—digestive tube; 2—honey sac; 3—mid gut; 4—small gut; 5—large gut; 6—rectal glands; 7—Malpighian tubules; 8—heart compartments; 9—aorta; 10—supra-pharyngeal ganglion (brain); 11—posterior ramification of the pharyngeal gland; 12—subpharyngeal ganglion; 13—nervous chain; 14—sting; 15—pharyngeal gland; 16—dorsal diaphragm; 17—abdomen-diaphragm; 18—thoracic gland; 19—supramandibular gland
II—breathing organs: 1—trachea; 2—brain aerial sacs; 3—thoracic aerial sacs; 4—abdominal aerial sacs; III—stigma: 1—orifice; 2—stigma valve; 3—valve muscle; 4—trachea; IV—digestive organs

Plate IV—Forest honey plants

1—goat willow; 2—small-leaf linden; 3—hazel nut; 4—heather; 5—willow herb; 6—lung wort; 7—Norway maple; 8—locust tree

Plate V—Honey crop plants and honey fodder plants

1—buckwheat; 2—sunflower; 3—white clover; 4—coriander; 5—esparcet; 6—white sainfoin; 7—mustard; 8—phacelia

Plate VI—Honey producing fruit trees, berries, leguminosae and melon fields

1—morello cherry tree; 2—apple tree; 3—cucumber; 4—raspberry bush; 5—black currant; 6—gooseberry bush; 7—melon

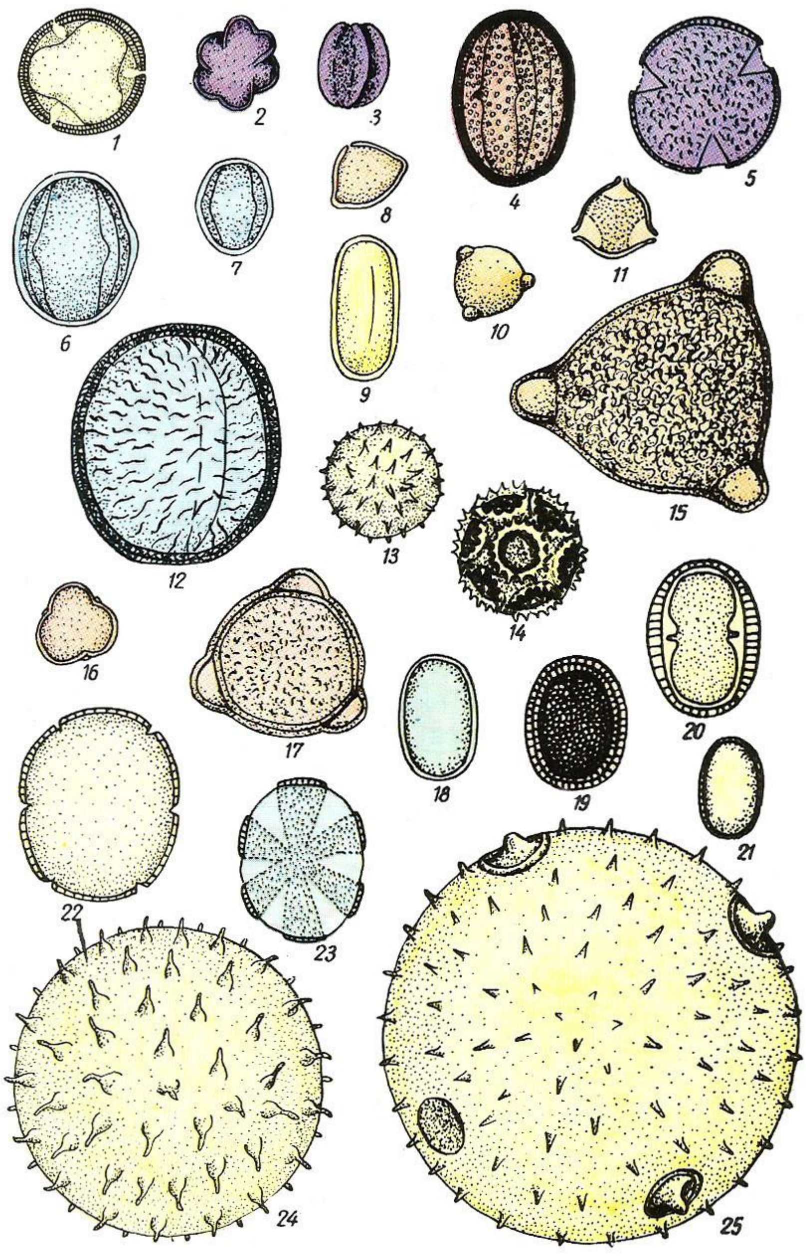


Plate VII—Pollen pellets of the most important honey and pollen plants

1—lime tree; 2 and 3—phacelia; 4—buckwheat; 5—poppy; 6—red clover; 7—white clover; 8—locust tree; 9—esparcet; 10—birch tree; 11—hazel nut tree; 12—bindweed; 13—sunflower; 14—dandelion; 15—willow herb; 16—willow; 17— cucumber; 18—lung wort; 19—mustard; 20—corn flower; 21—winter cress; 22—ground ivy; 23—common sage; 24—cotton; 25—pumpkin

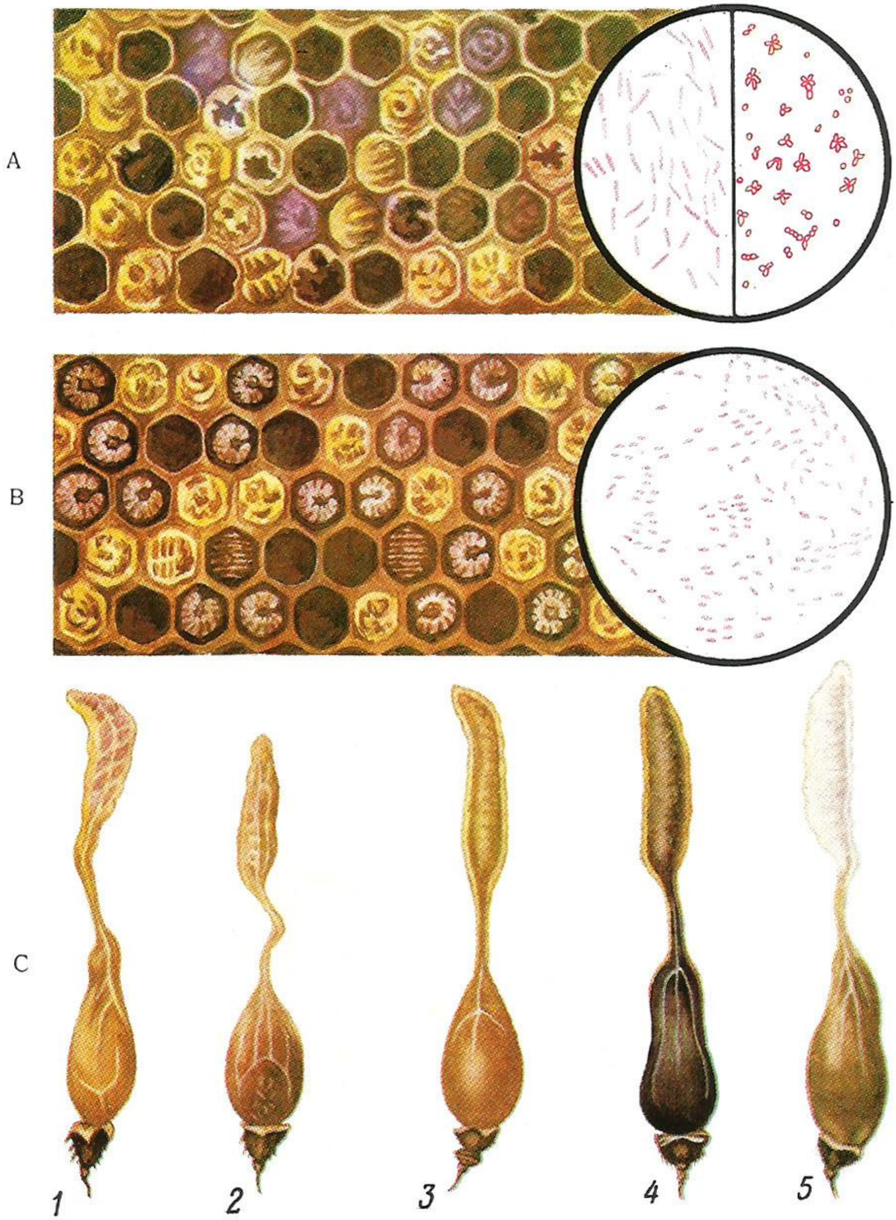


Plate VIII—Honey bee diseases

A—B American foulbrood attacked brood. In the circle — the pathogen of the disease (Bac. larvae) seen under microscope (left — vegetative form, right — spores); B—European foulbrood attacked brood. In the circle one of the pathogen agents (Strept. pluton) seen under microscope; C—bee toxicose: 1—gut of a healthy worker bee (above — mid gut, in the middle — small gut, below—posterior gut with the last abdomen segment and sting) with strong pigmentation of the mid portion; 2—same gut when chemically contaminated — the midgut is short and almost empty; 3—when poisoned with pollen — the gut is grey- yellow, overloaded with undigested pollen; 4—when poisoned with honeydew—the gut is dark blue to black and is overloaded; 5—when Nosema diseased — the gut is overloaded, midgut is milky white hot and dry days on the leaves of trembling poplars, lime and hazel nut trees, as well as of other trees and shrubs.

Bees gather this sweet liquid, deposit it into cells and turn it into honey called honeydew honey.

In terms of chemical composition, honeydew differs entirely from nectar. It contains much more minerals, dextrins and other undigestible substances, toxic to bees (in wintertime : APIMONDIA Editorial Board's note).

Pollen yielding plants are the plants from which bees gather pollen alone. Almost all flower plants which secrete nectar supply bees with pollen. Nevertheless, in certain periods the pollen gathered by bees from honey plants is insufficient in some districts. This happens mostly early in spring after wintering. During this period bees collect pollen from a number of plants which do not secrete nectar while producing much pollen (e.g. hazel-nut and birch-trees). When colonies are extremely short of bee bread, bees would sometime collect pollen from cereals and coniferae, although the latter are not a complete source of proteins.

Processing pollen into bee bread. Whereas the nectar is the bees' source of sugars, the pollen processed into bee bread, is a source of albumins, aminoacids, fats, minerals, vitamins and other substances.

Pollen processing in bee bread starts already during its collection. The pollen of very many plants, especially of amenophilous ones, is characterized by its dryness and spreading capacity. While making up pellets bees moist it with saliva and nectar.

The foraging bees deposit the pellets into worker cells and press them with their head.

The bees do not fill up the cells with bee bread, and cover it with honey. Bee bread can thus be preserved until spring. The pollen of various plants has different chemical composition (Table 7) and structure (colour plate VIII).

Table 7

Chemical composition of pollen of various plants (after Todd and Bretherick)

Plant	Pollen content (%)					
	albumins	fats	sugars	water	ash	Undetermined substances
Dandelion	11.12	14.44	34.93	10.96	0.91	27.64
Black willow	22.23	4.15	32.18	12.30	2.61	26.40
White clover	23.71	3.40	26.89	11.56	3.14	31.30
Plum-tree	28.66	3.15	28.29	9.79	2.62	27.49
Maize	20.30	3.67	36.59	5.53	2.55	31.34
Pine-tree	7.02	2.04	48.35	7.01	1.32	34.26

THE MAJOR HONEY PLANTS IN THE USSR

There are about 152,000 flower plant species on the earth. In the USSR there are almost 20,000 species of which over one thousand are yielding nectar. Nevertheless, only about 200 species have a practical importance for beekeeping.

There are both wild honey plants and cultivated honey crops. According to the time of blossoming they are early spring, spring, summer and autumn plants. It is obvious that under different natural conditions and in different years the blossoming periods are not the same. In terms of geographical location one may distinguish honey yielding farm crops, fruit-trees and shrubs, pastures, and forest honey sources.

Honey yielding farm crops. They do not hold a similar place in terms of importance in all areas of the country. In the steppe zone in the South and South-East of this country, farm crops are the main — and in most cases — the only forage source.

Large areas under first-hand honey plants such as sunflower, rape, coriander, white mustard, esparsette and others exist in the above two regions while in Central Asia prevalent are cotton and alfalfa in irrigated crops.

In the forest-steppe zone of the European part of the USSR farm crops are highly important for bees too. Widely spread are buckwheat, sunflower, white mustard and coriander. Nevertheless, wild honey plants also play an important part.

In the forest zone farm crops carry a very small weight. Only limited areas under buckwheat and white and red clover seed crops exist and in the Baltic districts there is also melilot which is a good nectar source for bees.

Buckwheat (*Fagopyrum aesculentum* Moench). (Colour plate V, 1) is one of the main groups and honey yielding crops. Our country holds the first place in the world as concerns the area under buckwheat (1.72 million hectares). This crop is mostly cultivated in Polesie region and in the forest-steppe zone of the Ukraine, in Bielorussia, in the central chernozem area, and in some areas with other soils (especially in the Kursk, Orlovsk, Riazansk and Briansk regions), in the Tartar, Bashkir and Udmurt Autonomous Soviet Socialist Republics, in the Urals, Western and Eastern Siberia, and in the Far East. The most widely spread are Shatilovskaia and Bogatyri varieties.

The main biological quality of the buckwheat is the diversity of its flowers : the heterostyly. The blossoming of buckwheat starts on the 30th—40th day after sowing and it lasts 25—30 days on an average at early varieties, and 30—40 days at late ones. Nectar secretion of buckwheat drops considerably on warm, dry, and on cold or rainy days. On such a weather, bees almost do not visit it. Buckwheat grows well on several types of soil, including drifting sandy soils. It develops well if cultivated after cereals, leguminous and root plants as well as potatoes. Buckwheat is also used as a stubble field crop ; its utilization with this purpose is highly recommended in the southern and south-western districts which have long frostless periods.

Phosphorus and potassium fertilizers contribute to increasing nectar secretion of buckwheat and thanks to this it is frequently visited by bees.

Bees collect both nectar and pollen from buckwheat. Under favourable weather conditions one may obtain 70—90 kg. honey from 1 hectare of buckwheat. Nectar is more abundantly secreted in the morning and before sunset. The daily extra intake recorded in the scale hive (in buckwheat fields) would be of 3—4 kgs, sometimes even of 5—7 kgs.

Sunflower (Helianthus annuus, L.) (colour plate V, 2) is the main oil crop in the USSR. In terms of area under sunflower (over 4.5 million hectares) our country ranks first in the world. The main zones under cultivation are the North Caucasus, the central chernozem area, Povoljie, the Ukraine, Moldavian S.S.R., and western Siberia. Sunflower is cultivated especially as silo plant in Krasnoyarsk, Irkutsk and the Far East regions (the Amur and Primorsk area).

Sunflower belongs to compositae family. Its inflorescence is a capitulum, 12—20 cm in diameter, as with most oil-bearing plants. On the edge of the capitulum there are vividly coloured flowers which are sterile but which draw insects, while in the interior — the bisexual tubular flowers. The number of the latter in a capitulum ranges between 600 and 1200, even more.

Sunflower is highly desirous of warmth and resistant to drought. It blossoms 60—80 days after having been sown, its bloosoming period lasting for approximately 30 days. The most widely spread are the varieties developed by Academician V. I. Pustovoit. Bees collect almost 40 kg. honey from 1 ha of sunflower.

White mustard (colour plate V, 7). Edible mustard *(Brassica juncea* Czern) and white mustard *(Sinapis alba* L.) are cultivated in the USSR. Both are excellent honey plants. The edible mustard is grown in the South-East of the country, while the white one — in the regions without chernozem. The total area under edible and white mustard stands at 0.3 million hectares. Mustard blossoms in the 40th—45th day after sow-

Fig. 31. Sunflower head (capitulum)

ing; the flowering period lasts for about three weeks. Bees can collect up to 100 Kgs and 50—60 Kgs honey from one hectare under white and edible mustard respectively. Mustard honey crystalizes easily; therefore it must not be left in the hives as winter stores.

Coriander (Coriandrum sativum L.) (Colour plate V, 4) is a plant containing volatile oils. At present this crop holds about 170,000 hectares in the USSR. Coriander is cultivated especially in the districts of the central Chernozem area, in Povoljie, North Caucasus and the Ukraine. It requires warmth — especially when in flower and for fruit ripening, and an appropriate soil. Its vegetation period ranges from 90 up to 120 days. In the North Caucasus good seed crops are yielded by the winter coriander. The coriander sown in spring blossoms on July 10—15, and that sown when winter comes — in mid June. Flowering lasts for about one month. Honey output per 1 ha of coriander under favourable conditions is 200 Kgs and even more. In the districts possessing massive such crops, this plant together with sunflower ensures the main flow.

Cotton (Gossypium). In the USSR *Gossypium hirsutum* (maximum variety) and *Gossypium barbadense* (variety with fine fibre) are cultivated. Cotton covers in our country over 2 million ha, especially in the Central Asian republics, Southern Kazakhstan and Transcaucasia. Its blossoming lasts for two months. In Central Asia — from the end of June to the middle of August, while in Transcaucasia — from July 10—15 until October. Cotton flower has a large corolla made up of five petals united by the generative tube. The petals are yellow, cream or white, according to variety. Cotton has floral and extrafloral nectaries. Floral nectaries are placed in the interior part of the calix, between calix and corolla; the extrafloral ones — at the basis of the calix (on the exterior part), on the bracts and on the central nervation of the leaf. Honey production of one ha under cotton may reach 50—60 Kg. With varieties with fine fibre it is much higher. Cotton pollen has large grains and bees hardly collect them.

Alfalfa (Medicago sativa L.) is a perennial plant belonging to the leguminosae family. It is largely spread in the Soviet Union, especially in the steppe region and the irrigated zones in Central Asia and Transcaucasia. For a good nectar secretion of alfalfa it is necessary to have warmth and a high humidity of the soil; such conditions are available in the irrigated fields in the South. When irrigated, nectar secretion of alfalfa reaches 300 Kgs. per hectare. In the Central Asian republics, where alfalfa is a good crop to be cultivated previously to cotton, these two crops are the main honey sources.

Esparcet is a valuable perennial and honey fodder plant of the leguminosae family. The following varieties can be met in the USSR: the cultivated esparsette *(Onobrychis sativa* Lam.) (Colour plate V, 5), the sand (wild) esparcette *(O. Orenavia* D.C.) and the Transcaucasian esparsette *(O. transcaucasica* Grossh). Both in single crops and mixed with leguminous plants and cereals, esparsette is cultivated in the Ukrainean SSR, Northern Caucasus, Transcaucasia, the central chernozem zone, and Povoljie. The plant is highly resistant to drought. It develops very well on soils rich in limestone. Erparsette is an exceptional honey plant. As many as 90—400 Kg. of excellent honey — and even more — can be obtained from one hectare under this crop. Highly productive are the Transcaucasian varieties such as Sisianskyi, Akhalkalaksky and Nakhicheranskyi. Esparsette blossoms before the other honey crops (by the end of May and beginning of June), offering the bees during this period an abundant nectar flow.

Alsike clover (Trifolium hybridium L.*)* is a perennial fodder plant of the leguminosae family. It is less pretentious than the red clover and it develops well on marshy lands, being handicapped by altitude and dry soil. Red clover is cultivated combined with hay and green fodder, as well as on pasture lands. It blossoms in the third part of June, i.e. a little later than white clover. The honey production of a hectare under alsike clover is about 120 Kgs. This crop may play a great part in improving the honey sources in the areas with insufficient humidity (for improving fruits and pasture lands).

White clover (Trifolium repens L.*)* (colour plate V, 3) is found in the forest, forest-steppe and steppe zones, and in the mountain districts of the country. It is resistant to wintering and flood. It grows well on humid and clay soils. As a pasture land plant it is slightly affected by cattle's treading it under their feet. In central area of the USSR, white clover blossoms from early June until late in autumn, but its mass blossoming is over in the second half of July. White clover is an important honey plant of the forest area without chernozem in our country. About 100 Kg honey way be obtained from one hectare under white clover.

Red clover (Trifolium pratense, L.) secretes quite a lot of nectar. Nevertheless, because it is deposited on the bottom of the thin tubes

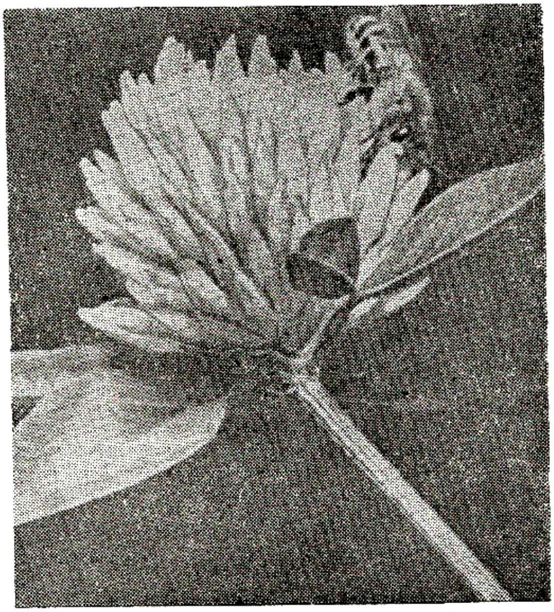


Fig. 32. Red clover inflorescence

of the corolla, it may be collected only by bees with long proboscis — the Caucasian and Carpathian ones, as well as by bumble bees.

Melilot (Melilotus) is an efficient fodder plant with a rich nectar secretion. It may be used as hay, silo or green manure. Biannual varieties — white melilot *(M. alba* Desr.*)* (color plate V, 6) and yellow melilot *(M. officinalis* Desr.*)* are pre-eminently cultivated. Melilot is resistant to draught and cold in winter. It grows on various soils, except the marshy ones, on acid soils and quick sands. It is very resistant to soils with high salt content. Melilot is a honey plant and in southern districts it often constitutes the main nectar flow. It blossoms from June till late in autumn. Yellow melilot blossoms 10—12 days earlier than white melilot. Over 300 Kgs honey may be obtained from one hectare under melilot.

Nectar yielding fruit trees and berries carry a great weight in the bee forage of many districts where fruit-tree growing developed extensively. Most of them blossom early in spring and they constitute the main source of the spring maintenance nectar flow, extremely necessary for increasing the strength of bee colonies. In the zones where all kinds of fruit-trees and berries exist bee colonies have enough time to develop well and in certain years the strongest yield much honey. With combined plantations of shrubs, fruit-trees, gooseberry, currant, morello-cherry, plum and apple-trees as well as raspberry (colour plate VI, 1, 2, 3, 4, 5, 6) the successive maintenance nectar flows may last for four or five weeks. Honey production per 1 hectare under apple, pear, plum, morello-cherry and cherry-trees is of about 20—30 Kgs ; under gooseberry and currant — 50—60 Kgs.

Raspberry holds an outstanding place among the plantations of fruit trees and shrubs. The honey production of one hectare under raspberry stands at 120—125 Kgs. In favourable years and with advanced farming techniques one hectare of raspberry may yield up to 200 Kgs honey. Raspberry blossoms later than other fruit trees and shrubs. Bee colonies have time enough to become strong and under favourable conditions they can gather 10—15 Kgs. honey.

Most of subtropical fruit-trees are good honey plants : orange, lemon, tangerine, peach, olive, almond, quince-trees, and many more. They can provide an abundant nectar flow in southern districts.

Bees can collect important quantities of nectar from **leguminous and pumpkin crops.** One hectare under cucumber (colour plate VI, 3), melon, pumpkin, water melon (Colour plate VI, 7) can yield 25—30 Kgs. honey and the sugar-beet, cabbage, turnip cabbage, radish and early radish carrot seed crops can produce almost the same quantity.

Hayfields and Pastures as Nectar Sources. Natural hayfields and pastures cover 12 per cent of the area of the USSR. The most important for beekeeping are the hayfields whose total area exceeds 39 million hectares (by the beginning of 1973). Abundant honey sources are provided by subalpine and alpine meadows which offer an abundant and long nectar flow. The hayfields in dry valleys are highly important in zones without chernozem and with a relatively humid climate.

The main honey plants of hayfields and pastures are the legumes (white, alsike, and red clover, alfalfa, bird's foot trefoil) as well as representatives of the Compositae and Labiatae families, etc.

Relatively less important for bees are the marshy hayfields and the marshes, especially in the northern districts of the USSR, except pine-tree and peat bags where there are many good honey plants : cowberry, bilberry, red bilberry, tundra blackberry, heather, tundra ledum, herb bennet, etc. Usually they blossom late in May and at the beginning of June, providing a good maintenance nectar flow to bees. An important amount of honey is ensured in some zones by heather which blossoms in August.

Unfortunately the honey plants of hayfields are used only partially by bees since at the height of the nectar flow they are mowed.

The commons or areas good for orchards used for grazing provide similar honey flows. From the apicultural point of view the commons are less valuable because the honey plants are affected by the cattle trodding on them.

Honey sources provided by forests. Of the total area under forests in the world of three thousand million hectares, 1.1 thousand million is to be found in the USSR. Almost 800 million hectares of forests are to be found in the Asian part of the country, and about 200 million hectares in the European part. As much as 80% of the forests are of coniferous trees which are not important for beekeeping. The remainder of 20% consists pre-eminently of deciduous trees including highly valuable honey plants.

Very important for beekeeping are zones of felled or burned down forests. Here are to be found exceptional honey plants such as fireweed, raspberry, angelica, etc.

The most valuable forest honey sources are the lime, maple and willow trees, heather, willow herb and angelica.

Small-leaf linden tree (lime tree) (Tilia cordata Mill.*)* (colour plate IV, 2). This lime tree variety is to be met especially in the forests of Central Povolzhie, Ural and Priuralie. In the broad-leaved forests of the Far East grows the Amur lime-tree *(T amurensis* Kom.*)*, the Manchuria lime tree *(T. mandschurica* Kupr. et Max*)*, and the Taket lime-tree *(T. tacueta* E. Schm.*)*. Lime-tree is the most valuable source of nectar of all trees. The lime-tree forests cover about 2.5 million hectares in the USSR.

Lime-tree needs a high-quality soil and its development in forests indicates a high fertility of the soil. The areas having large lime-tree stands are famous since long for their developed beekeeping and their high honey crops. In Southern regions lime-tree blossoms in mid June ; in the central area — in the first days of July — for 12—14 days. In the Far East, where three lime-tree varieties are grown blossoming at an interval of 6—7 days from one another because of the varied relief, the flowering period lasts almost one month, 15—18 days being at its height. During the latter interval, the scale hive sometimes indicates a daily increase in weight of 24 Kgs.

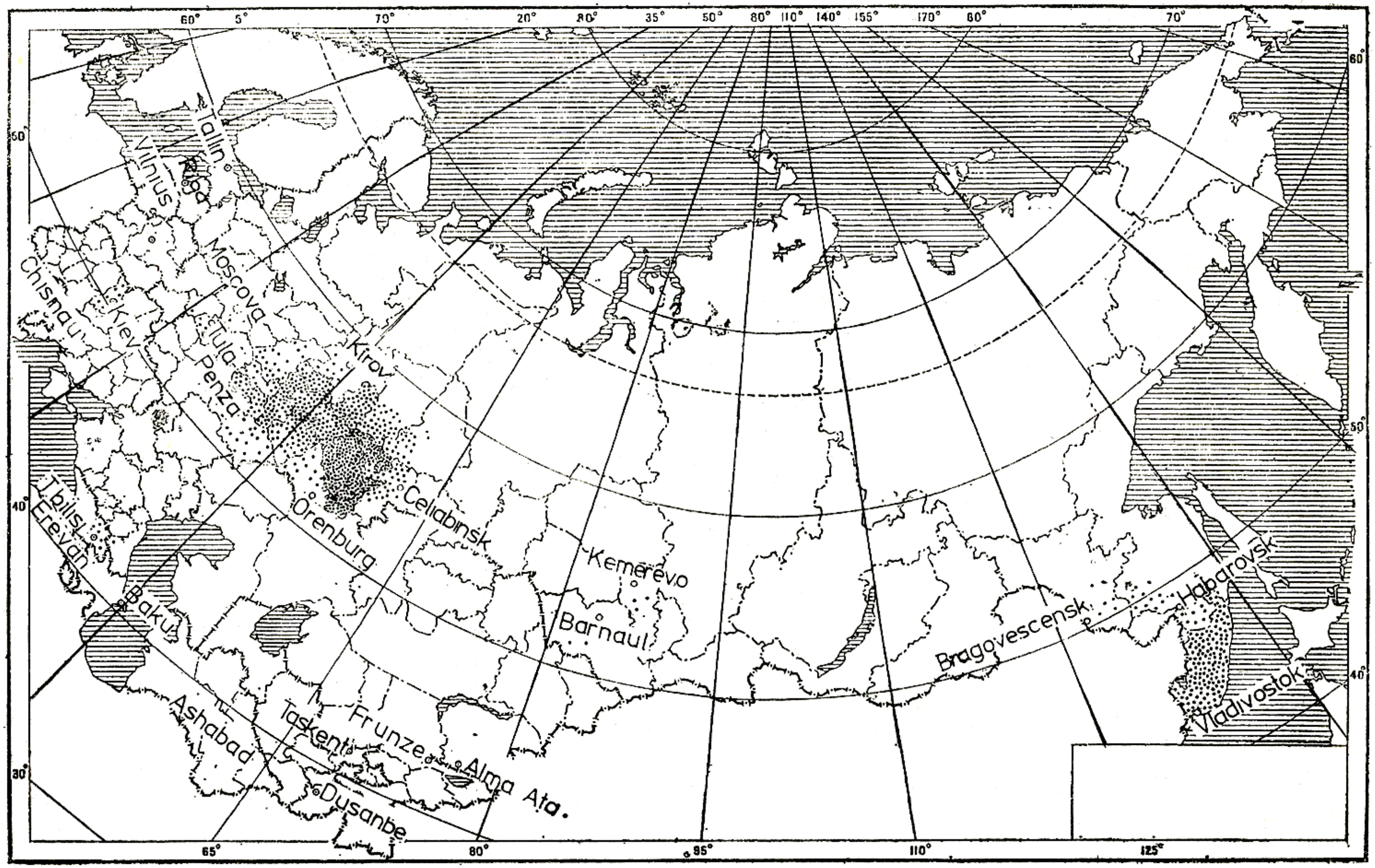


Fig. 33. Map of lime — tree forests in the USSR
one dot — 2000 ha

Nectar secretion of lime trees is abundant. The average honey production is 3—4 Kgs. per tree (a well-developed tree may yield 10 Kgs honey, and one hectare under lime trees — up to 1,000 Kgs. However the lime-tree nectar flow is not constant, because it is readily affected by weather conditions. Cold nights during blossoming as well as dry winds and drought substantially decrease or even suppress nectar flow. Abundant rains wash the nectar off the open nectaries. Pollen pellets of lime-tree flowers are pale green.

Norway maple (Acer platanoides L.) (colour plate IV, 7). It grows in the forests of the European part of the country, as well as in the forests of the South Urals and of Caucasus. North of Tula and Smolensk it is not found in large stands therefore it suffers because maple yields aproximately 200 Kgs of high quality honey.

In the family of maple tree very good for honey production is the Tartar maple tree *(Acer tataricum* L.). It is either a bush or a not too tall tree, rather unpretentious as far as growing conditions are concerned. It is spread over large areas and it blossoms in the second half of May or the beginning of June. It offers nectar and pollen to bees.

Willow (Salix) has about 170 species which are unpretentious as concerns soil and climate. Of the great variety of species the most valuable for beekeeping are the goat willow, long eared willow, laurel willow, and white willow. All species are valuable because they provide nectar flow early in spring when few or no honey plants are in flower.

Goat willow (Salix caprea L.) (colour plate IV, 1) is a bush or a 2 m — 6 m. tall tree. It blossoms in the second half of April and May. It is a very resistant honey plant. A hectare of plantation of goat willow produces about 150 Kgs of honey. From it bees also collect a large quantity of pollen, indispensable for the spring build up to the colony.

Willows of various species blossom at various times, ensuring the bees a continuous flow from the second half of April until June 5—10. First of all blossoms the red osier ; in the central zone it blossoms in mid April. In the last third of April the goat willow is in bloom, and by the beginning of May the long eared willow. White willow and osier blossom in the second third of May, while in the third — laurel willow in dump places and marshes. Marketable honey is also obtained sometimes in the areas with large willow stands.

Forest raspberry (Rubus idaeus L.) is a highly valuable honey plant growing in Siberia and Priuralie zones, and in the northern and central zones of the European part of the USSR. Raspberry develops very well in the areas of felled or burnt down forests. It blossoms about June 10—15, the flowering being at its height for three weeks sometimes. A hectare of forest raspberry yields about 200 Kgs. honey. The nectar flow is constant and in the zones with large plantations it assures the main flow. Pollen pellets of forest raspberry are whitish grey.

Fireweed (Epilobium angustifolium L.) (colour plate IV, 5) — a herbaceous honey plant growing in the zones of felled and burnt down forest with no chernozem in Siberia and Altai. On the place of a recently burnt down forest fireweed grows very well and secretes plenty of nectar in the first 4—6 years, then it is gradually replaced by forest raspberry and ninebark.

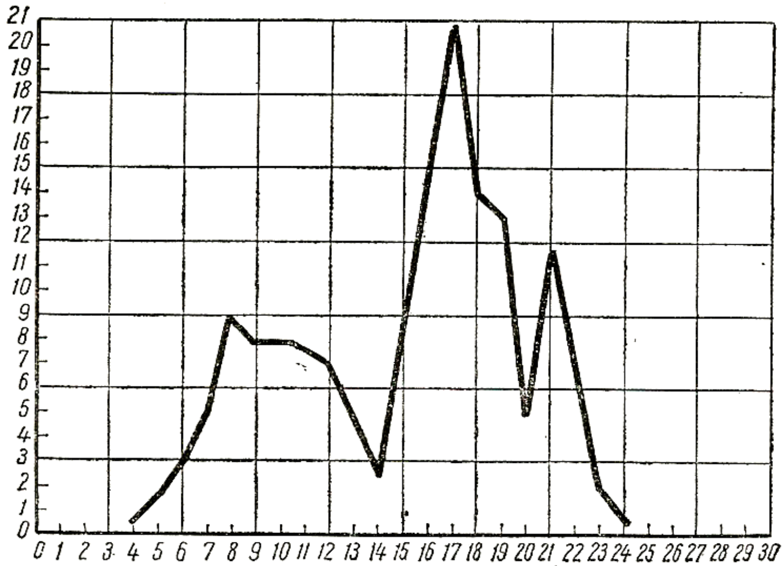
In the central zone of the USSR fireweed blossoms from the end of June until September ; it provides a rich nectar flow especially in July and in the first half of August. Fireweed is a highly valuable honey source. It ensures the main nectar flow in the areas under coniferous forests. One hectare of fireweed yields 300—350 Kgs. of honey. The daily intake in the scale hive (when fireweed is in bloom) reaches 12 Kgs on some days. A large amount of pollen is also collected from it. The plant is frequently visited by bees on warm weather with a sufficient humidity in the air. The best temperature for fireweed nectar secretion is 23—25°C.

Angelica (Arhangelica decurrens L.), is one of the best honey plants of taiga belonging to umbelliferae. It is spread in the Siberian taiga and in river meadows, in areas of felled down woods, forest glades and the skirts of the forests. Siberian angelica blossoms in the second half of June for two weeks. It best secretes nectar in the morning and evening hours. On the best days, the weight increase of the scale hive was of 5.5—6 Kgs.

Heather (Calluna vulgaris Salish.) (colour plate IV, 4) is a not too high ever green bush. The leaves are tiny and resemble those of coniferae. It is spread in the west, north-west and north European part areas of

Fig. 34. Lime tree blossom

Fig. 35 — Readings on the scale hive during lime tree flow
On the abscissa — 1978 July, in the apiary of the kolkhoze Spasski, Primorie ; on the ordinate — kg, on the scale hive



the USSR. It can be found in forest skirts, glades, in rare pine-tree forests, and on peat bogs where it sometimes forms compact stands. Heather blossoms from July till late in autumn. Bees visit it intensely in the first half of the day. In some districts in north and north-west, heather provides the main nectar flow. A hectare under heather can yield about 200 Kgs honey. Heather honey is dark and of low quality, has no aroma, and is slightly bitter. It is very dificult to be obtained in centrifugal extractors.

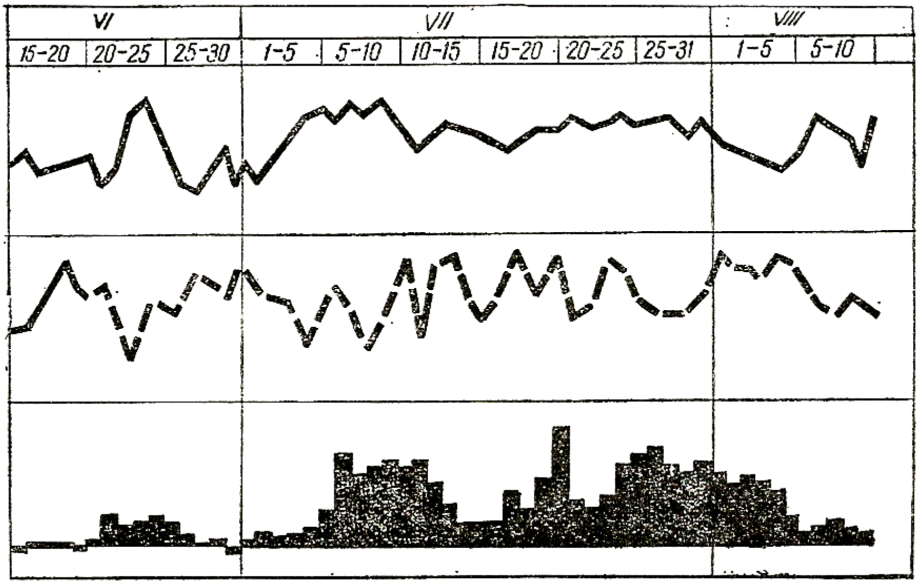


Fig. 36. Readings on the scale hive during nectar flows in fireweed, blueberry and forest raspberry

Estimation of the honey potential is highly important for a rational and planned use of the bee forage available. Unfortunately very specific and precise methods have not yet been developed for objective assessment of the honey resources of a certain area, because there are many factors which influence the growth, development and nectar yield of the honey plants, as well as their use by bees.

Appreciation of the honey potential of a zone is made by recording the major honey plant species and area covered by them, of their nectar yield and flowering periods.

Useful to this end are the maps illustrating the land use in farms, as well as those of tree and shrub species existing in forest zones.

Assessment of honey sources may be made of beekeeping farms (of sovkhozes or kolkhozes) or of single out apiaries. When estimating the bee forage available for an apiary one must consider that bees forage efficiently within a 2 Km-radius. This means an area of about 1250 ha.

Then, on the maps mentioned above, plots within the 2 Km radius are divided, and another division is made according to the honey sources available (as indicated in the land use maps) — farm crops, orchards, hayfields, forests, and areas under rotating crops. Next the areas under various forest honey sources (lime, maple, sweet chestnut, raspberry, etc.) are marked, according to the relevant maps.

Where no maps of forest species exist, the major honey plant species must be precisely established. To this end, one must record the number and species of trees in a 2—4 sq m area, counting them in 8—10 directions, in straight line. From the figures obtained, the percentage of various species and area covered by each of them are calculated.

In order to appreciate the honey plants in hayfields and on other grounds, one must delimit small plots of 1 m × 1 m on a diagonal line, every 100 m, on which the number of plants, the major honey sources included are recorded. Summing up the data obtained from all plots one can determine the percentage of each honey source and the area covered by each.

Let us assume that on a forest area 1,000 trees were recorded, of which 200 lime-trees and 50 maple-trees. Lime-tree represents 20% while the maple tree 5% out of the total number of trees in the forest. It results that in an area of 200 ha of forest, lime holds 40 ha, while maple tree 10 ha.

The same method is used for determining the major honey-producing plants in hayfields.

The data concerning the areas under honey farm crops (buckwheat, sunflower, pasture shrubs, etc.) can be taken from the production plans of state or collective farms. The honey production of each and every plant species is determined on the basis of the indications in page 119, not losing sight of the necessary corrections according to the local conditions (soil, climate, peculiarities of the respective variety, farming methods used, etc.).

On the basis of the existing honey plant species and the area covered by them one can determine the honey potential available for each out apiary of the respective beekeeping farm, specifying the areas of individual plots, the species and areas under certain honey plants, their nectar productivity and the peculiarities of the nectar flow.

Table 8 exemplifies how is determined the honey potential of an apiary in the forest-steppe zone.

Table 8

Honey potential of the apiary

Type of bee pasture and area	Honey plant species	Area of efficient foraging by bees (ha)	Nectar yield (Kgs/ha)	Total	Type of flow
Forest — 300 ha	lime tree	40	700	28000	main flow
	Norway maple	10	175	1750	early spring flow
Hayfield — 80 ha	white clover	10	80	800	,, ,, ,,
	alsike clover	4	100	400	summer flow
	combined legumes	6	50	300	,, ,,
Field crop rotation — 700 ha	buckweat	50	60	3000	main flow
	fodder crops	20	20	400	late summer flow
Orchard — 30 ha	apple tree	10	25	250	early spring flow
	morello cherry	5	20	100	
Shrubs — 20 ha	raspberry	4	50	200	,, ,, ,,
Vegetable garden — 30 ha	cucumber	4	25	100	,, ,, ,, late spring flow

In the above-mentioned example the honey potential within the bees' efficient foraging radius is of about 35.3 thousand Kgs, distributed as follows: in spring — 3.1 thousand kgs, in summer — 1.1 thousand kgs., and during the main flow (lime-tree and then buckwheat — 31.0 thousand kgs.

Each and every colony consumes about 90 kg. honey the year round. Let us admit that one expects each colony to yield 25 kgs of marketable honey. Consequently about 115 kgs honey will be collected by each colony. Account must be however taken of the fact that the honey potential of the region is not fully used by bees because of unfavourable weather conditions or of bee colonies, and of a number of other factors. Usually bee colonies are considered to be able to efficiently forage almost half of the honey potential of a region, which in the case in point would stand at 17,650 kgs. In conclusion, to determine how many bee colonies can be kept in the respective area, one must divide 17,650 kgs to 115 kgs (the necessary amount of food for each colony plus the marketable honey).

It results that 153 bee colonies can be profitably kept in the respective area.

Bee colonies are most abundantly provided with nectar during the main flow — of lime and buckwheat. It is from these sources that they will produce the surplus honey as well as the food stores for the autumn-winter and spring periods.

Nectar productivity of several plant species (kg/ha)

Black locust (false acacia)	300—600	Red clover	10—200
Laburnum (pea shurb)	100—150	Norway maple	150—200
Pumpkins	10—30	Coriander	150—200
Fodder leguminous plants	15—25	Small-leaf lime	600—1000
Heather	150—200	Non-irrigated alfalfa	25—50
Honey locust	200—250	Irrigated alfalfa	250—300
White mustard	100—150	Raspberry	150—200
Buckwheat	50—150	Fruit trees	20—30
Melilot	200—500	Sunflower	30—60
Willow	100—150	Rape	40—50
Ambary hemp		Blackthorn	25—30
(Kenaf hibiscus)	40—50	Phacelia	150—200
Fireweed	350—500	Common sage	400—600
White clover	75—100	Esparsette	100—400
Alsike clover	100—150	Berries	25—40

Worth mentioning is that the figures recorded on the scale hive do not always reflect the real situation. Highly important for determining the honey sources available in various areas are the indications provided by scale hives and results obtained in several years in apiaries under similar conditions. The records of scale hives and phenological data — concerning flowering periods of major honey plants indicate how heavy is one or another flow and how long it lasts.

A scale hive ought to exist in each and every apiary. When bees are ready to start activity in spring a hive with a strong colony must be put on scale. Weight values are recorded every day, in the evening, when bees cease flights. The differences in weight of the hive show the efficiency of the flow. When no nectar flow is available, the weight of the hive decreases.

A daily increase in weight of 250—300 g of the scale hive in spring indicates a poor maintenance flow, of 500 g an average flow, and of over one kg — a good flow. A main, averagely abundant flow provides for a surplus of 2—3 kgs., while a good one — of 5 kgs or more.

The daily weights of the scale hive are registered in the record book of the apiary, just as the weather conditions, how have bees foraged, and what major honey plants are in flower.

The data of the record book are plotted in a graph illustrating the intensity of flow throughout the season.

Account being taken of the food stores collected by the bee colonies, and of the data recorded with respect to the honey plant species available and of how heavy is the flow, measures apt to improve and rationally use the bee forage are decided upon.

Improvements of the bee forage of beekeeping farms must be made so as to meet the interests of the farm and according to their main spe-

Table 9

Record card of the scale hive of the beekeeping farm of the sovkhoze

Apiary No.

Month and day	Weight of the scale hive (kgs)	Changes made by the bee-keepers	Figures recorded for the scale hive in 24 hours		Temper-ature hours			Weather conditions	Flight activity of bees	Honey plants in flower
			Inc-rease	Dec-rease	7	13	19			
June 4	60.2	—	—	0.1	12	20	14	Cloudy, windy, rain at 16.00 hrs.	weak	raspberry
June 5	62.2	A 12 kg super was added	2.0	—	16	24	17	clear sky, slight wind	good	bees foraged on raspberry and white clover

cific production branches. Large possibilities now exist for intensification and chemicalization of farming and for expanding the areas under irrigated crops.

In most forest and mountain districts of our country, with rich honey sources, the main problem is how to use best the honey sources available. In some southern districts of the steppe and forest-steppe zones with relatively scarce wild honey plants, many apiaries do not avail the necessary bee pasture. There, attention ought to be focused on improving the honey sources, by :

1. Expading *entomophilous farm crops* by crop rotation — buckwheat, sunflower, coriander, white mustard, melilot, alsike clover, alfalfa (especially on irrigated areas) etc. — and use of better farming methods. Likewise, one must not loose sight of the fact that for increasing nectar production of these crops phosphorus and potassium fertilizers are highly important, as well as irrigations in the districts with irrigated farming. Cultivating honey farm crops (buckwheat, sunflower, white mustard) in various periods, one can prolong the nectar flow period and increase the efficiency of their pollination by bees.

Highly important for raising the yield farm crops is the introduction of varieties with abundant nectar secretion, which as a rule yield large crops. Also very important is to provide for a flow in between the blossoming period of orchards and that of sunflower and buckwheat. To this effect crops such as white mustard, phacelia, combined with peas and vetch are recommended to be cultivated. In some farms honey plants are alterned with maize.

In southern districts with long vegetation period one can prolong the nectar flow till late in summer, by sowing honey plants in stubble fields. After the nectar flow is over, they are harvested for seed production or used as green manure. Conditions for widely cultivating buckwheat in stubble fields are available in Central Asia, Transcaucasia, Khazakhstan, Northern Caucasus, the Ukraine and Moldavian SSR.

A number of farms in the USSR pay a great deal of attention to improving bee forage according to main agricultural branches of activity.

In one of these farms "The 22nd CPSU Congress" (Vershadski district, Vinnitskaia region), the honey crops are peas combined with alfalfa (1.5 kg seed per 1 hectare), the latter being also sown in the maize fields. Buckwheat and sunflower also contribute to the honey sources of the kolkhoze farmers reported that when phacelia was cultivated together with peas, it drove away, by its smell, the peas weevil and as a result the damage it caused to peas decreased to half.

So, a good bee forage was provided for, the entomophilous crops were pollinated by bees, high yield of buckwheat, sunflower and peas was obtained and the farm benefited from marketable honey.

2. *Use of legumes as fodder for animal breeding.* It is commonly known that in many regions of the USA, New Zealand and in a number of other countries the main honey sources include fodder leguminous crops (clover, melilot, alfalfa). The experience of many apiaries in the Baltic Republics, Siberia, Kazakhstan and Altai confirms the efficiency of leguminous plants, especially of the melilot on salty soils. This plant produces a large quantity of green manure, rich in proteins, which enriches the nitrogen content of the soil being at the same time a valuable honey plant.

In the "Pobeda" Kolkhoze (Shipunovski district, Altai region) melilot was planted on hayfields in addition to the naturally growing plants. As a result, the farm harvested more hay, and bee colonies were provided with more abundant and more regular nectar flows for 4—5 weeks.

For improving the quality of hayfields and pastures, both at the surface and in deeper layers, white and alsike clover, bird's foot trefoil and alfalfa are recommended; the amount and quality of the green manure increases and improves, and at the same time nectar production of these crops rises. Very efficient is also the administration of phosphorus and potassium fertilizers (2—3 g of superphosphates, and 1 q of potassium salts per 1 ha).

According to the data reported by the Bee Research Institute (N. I. Burminstrov) the nectar production of meadow hayfields in the Riazan region has increased by 64—94% as a result of using mineral fertilizers.

Alsike and red clover is advisable to be sown in the sufficiently humid areas. Nectar production increases accordingly and the bees visit more frequently the seed red clover crops, this fact being at the same time conducive to a heightened seed output.

3. *Nectar-yielding fruit trees and shrubs planted* in protective belts and for afforestation, for preventing soil errosion, along roads and in public places, in living hedges around apiaries, gardens and farms.

In the central area of such plantations lime-tree, Norway maple, laburnum, as well as various willow, hazel-nut and fruit tree species, raspberry, black currant and other honey sources must be included.

In the southern regions of the country one may use false acacia, chest nut, blackthorn, cork elm, mirobolam, fruit trees, common maple, tartar maple, as well as other trees and shrubs. Concurrently with their plantation, the existing plantations must be taken care of and protected.

For improving bee pasture one can also cultivate farm honey crops (buckwheat, phacelia, white mustard) in the orchards. Function to local conditions they can be used either for seed production or as green fodder after their blossoming is over.

For rationally utilizing the honey sources available, increasing the productivity of bee colonies and efficiently pollinating farm crops, highly important is the migratory beekeeping. Even within the limits of the farm there are usually abundant honey suorces which blossom in various periods, located at various distances from the apiary. They, as well as the orchards and the shrubs which flower at the beginning of spring, the legumes in the hayfields which blossom later on, the sunflower and buckwheat crops, the thickets of fireweed, raspberry, and the lime-tree strands are abundant honey sources in the forest districts.

In order to plan the moving of colonies to the massifs of honey plants before the season begins the local conditions and the peculiarities of the honey sources available must be considered for more rationally and efficiently using bees for pollinating farm crops, and for obtaining higher honey production. Transport facilities must be provided for. Hives can be moved within the limits of the respective farm, district or region. Lately, many farms in this country and abroad (especially in the USA) practise large-scale moving of colonies to about 2,000—3,000 Km (and even more) to various nectar flows.

In our country for instance, after the pollination of orchards in the Krasnodar region, bee colonies are transported to the Krasnoiarsk, Kirovsk and other northern regions on fireweed and raspberry (in "Mikhailovskii pereval" and "Sad-ghigant" sovkhozes).

Moving of colonies to nectar flow is not required only for obtaining surplus honey and for pollinating farm honey crops. In many districts it is advisable to move them to honey flows of wild plants which blossom early, for their spring building up and their becoming stronger (for instance in the forests of pre-alpine zones of the Caucasus). Sometimes migratory beekeeping is practised for using the honey plants which blossom late, for the colonies to collect honey stores for winter.

The experience of several years of profitable beekeeping farms and of numerous other countries has shown that a rational migratory beekeeping is one of the main means of increasing the efficiency of apiaries and reducing production costs.

BEE REARING AND MANAGEMENT METHODS

FACTORS ON WHICH VIABILITY AND PRODUCTIVITY OF BEE COLONIES DEPEND

The productivity of the bee colony, the bees' capability of overcoming unfavourable conditions depend on many interrelated external and internal factors. In the process of evolution of honey bees, complex relationships have been developed within the bee colony on the one hand, and between the colony as a biological unit and the environmental conditions on the other hand.

The main concern of beekeeping as an agricultural branch is to control the factors influencing the productivity and viability of the bee colony towards obtaining maximum productivity with minimum labour and costs.

Productivity and viability of the bee colony are influenced by the main factors. Preeminent in this respect are the environment conditions — the climate and weather, flora and fauna, honey sources, useful and harmful, organisms to the bee colony. Man is rather unable to control most of these factors or when this is possible it entails too large expenditure being unprofitable economically. The environmental conditions have an over-riding importance for the activity and productivity of bee colonies and they must lie at the basis of rational distribution and specialization of beekeeping. In addition to this, honey sources can be improved, especially in the areas with intensive agriculture, measures can be taken for most efficiently exploiting them (moving bee colonies to close flows), and bees can be protected from the damages caused by living organisms (by prophylactic measures and by controlling pests) also by taking account of the environment conditions.

The second group of environmental factors influence the activity of the bee colony as an integral unit. They include combs, processed food stores, temperature, humidity, and ventilation which are all under bees' control, as well as useful and harmful living organism which live in the colony. These factors are highly important for the productivity of the bee colony and they can be controlled by man to a large extent. Ensuring the colony abundant food and foundation is one of the decisive conditions of increasing honey production.

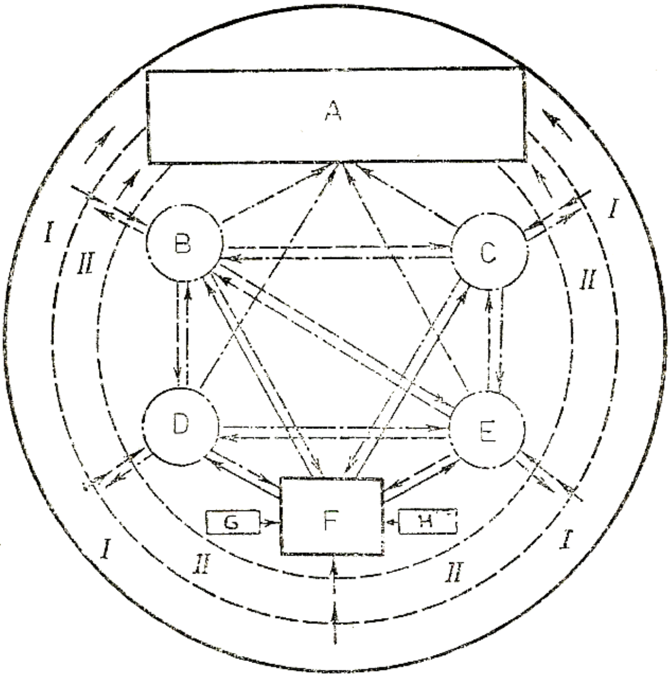


Fig. 37. The influence of various factors on the productivity and viability of the bee colony as a biological and economical unit :

I — external conditions (climate, weather, honey sources, harmful and useful organisms) ; II — conditions in the nest (food stores, combs, temperature and aeration, humidity, living organisms); A — Productivity and viability of the bee colony ; B — queen ; C — number of bees ; D — quality of bees ; E — age group of bees ; F — instincts and reflexes determining the functions and behaviour of individuals ; G — instincts and reflexes determining functions and behaviour of individuals and of the colony as a biological unit ; H — queen's father ; I — queen's mother

Of these internal factors the most important for nectar collecting and surviving of the bee colony is the number of bees in the colony. The larger the number of bees in a colony, the higher the honey crop and the weight. Stronger colonies do no only gather more honey but also the production per fresh weight of such colonies is higher than with medium and weak colonies. Strong colonies rear larger bees with bigger honey sacs and longer proboscis. They live longer than the bees of medium and weak colonies. Finally strong colonies require management work.

Of cardinal importance is the age of the bees in the colony, as well as the predominant instincts and reflexes, which determine the behaviour of the bees and of the entire colony. It is very important for the colony to have much brood and many young bees during the build-up period, as well as many foragers during the nectar flow. Uncontrolled swarming instinct entails great and unprofitable labour expenditure. Therefore, preventing natural swarming and its replacing it by artificial multiplication of colonies is one of the major requirements in controlling bee colonies.

The prolificity of the queen and its hereditary qualities which are transmitted to her offspring are highly important for the activity and efficiency of the colony. The larger the queen and better developed its ovaries, the higher her prolificity and performance of her colony. It is necessary to take into consideration the fact that through the eggs and spermatozoa in her spermatheca the mated queen, transmits to their descendants the hereditary qualities which determine their specific quality, and the response to the external conditions of both the individuals and the bee colony as a whole. Also, it is on the account of the nutritive substances in the egg, produced by her body, that the embryonary development of bees takes place. This makes the part played by the queen in the activity and productivity of the bee colony even more substantial. In practice, for controlling the activity of the bee colony towards increasing its efficiency, it is necessary to take into account the interrelation of the various factors influencing the productivity, the unity, and survival of the bee colony.

Following investigations for several years and data recorded, a number of rearing and management methods have been devised, directed primarily to raising apiary and labour productivity, as well to reducing production costs.

HANDLING OF BEE COLONIES

For correctly controlling the activity of bee colonies for profitable beekeeping operation the apiarist must know their condition ; this is possible by regular inspection of colonies.

But utmost care should be taken, because any inspection in the nest, of whatever extent, disturbs the colony, negatively bearing upon bees' work. Therefore the number of inspections and their duration must be reduced to minimum, lest the bees should be too much disturbed.

When inspecting the colony, one must disturb it as little as possible, lest the bees should become aggitated and sting. When inspecting the nest, the outside temperature must not be lower than 11°—12°C. During a not too abundant nectar flow, when it is warm and the sky clear, bees are less vicious. In spring, inspections are better to be made in the warmer period of the day. By the end of summer, when the nectar flow is over, colonies must be inspected in the morning hours or in the end of the day (when cooler). In order to shorten the inspection, all necessary materials and tools — the smoker, bee veil, hive tool, working box, wired foundation, frames, super frames, etc. — must be at hand. The beekeeper must put on a light-coloured overall. One must not forget that wool cloths as well as those of dark colour, strong smells and brisk movements irritate the bees and incite them to stinging.

To subdue the bees smoke is used ; under its action bees fill their honey sacs from the food stores, becoming calmer and less inclined to sting. This response to smoke is a consequence of bees having lived in forests where smoke always meant fire which destroyed their nests. The instinct of filling their honey sac when smoked is highly important for the preservation of the species, since it enabled the bees to hive a few days in a new place and to build a new nest. The smoker produces the necessary smoke.

The bee veil protects the face against bees' stings. The southern bees — especially the Carpathian and Caucasian bees are less vicious and that is why on fine weather one may inspect the nest without smoker and bee veil, which is impossible with northern bees.

When inspecting the hive, the beekeeper must not stay in front of the hive entrance since this irritates the bees and hampers their coming in and getting out. The apiarist must stay on one side of the hive, if possible on the sun-lit one. Thus, light falls on the frames and they are easier to be inspected. After having removed the hive cover and the insulating material (the quilt), a corner of the crown board (cloth or wood lath) should be raised and a few squalls of smoke be blown over the frames to drive away the bees from the top bar of frames. When the bees are very vicious and irritated, or when the inspection is undertaken in unfavourable weather conditions, before opening the hive one must blow smoke through the main entrance and wait for 30—40 seconds for the bees to fill their sacs with honey, and then one may proceed to checking them as usual. Only 2—3 frames must be taken out at a time. After checking them and putting them back into the hive, other frames are taken out while the others are covered with cloth and crown board. Frames must be held above the hive in vertical position. Otherwise the queen or bees may not fall in the hive but on the earth and the queen may be lost. When held horizontally, especially on warm weather, combs may bend, break and detach from the frame and the liquid nectar may leak in drops from the cells of the lower part of the comb.

When looking for the queen, one must produce less smoke lest the bees should become excited and leave the frame. In this case, one must thoroughly examine all frames, paying special attention to combs with recently laid eggs where the fertilized queen is usually to be found.

When it is necessary to take the frames out of the hive, they must be taken out together with the bees on them and be introduced into a box with lid. When the inspection is over and the nest is in order again, the bees of the frames taken out are shaken in the free space between the queen excluder and the outermost frame. For this, the frames are held with both hands by their lugs, are kept half way in the hive, and bees are shaken off with several sudden and short moves. The bees which still remain attached to the comb are removed by brush, a small broom or by a goose feather.

Bee colonies *must be inspected most carefully during flowless periods* in order to prevent robbing. When there is no nectar flow robbers try to penetrate into a foreign hive not only by the main entrance but also through the splits in the walls; they fly round the hive attempting to enter it. If preventive measures are not taken robbery, which is first imperceptible, may extend to many colonies and cause honey loss.

Robbery is much easier to be prevented than to be eliminated. Therefore, strong colonies must be kept in the apiary and queenless or weak colonies should be brought to normal condition. Shallow frames and those with food stores as well as any equipment smelling of honey must be in places out of bees' reach. During flowless periods hive entrances are reduced function of the strength of the colony, to 2—6 cm., and the slits in the walls or where various hive parts do not fit snugly must be carefully plastered. Bees must be fed in the evening when they cease flying; spilling food on hive walls or on the ground must be avoided. In the flowless periods, colonies must be inspected in the evening when bees no longer fly heavily. When it is necessary to check

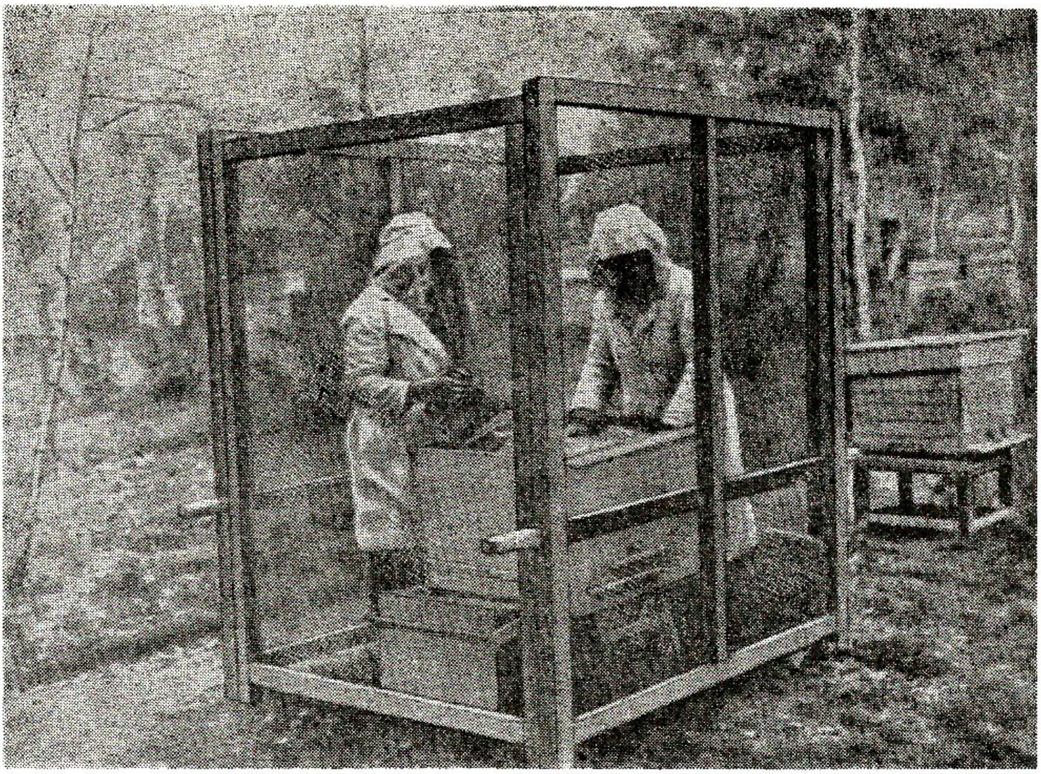


Fig. 38. Cage allowing the control of the colonies during dearth periods

them at an earlier hour special tents (cages) with gauze or wire cloth must be used.

If in spite of preventing measures robbery still occurs, then the hive entrance of the robbed hive shall be reduced so as to allow for the access of only 1—2 bees at a time.

The hive entrance can also be plastered with clay and a hole for bees made in it with a pencil. Sometimes the flight board and walls around the hive entrance would be sprinkled with kerosene. If robbery still continues and becomes heavier, the hive concerned must be moved to a cool place (cellar, bee house) and left there for 1—2 days ; an empty hive will be put instead. The moved hive is brought back after one or two days.

SPRING OPERATIONS IN THE APIARY

When the first honey plants are in blossom and spring sets in the active period of the bee colony starts. After the cleansing flight, the queen gradually increases its egglaying : with every passing day the brood nest expands and the number of young adult bees is greater. During the first 4—5 weeks of spring, the over wintered old bees die and are replaced by young ones. The spring build-up of a colony determines to a large extent its efficiency in collecting nectar and in pollinating farm crops. The main concern of the beekeeper is to keep his bees in good condition and to provide them with the best food supplies — with the aim of their heavy build-up.

The beekeeper must prepare in due time for the spring operations such as inspection of hives, preparing necessary equipment and tools, preparing the necessary frames and wiring them, buying new foundation, making and repairing the insulating materials used in winter, and the hive stands. Likewise, before taking out bees' from the cellar, the location of the hives in spring must be cleaned.

Location is recommended to be a garden, at a certain distance from populated areas and animal-breeding farms. Locating apiaries close to large water sources, rivers and lakes is not advisable. The apiary should be sited in a dry place, sheltered from cold winds. It ought to be surrounded by a fence (to protect hives from wind and cattle) or better by nectar-yielding shrubs. Also advisable is to have some shrubs or trees which help bees to orientate ; at the same time, their shade is welcome in summer.

The location should be also prepared for the hives: cleaning the dirt and snow, laying the stands so as to have the hives slightly inclined forward to permit the rain water to run out of the main entrance. At the same time a drinking place for bees must be provided for.
and a scale for the control hive. If the bee colonies wintered in the open, when warm days come hives should be cleaned from rests of snow as well as the main entrances for facilitating the bees' flight. The outside packing of hives must not be removed until the stable warm season has set in.

Handling colonies after wintering. After wintering in good conditions colonies are placed on the outside location when the first honey plants blossom (colt's foot, hazel tree) and the air temperature in the shade rises up to 12°—13°C. On the contrary, when wintering was poor and bees were disturbed, they must be taken out of the cellar as early as possible, sometimes ahead of term. The future location of the apiary is cleaned from snow (to speed up thawing we must spread ashes) and when relatively warm days come (air temperature in the shade +7°—+8°C) the hives are taken out and located on their places. The bees must be taken out the cellar early in the morning so that at about 10—11 o'clock all hives are in position.

Hives are taken out with main entrances closed. The are set on a special cart, their main entrance facing the beekeeper who drives the cart so that they can be observed. When all hives are on the location and bees get quiet, the main entrances can be opened. On fine weather all bees fly out of the hive and perform the cleansing flight, discharging the faeces accumulated in wintertime.

It is necessary to check the cleansing flight since it is the first indication of the colony's condition. In strong colonies, which wintered in good conditions the bees come out all at once from the hive and leave the flight board immediately. The colonies which wintered poorly, those affected by Nosema disease, queenless and weak colonies, perform a less energetic cleansing flight and some bees move along the flight board and the front wall, staining them with feces. There may be also hives from which no bee come out — either the colony died during wintering or the main entrance is blocked by the great number of dead bees. Such colonies as well as those which performed an unsatisfactory cleansing flight must be first and foremost observed and inspected, and they must be given urgent assistance. It is recommended to inspect them in the very day of the cleansing flight without, however, disturbing the brood nest too much. Suffice it to take out a part of the crown board, and 2—3 marginal frames to assess the condition of the colony : its strength, stains of diarrhoea, food stores and the brood. After inspecting the colony, urgent measures for removing the shortcomings must be taken. For the large commercial apiaries such a general spring checking of all colonies is recommended, which can be done in all apiaries. Another general inspection is advisable to be also made before the main flow, and when the foraging season is over (before preparing the colony for wintering).

The general spring checking is made for knowing the condition of bee colonies before the beginning of the active period, and for providing for favourable conditions for their subsequent development. When inspecting each and every colony, one must appreciate its strength (number of combs completely covered by bees), the amount of brood (expressed as "combs"), food stores, the brood nest (dry, stained by diarrhoea, number of dead bees). The registered data during inspection are noted down in the apiary record. They are fundamental in attesting the condition of the apiary in spring.

The general spring inspection of the colonies must be undertaken in the first warm days after the cleansing flight. It is not necessary to open the whole nest, thoroughly examine each frame, to look for the queen and to clean all frames. The amount of bees as well as the amount of brood and food stores may be roughly estimated, by slightly removing the frames and weighing them with both hands (not necessarily taking them out). If the examination evinces normal brood this means that it is queenright. Likewise, it is not recommended to waste time with scraping the wax and propolis of frames.

The shortcomings noticed at the spring inspection must be immediately eliminated. The colonies with scarce food stores should be given frames with honey and bee bread so that each should have at least 8—10 kg honey and 2—3 frames with bee bread. The combs which are no longer fit for the colony (stained with faeces, old, burr, drone combs, etc.) must be replaced with new combs. In order to save labour it is advisable to prepare the necessary number of combs with food as well as new ones in due time and to put them in a closed box.

The beekeeper must also have at hand an empty box for the frames he takes out the hive, in order to be able to replace and add the necessary number of frames on the spot.

When controlling the multiple-storey hives, the beekeeper must remove the bottom body (free from bees if they wintered in two bodies),

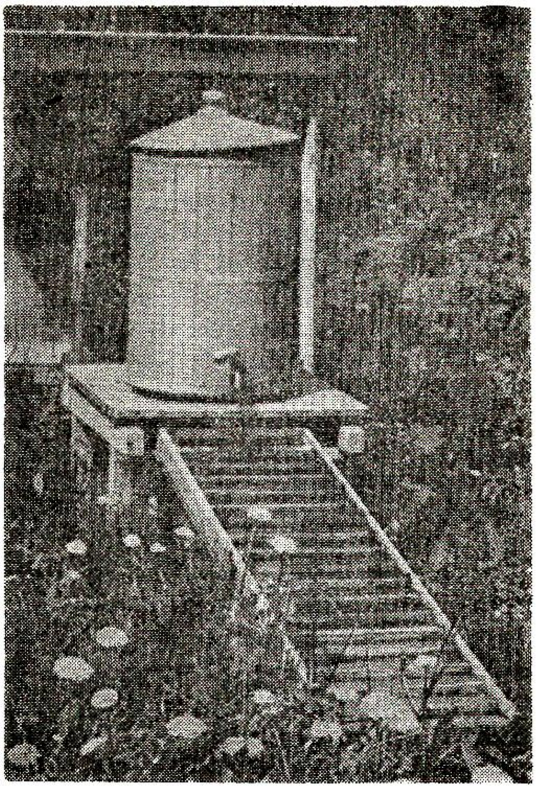


Fig. 39. A drinking place in the apiary

and put the top one, containing food stores,on the bottom board. If bees have not all moved to the top body the colony is left in both bodies.

The spring general inspection is a good opportunity for cleaning the bottom boards as well as for disinfecting the hives. If the bottom board is removable (the case of 12-frame hives as well as these with two or more bodies), after inspection the hive is placed on a new bottom board and the old one is cleaned of waste and dead bees ,and disinfected (washed with an alkaline solution or slightly sterilized at the flame of a welding apparatus), after which it can be used for another hive. In long hives (with fixed bottom board) one must first clean the part with no frame above, then the frames are moved above it.

If the hive is very dirty with faeces, especially in the case of Nosema disease, the colony is moved into a new hive or into a sterilized one and the dirty hive must be cleaned and sterilized.

Handling poorly overwintered colonies. When colonies were prepared for winter and overwintered well, as a rule there are only a few colonies which need an urgent assistance in spring (food supply, introduction of queens and strengthening the colony). However, if the spring inspection shows the existence of poorly — overwintered colonies, urgent measures must be taken for bringing them to normal condition.

Providing for normal conditions in queenless colonies is a task which cannot be postponed because such a colony is doomed to perish.

The overwintered old bees of a queenless colony would die 5—6 weeks after the cleansing flight and without help the colony will gradually die. The queenless colonies cannot defend their nest and they constitute an easy prey for robbers and often the source of infectious diseases. They collect less pollen and nectar and sometimes they do not build combs. If the queenless colony is strong enough it is supplied with one of the spare mated queens, which are maintained in nuclei. Before introducing the queen the beekeeper must be sure that the colony is really queenless : the control frame with eggs and young larvae is introduced into the hive. The queenless colony will build emergency queen cells on this frame — a relevant sign of queen's absence.

The caged mated queen is introduced into the colony after all the emergency queen cells are destroyed.

There is no use to wait for a new queen to hatch from an emergency cell because as a rule it is of a poor quality and early in spring it cannot mate because of the absence of drones. The bees of the weak, queenless colonies must be introduced into a colony or into a nucleus with a vigourous, mated queen.

Strengthening weak colonies: under good conditions of feeding and management such colonies must not exist in the apiary. If the weakness of the colony is due to the poor quality of the queen, it is advisable to kill the queen and to move the bees into a strong colony, with a good, mated queen. If the weak colony is headed by a young prolific queen, it must be strengthened on the account of queenless colonies and supplied with 1—3 frames with sealed brood.

Protection against cool and spring dwindling is highly important for the development and efficiency of the bee colony. During the buildup period, when brood appears, a temperature of about 34—35°C is maintained in the nest. Because in spring the air temperature is much lower and sudden changes frequently occur, the maintenance, in the nest, of this high temperature, more or less constant, requires a great consumption of food and energy from bees. The stronger the colony the less the consumption of food and energy necessary for maintaining the necessary temperature.

According to the data of the Institute of Bee Research a 2 kg colony produces 12.2 Kcal/hour when rearing brood, while an 1 kg colony — 18.6 Kcal/hour and a half a Kg colony — 27.8 Kcal/hour. Thus, for maintaining the necessary temperature in the nest a weak colony produces almost 2—3 times more warmth per unit of live weight.

It is very important to restrict and to insulate the nest in spring. On cold weather, especially in spring, the hive must have as many combs as the bees can cover (about 200—250 g bees for a comb). The extra combs, which are not occupied by bees, must be taken out and the free space may be filled in with insulating material (side cushions, straw quilts). Relevant experiments made at the Institute of Bee Research (V. A. Temnov) showed the great importance of hive insulating and restricting the nests for diminishing the consumption of warmth and food.

Energy losses at various degrees of hive insulation (Kcal/h for 1°C difference between the inside and outside temperatures).

Single walled hive, with no insulation	3.61
The same hive with top insulation (9.5 cm thick)	2.49
The same hive, with nest restricted to 8 frames and side insulation	1.69

For top and side insulation one can use sack cloth filled with insulating material. The top cushions are 10—12 cm thick and they are sized so as to cover well not only the crown board but also the top ends of the side walls of the hive. Lateral cushions must adhere well

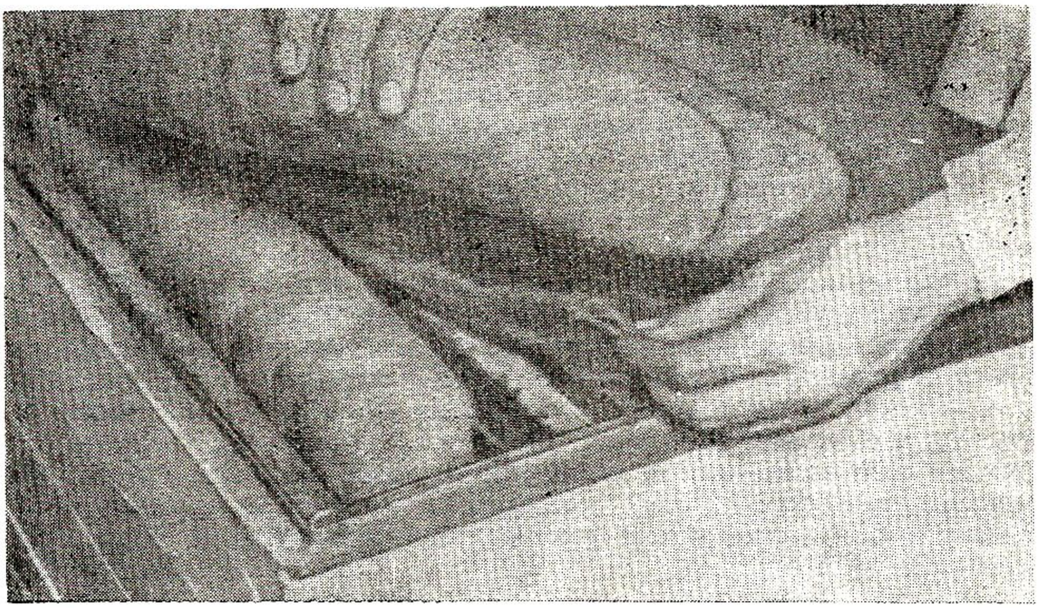


Fig. 40. Thermic insulation in spring

to the interior and bottom of the hive. Straw quilts are used for hive insulation in southern districts. Very appropriate for this are the synthetic lining materials (expanded plastic material for instance). They are light, hygienic and they may be readily obtained from the residues of the chemical industry.

Stimulating feeding is often recommended for stimulating the queen's egglaying, when there is no nectar flow. In this case the colony is given daily or every two days not too large portions of sugar syrup or honey (200—300 g.). Some beekeepers replace stimulating feedings with uncapping the marginal honey frames of the hive. Sometimes people resort to feeding bees with pollen supplement (yeast, milk, flour, etc.). or with a mixture of honey and pollen. These methods are commonly used in small apiaries of amateur beekeepers, but are not widely applied in large beekeeping farms of the kolkhozes and sovkhozes, since they are labour consuming and not rewarding economically.

According to data supplied by the experimental apicultural station of Kemerovo, the daily stimulating food (200—300 g honey syrup) was not conducive to increasing the amount of brood reared in spring. The periodical uncapping of honey in the marginal frames increased the brood rearing by only 8%. The spring stimulative feeding yields good results for strengthening bees for other honey flows in the country's sorthern districts.

For a heavy build up of colonies, abundant honey and pollen stores must exist in the hives. Also, in spring, apiaries must be placed close to some honey plants with early bloom, or moved to districts with early moderate flows and measures should be taken for improving the honey sources.

Expansion of the nest. Two or three weeks after the spring check up of bee colonies, as the amount of brood and number of emerging young bees are increasing, the necessity arises of expanding the nest and adding extra frames too. The stronger the colony and the more prolific the queen, and the better the weather conditions and the greater the nectar and pollen intakes — the soonest must the nest be expanded lest it should hamper the growth and development of the colony. For the first period when there is no nectar flow, the nest is expanded by adding 1—2 light brown combs, which are placed between the last brood frames and the honey frames. As soon as they are accepted by bees, extra frames are added, in the same places. When the warm weather sets in and a nectar flow, even slight, appears, the nest is expanded by means of foundation which must be previously prepared. The foundation is added next to the marginal brood combs, their wired side facing the nest. As a rule, bees first build this part of a foundation, fully embedding the wire in the middle of the future comb. On warm weather, the beekeeper can add 1—2 empty combs and foundation in the very middle of the brood nest of strong colonies, thus providing for their ready acceptance by bees.

Throughout the build-up period, especially when there is at least a good enough nectar flow, one must take full advantage of the bees' building and wax secreting capacity ; they ought to be induced to build as many combs as possible.

Foundation is pure bees wax drawn out by special appliances. It is a thin wax layer — the midrib of the future comb — the basis of the future cells. The utilization of foundation induces the bees to build mostly worker cells, thus limiting their tendency to build drone cells too.

The foundation is inserted in the frame with 4—5 longitudinal rows of thin, tinned wire. It is threaded through the holes previously made in the end bars of the frame. The wires are embedded, in the comb foundation, by means of the roller and spur embedder : the frame is first placed on the mould ; the edge of the foundation is fixed to the under side of its top bar with a heated roller. Then the frame is laid on the mould and by means of the spur the wires are embedded into the comb foundation. The process is faster if one uses electricity for wire embedding. In this case, it is not necessary to fix the edge of the foundation to the top bar of the frame (it is laid over the wire, fixed 10—15 mm below this bar).

The wax processing factory of Kolomna (Moscow region) is now making tests for mass production of wired comb foundation which are inserted in the frame by means of a special top bar. Use of wired foundation spares the beekeeper's time; the combs drawn out on wired foundation are more resistant, a fact which is highly important for migratory keeping and honey extraction by means of radial centrifugal extractors.

Having good combs in store is decisive for developing bee colonies, increasing honey production and raising the beekeeper's efficiency if the combs in the hive are not sufficient in spring, egg laying and build up could decline. A small number of combs before the main flow leads to its wasting.

Extraction of unripe honey happens many a time because the small number of combs results in lower honey quality and labour productivity.

A comb in a standard frame (35×300 mm) has 9,000 worker cells on both sides (about four cells for each square centimetre of frame). Approximately 5,000—7,000 of them are used for brood rearing depending on the strength of the colony, the quality of the queen, etc. The colony needs combs, according to egg-laying: at an average daily egg laying of 1,000 eggs it needs 26,000 cells (5—6 combs), and of 2,000 eggs — 52,000 cells (11—12 combs).

During the main flow the colony needs more combs for nectar processing and honey storage. The calculations showed that after five days of nectar flow, with a daily weight gain of 1 kg on the scale hive, as many as 18,000 cells (2—3 combs) are needed for nectar processing and storage; with a 4 kg weight gain — 74,000 cells (9—10 combs), and with an 8 kg gain — almost 150,000 cells (19—20 combs). Therefore for each colony in 12-frame hives, one must also have another 12 empty full-depth and 22—24 shallow frames; for the horizontal hives — 20 standard frames and 20 shallow frames; for the two-story hives — 24 combs; for multiplestory hives (frame sizes: 435×230 cm), 30—40 combs, and in the areas with abundant nectar flow (Far East, Eastern Kazakhstan, Ural) — 50 or more combs. The best conditions for developing and increasing the efficiency of the colonies are provided by large hives.

Likewise, important for developing and raising the productivity of the colonies is the quality of the combs. Every generation of brood leaves behind larvae cocoons and faeces which stick to the walls and bottoms of the cells. The bees remove part of the pupal remains, nevertheless an important part of them as well as the faeces remain in the cells restricting their volume. Following the accumulation in the cells of pupal skins and faeces, the comb becomes darker almost black. A newly-built comb weighs about 140 g. After emerging of 6—7 generations, its weight increases up to 280—300 g, and after 15 generations — to 45 g. With the increasing number of hatched generations the walls and especially the bottoms of the cells become thicker. Although thanks to this the resistance of the cells and combs increases, the diameter and the volume of the cells diminish. While the volume of the worker cell in a new comb is 0.27 cu cm, after 10—12 generations it decreases down to 0.25 cu cm.

Bees spend much energy with taking out pupas and cleaning the old cells. The faeces accumulated on the bottom of cells contain many micro-organisms, some of them harmful to bees. Likewise, the old combs with small cells produce small bees with a smaller live weight and with shorter proboscis, wings and tergites. Therefore, after the hatching of 10—12 generations of bees, i.e. after 2—3 years, the combs must be replaced. Refuse combs must be melted.

Also replaced must be the light coloured combs which contain a large number of drone cells, those which are mouldy and stained by faeces. Melting of refuse combs is carried on during the entire season but most of them are taken out of the hives in spring, after restricting the nests, and in autumn, when the nectar flow is over. The larger the number of newly-built combs in a season (corresponding to the number of old, refuse combs), the higher the wax productivity of the apiary.

Processing crude wax and storage of combs. In case of improper storage, many good combs become mouldy or are destroyed by the wax moth, both resulting in great damage in the apiary. Once taken out of hives the frames with good combs must be cleaned and stored in special cool rooms — comb store houses or cupboards. For this, the stacked reserve hive bodies or honey supers may be used. Measures must be taken to prevent appearance of wax moth (see pp 263—265).

The refuse combs (with a large number of drone cells, old, mouldy, stained by faeces, broken and torn) must be taken off the frames and before being melt they must be selected. One must make separate groups as follows : the light coloured combs which contain 85—90% wax ; light brown combs with translucent bottom cells containing up to 70% wax ; the darker combs with less than 50% wax and finally, mouldy combs which have a large amount of bee bread. From them, different grades of wax are obtained (from the first — a better wax while from the remainder — a wax of a poorer quality), and therefore each and every group must be melted separately.

Wax processing is made on the spot. The wax is kept in warm water for 2—3 days, then it is boiled in unhardened water for 30 minutes until it turns into a soft paste. Wax is then extracted from the paste by the wax press. The hot mass is laid in not too thick layers — on sack cloth ; between layers straw must be put to help draining ; wax is then extracted.

Small amounts of light-coloured crude wax or combs remainders are processed in the solar wax extractor.

The residues of the crude wax processing contain much wax (up to 20—25%), therefore they must be delivered to special collecting units in order to be further processed in the wax extracting plants.

Depending upon the quality of the initial raw material, the wax obtained after processing may have different aspects : from white up to light amber (obtained by melting light-coloured combs and cappings); yellow, light brown, dark brown and grey — from crude light wax melted in the solar wax extractor. The white or light-amber wax is the best for comb foundation.

REPRODUCTION OF THE BEE COLONY

By the end of spring, after the old overwintered bees have been replaced with young bees, the queen's egg laying increases with every passing day. The number of larvae reared in a colony also increases.

Under favourable conditions, the colony population increases with 1.2—1.5 thousand bees daily. The number of bees increases at a more rapid rate than the number of eggs laid by the queen. Usually, during this period there is no abundant flow in most regions; sometimes there is no flow at all and in this case only a small number of bees are collecting nectar and pollen. Whereas early in spring for every larva there is 1.2—1.5 nurse bees, in step with the colony growing stronger, after 2—3 weeks, the number may double, and after 4—5 weeks it may treble. As a consequence, a great number of idle young bees may appear.

The accumulation of a great number of idle young bees is the main cause of the appearance of the swarming impulse in the colony.

Swarming is the natural way of reproduction of the honey bee colonies.

It was the way the wild colonies and those in primitive hives multiplied. Swarming still takes sometimes place in apiaries of side-liners and some out-of-date beekeepers in kolkhozes and sovkhozes. The experience of advanced beekeepers in our country as well as of the commercial apiaries in the USA and in other countries shows that swarming is useless in modern apiaries as it makes no contribution to increasing the colonies' and beekeepers' labour productivity, or to reducing the cost price of the hive products.

In preparing for swarming, the bee colony restricts egglaying and brood rearing, ceases comb building and nectar and pollen collection. The idle bees cluster on combs. As a result the honey and wax production reduces substantially.

Under the conditions of swarming colonies, selection work is difficult because usually the less productive colonies are multiplying in this way not the highly productive ones. Moreover, instead of improving the inherited qualities of the bees, the negative selection occurs of swarming, less productive colonies.

Swarming is incompatible with planned management of beekeeping economy because it is impossible to know how many swarms will issue in the respective season.

Finally, the main drawback of swarming are the large unproductive expenses, because beekeepers have to watch catch and take care of swarms in the busiest period of the season. During the swarming period, a man must be permanently present in each and every apiary, to see which colony swarms and where has new swarm issued. That is why at the apiaries attended to by advocates of swarming, especially in the north-western regions of the R.S.S.F.R., a beekeeper and his assistant can hardly handle 50 bee colonies.

Some of the supporters of swarming justify themselves by the fact that in its location the swarm builds many combs. It is true that the bees of the swarm build the new nest quickly. This fact is not due to an outstanding swarming energy but to the accumulation of nutritive substances during the idle period in the old hive, which they now use in the new hive. In addition to this, before leaving the old hive, the bees fill their honey sac with honey.

Nevertheless, the bee-keeping farms with highly productive colonies, where the beekeepers' labour is very efficient, do not admit swarming. For increasing the number of colonies they use artificial swarming and help the colonies to reach the optimum strength for the main nectar flow. The frontranking beekeepers in Yakovlevskii, Sposskii, Primorie and Habarovsk regions, as well as many beekeepers in the Tartar A.S.S.R., etc. manage their bee colonies in this way. It is worth mentioning that A. Wulfrat, the manager of the largest beekeeping operation in the world "Miel Carlota", considers the control of swarming as one of the main conditions of their success in increasing the productivity per apiary and per beekeeper. Many commercial beekeepers in the USA, operating thousands of colonies — are of the same opinion.

Undoubtedly swarming cannot be eliminated at once. In spite of the many successes in this respect it still occurs in many apiaries. Therefore, concurrently with the measures for preventing swarming it is wise to rationally use the issuing swarms. During the swarming period, someone to watch the colonies must be always present, with the necessary equipment ready to catch and hive the swarms (mobile ladder, basket for taking swarms, scoop, empty hives, frames with foundation). When the swarm issues it is very important to locate the queen. The queen must be caged and placed in a swarm-taking basket on top of a long pole. The basket with the queen is kept in the middle of the flying swarm : the bees discover the queen and cluster around the cage. When the swarm with the queen gathered in a tree or some other place, the basket is placed under the swarming bees and the whole cluster is shaken into it. The swarm in the basket is then weighed and put into a dark and cool room (the wintering room or the cellar).

An early strong swarm (weighing over 2 Kg) with a good queen may be hived at sunset. It is provided with a few frames with foundation (one for every 300 g of bees), one honey comb and one board comb with brood of different ages. The swarm bees are either poured over the combs or driven inside through the main entrance.

In order to prevent a second swarm all queen cell cups must be destroyed, leaving only the best one, to obtain a new queen.

Swarm control is one of the main concerns in hive management and bee breeding. It requires several operations, the most important of which are :

1) removing in due time (before the appearance of swarming fever) the idle bees which overcrowd the hive. Young colonies are formed with such bees and combs with adult brood : they can be used to increase the number of bee colonies in the apiary or to strengthen colonies before the main flow (see pp 140—142) ;

2) Keeping in the colonies only young prolific queens, which ensure a high rate of bood rearing ;

3) Selection and breeding for high honey production and low warming tendency ;

4) Providing the bees with combs to be built and with nectar sources to be foraged — during the period when colonies are most likely to attempt swarming ;

5) Keeping the colonies in high-capacity hives and expanding the nest by adding honey supers or the second body to 12-frame hives, and supplementary hive bodies or honey supers to multiple-storey hives ; placing of the hives in the shade, and providing for adequate ventilation;

6) Replacing of swarming race bees (such as the Cuban, the Central Russian) with Carpathian or grey mountain Caucasian bees (in the steppe and forest steppe area) which are gentle and have a low tendency to swarm.

"Artificial" increase of the stock means increase according to a previously established plan and at the same time is an efficient way to prevent swarming. When practising the artificial increase, the average yield per colony increases parallel with the decrease of labour consumption by several times as compared with the natural way — swarming.

Some beekeepers secure increase in their apiaries by making up auxiliary colonies. This method is the most widespread in frontranking apiaries in various areas of this country and abroad. It is the simplest method and it saves a lot of work. Some beekeepers practise the division of colonies while flying ; more rarely is practised the so-called queen's flight.

One must take into account that the earlier the auxiliary colony is formed and the longer its build up before the main nectar flow, the more bees can be reared and the larger the amount of nectar gathered by them. Before dividing or shaking the new colonies one must have at hand the necessary young queens ; one must have also the drones which should mate the queens (see pages 148—154).

The new colonies may be given a virgin or a mated queen or a mature queen cell. New colonies can be made up too with bees and brood combs coming from two or more colonies.

Making new colonies with a virgin queen or with a mature queen cell is most frequent in beekeeping practice. 2—3 combs with mature brood from a strong and very productive colony which has at least more combs with brood and 10—12 cmbs with bees, are put in a hive box

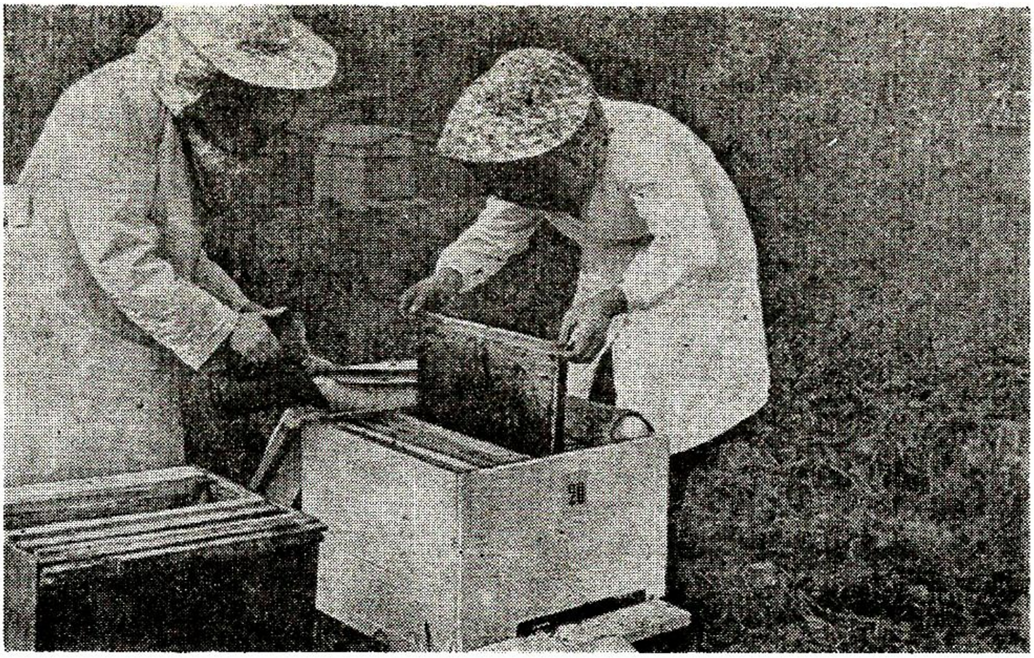


Fig. 41. Making a new colony in spring

The bees from two extra combs are also shaken into the hive and 1—2 combs with honey are given the new colony. The nest must be insulated laterally and on the top. Before taking the combs it is necessary to find the queen of the mother colony lest one should bring it into the new colony (it may be kept under a glass cage or temporarily isolated together with the comb behind the diaphragm of the hive or in a transport box). The combs taken off from the hive of mother colony must be replaced by frames with empty combs and foundations.

By the end of the day, when all the field bees of the new colony fly back to the parent colony, the new one is given an unmated queen or a mature queen cell. If the combs of the new colony contain no nectar or fresh honey. on the first day the bees are given about one liter water which is poured in the empty cells of honey combs. A day or two later the beekeeper must check if the queen or the queen cell have been accepted. If the young queen has been accepted, the mating flight takes place, she starts laying eggs and the young colony builds up. If the queen cell or the cell have not been accepted, emergency queen cells are built where eggs and young larvae exist. They must be destroyed and the young colony is given a new mature queen cell or a queen.

When the new queen has started to lay eggs some beekeepers move another 1—2 combs with brood from the mother colony into the new one. Further on, the colonies are submitted to the common management practices.

The new colonies with unmated queens may be formed 7—8 weeks before the main flow. They have time enough to build up on account of the emerged adults and they will be able to make a good use of the main flow, will ensure food reserves and will produce extra honey.

Making new colonies with mated queens means the same but instead of queen cell the colony is given a young mated queen. In this case the development of the new colony starts almost two weeks earlier because the queen will start immediately to lay eggs and the colony will build up in a shorter time.

New colonies with mated queens may be formed 5—6 weeks before the main flow. In order to allow a mated young queen to use immediately and thoroughly the existing nectar flows the young colony consists in a large amount of brood and adult bees : as a rule 4—5 combs with brood covered with bees and another 2—3 combs must be shaken down into the hive box.

The mixt colony differ from the previous type being formed of brood and bees coming from 2—3 colonies. Such new colonies may be made up in the apiaries where there are not infectious diseases (otherwise there is the risk of spreading the disease). The advantage of this new colonies is that the mother colonies are not weakened as a consequence of taking out large amounts of brood and bees. Besides, on account of several colonies and without being determined to them, one can make up stronger new colonies.

Strong mixt colonies can be made up only 2—3 weeks before the main flow. This operation will prevent to a certain extent swarming in the main colonies and the new colonies will supply some honey for market. Successful new colonies may be made by using mated queens, reared at the breeding stations in the south.

The experience of the Tartar section of bee-keeping in making up early colonies, with queens obtained from the state queen rearing stations of Kabardino — Balkar and Uzbek Republics, has demonstrated the efficiency of this method. New colonies, formed in May, are successfully used, for increasing and strengthening colonies before the main flow.

Division of the colonies during the flight. This method of "artificial" increase is rather more complicated than the formation of the colonies but it has an advantage : the resulting population consists of bees of various ages (not only house bees but also forage bees). The method requires strong colonies which have 8—9 combs of brood and 12 intervals with bees. Near the hive of the mother colony the beekeeper must place an empty box of the same colour and form.

Half of the combs with brood, bees and food stores from the main colony are transferred into the empty box. The queen is left within the old colony. 2—3 frames with empty combs and foundations (if necessary a comb with honey too are added in each hive. The new colony is given a young queen, better a mated one.

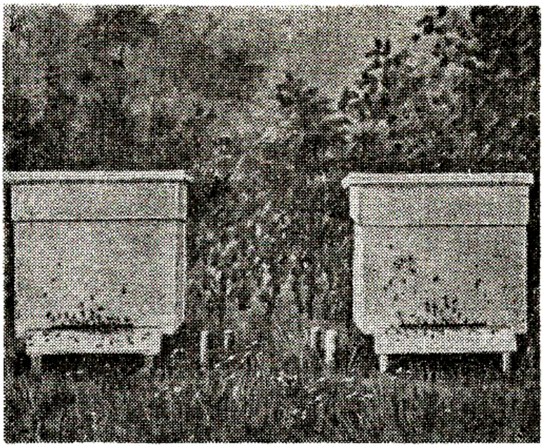


Fig. 42. Position of the hives when one colony is divided in two

One must insulate the nests of both colonies. Then the hives are placed 1 m apart on either side of the former location of the mother colony. The bees coming back from the field do not find the entrance at the old place ; they will part in approximately two equal populations, in the hives. If one of the hives attracts more bees, it will be moved a little farther as compared to the initial position of the entrance. Thus one can control the distribution of the field bees in the two hives. As a result a colony is divided into two swarms with equal amounts of brood, young bees (house bees) and field bees.

A queen is used to attract the bees in case of colonies which prepare for swarming. In a nice summer day 3—4 combs with brood of various ages, adult bees and the old queen are introduced into a new hive. On either side of the brood combs one must place 5—6 empty combs and foundations as well as two honey combs. The new hive is placed where the mother colony used to be and the latter is moved to some other place. All flying bees of the mother colony coming back from the field will enter the new hive. So the new colony contains no flying bees. It is given a young queen or a mature queen cell.

In the first 2—3 days the bees of such a colony must be supplied with water.

QUEEN BREEDING

Supplying the apiaries with young mated queens which possess valuable hereditary qualities as concerns prolificity and lifespan is highly important for bee-keeping. On the queen's prolificity depends the rate of brood rearing of the colony. The higher the egglaying the larger the number of bees emerged in the hive and the greater the amount of nectar input.

The planned management of the beekeeping units, the increase of apiaries' productivity are inconceivable without the correct organization of queens breeding and without selection programmes. At every apiary young and prolific queens are necessary to form new colonies and their further build up.

The queen lays many eggs in the first year of life. In the second year her egglaying rate decreases by 30—40% while in the third by more than half. Besides, the older the queen, the larger the number of unfertilized eggs she lays, which develop into drones. The young queens go on laying eggs until late in autumn much after the old ones have stopped. This fact is very important : strong colonies containing mostly young bees, will have a successful overwintering. Colony headed by young queens swarm less and yield higher honey crops.

Therefore keeping queens older than two years is not advisable.

The frontranking beekeepers obtain good honey crops and avoid swarming, provided they replace systematically the old and unefficient queens.

In order to increase the productivity the age of a queen is not her only important feature to influence the colonies honey yield but also her prolificness — which depends on the breeding conditions and her race features.

Special researches, undertaken on several thousands bee colonies (G. Avetisyan) have demonstrated the existence of a direct relation between the egglaying rate and the honey and wax yields of a colony (the correlation coefficient between the amount of brood and honey productivity of the colony is 0.6—0.8).

The larger the queen and the more developed her ovary tubes, the higher her prolificness. Therefore when organizing queen breeding stations one must take into account their quality.

People often share the mistaken idea that artificially reared queens are of a poorer quality than those emerged from swarming.

Researchers of the beekeeping department of the "R. I. Timiriazev" Academy of Agricultural Sciences (A. Levicev) showed that provided the breeder observes some requirements the queens he obtains have higher qualities than swarming queens (the number of ovarioles, the weight of ovaries and of the queen). According to the above-mentioned indications the poorest proved to be the queens bred by bees in emergency cells, which once again showed that the utilization of such queens is not advisable.

Breeding queens uses many different methods. For most apiaries is suited the simplified method of obtaining a small number of queens without grafting larvae. The best method is to rear queens from grafted larvae ; a large number of queens are reared so in specialized apiaries of the beekeeping farms or in queens breeding stations.

Any rearing method gives satisfaction provided the breeder colonies are strong, highly productive, with abundant food (proteinic and glucidic) stores and with an abundant nectar flow. Queen breeding requires first to choose mother-colonies future source of larvae, nurse colonies

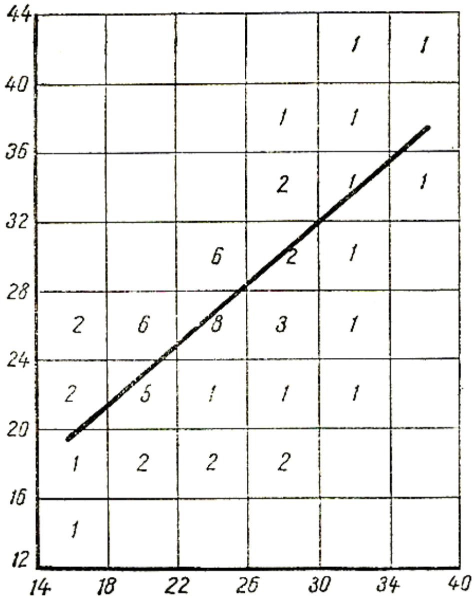


Fig. 43. The relation between egglaying rate and honey productivity of the colony ($r=0.589 \pm 0.088$; the figures in the squares refer to the number of bee colonies). On ordinate; honey yield (kg); on the abscissa; brood cells (thonsand)

— whose bees breed these larvae, and father-colonies — future source of drones. With an apiary having 120—150 colonies the beekeeper must choose 2—3 mother-colonies, 3—4 nurse colonies and 5—6 drone-rearing colonies a total of 11—12 productive, strong colonies. Two weeks before starting queen rearing, drone cells combs are given the drone-rearing colonies. Drone-rearing is limited in all the other colonies of the apiary.

Rearing queens without grafting larvae. This method has many variants all of them, however, lying on the same principle : young larvae of worker bees are introduced in a very productive and strong orphaned colony ; the bees in this nurse colony intensely feed them on royal jelly ; under these conditions the bees build queen cells and rear queens. Usually one day-old larvae (the fourth day after oviposition) are used. The length of such a larva does not surpass 2—3 mm. ; it occupies the bottom of the cell without reaching its walls.

9—10 days before introducing the larvae into the nurse colony, its queen together with 3—4 combs are isolated by means of a separating grill from the rest of the nest. Later, 5—6 hours before introducing the larvae, the queen and all the sealed brood is taken out of the colony and is temporarily placed in an auxiliary colony, which is kept in a well isolated part of the hive. The nurse colony is left all the sealed brood, a minimum of 12 kg honey and two combs with bee bread.

Obtaining young larvae of the same age ; the beekeeper introduces an empty comb in the middle of the mother colony and he must notice when the queen starts to lay eggs. The fourth day after the beginning of egglaying, the young larvae hatch. If such a comb is given to a queenless colony the latter will draw queen cells and will rear queens.

Lest the future queen cells should be too close to each other and in order to allow easier handling, one must cut in the comb a thin stripe of cells with young larvae with a sharp knife warmed up in hot water.

The cell walls are shortened; the stripe is out in pieces so as to obtain district cells with larvae. Then the cells contaning young larvae are fixed by means of melted wax against little wood plates (2×2 cm) and these in their turn are fixed up on the bars of the special rearing frame. Each bar of such a frame receives 12—13 holders with larvae and the frame has as a rule 2—3 bars (at distances of 5—6 cm from each other and from the top bar of the frame). All these operations may be performed very quickly in a closed room at about 30°C and with high humidity (the floor must be wet with water).

The rearing frame prepared in such a way is placed in the middle of the nurse colony, among brood combs. The hive should be well isolated. If there is no natural maintenance flow the nurse colony is fed on sugar syrup and a mixture of honey and bee bread.

The nurse colony (of Central Russian bees) is given 15—20 larvae once. Later on, when weather becomes fine and nectar flow appears the number of introduced larvae may be increased up to 20—25. The southern bees, especially those of Caucasus and Kuban regions can receive by 25—30% more larvae.

The second day after introducing the larvae within the colony one must check up if they have been accepted and if the building of queen cells has started. If the nurse colony has not accepted the larvae, the hive must be thoroughly checked up. If emergency queen cells are discovered, built on larvae left by chance, they are put out and a new frame with larvae is introduced. Five days after the introduction of the larvae within the colony, the bees start to cap the queen cells.

After the emergence of the first queen out of a mature queen cell all the other queen cells will be destroyed and the queens will be killed.

Therefore not later than the tenth day after the introduction of larvae, the mature queen cells must be either taken out the nurse colony and given to colonies or individually caged. In the last event a little honey or sugar candy are put in every cage and ten bees are introduced. The cages with queen cells must be placed in a special nursery frame, in the centre of the nurse colony's hive or of other queenless colony (until the emergence of all queens). All under-sized queen cells must be destroyed because they result in small, unproductive queens.

The newly-born queens cannot be held too much in the cage; they must be used for making up new colonies, replacing old queens or introduced into mating nuclei.

Queen rearing with grafted larvae is made at stations specialized in breeding queens and special apiaries of a big farm. It may be successfully practised at the apiaries of kolkhozes and sovkhozes.

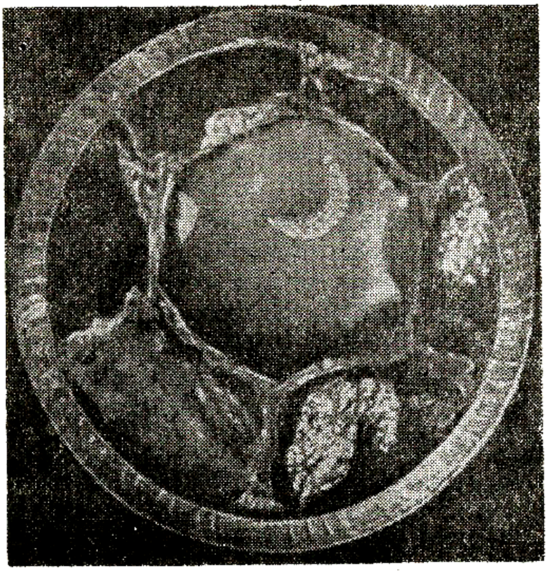


Fig. 44 — Young larva in bees' cell ready to be grafted into artificial queen cell cups.

In a beekeeping farm specialized in queen breeding one must choose 6—7 of the best colonies as sources for larvae. These highly productive colonies, with good over-wintering, have bees with external features and colour specific to the race bred by the respective apiary. About 12—15 highly productive colonies are used as father colonies and the same number as nurse colonies.

Early in spring, 2—3 frames with drone cells are placed in the centre of each colony ; the nests must be well insulated. In case nectar is scarce, they are given a supplementary food (mixture of honey, pollen and a sugar syrup). As soon as the first drones emerge, the beekeeper must begin the queen rearing. Young larvae of the same age are easily obtained allowing the queen to lay eggs on a light brown comb isolated with queen excluders in the very centre of the nest. After four days this comb will have many eggs and one-day-old larvae.

Before grafting the larvae. artificial queen cell cups are made by means of a wood moulding tool. It is a compact wood stick, 100—120 mm long, 9 mm in diameter, with one end well rounded and polished.

One must use the lightest wax, which is melted at low fire or better in a warm water bath. First the moulding tool is dipped into cold water, then the adhering water drops shaken off and then it is dipped 2—3 times in liquid wax ; first 10—12 mm. deep, then 9—10 mm. The cup is allowed to cool and discarded off the moulding tool. Each cell cup is fixed on a wood holder by means of melted wax, and subsequently the holders are set on the cross bars of the special rearing frame. For large batches of queen cell cups it is preferable to use a device joining together more queen cells moulding tools or better G. C. Vasiliadi's device.

The frame with young larvae to be grafted must be held in such a manner as to allow the operator to see inside the cells. The breeding frame with artificial cell cups must be placed over.

Before grafting the larvae in the cell cups, in each and every one the beekeeper puts a droplet of fresh royal jelly taken from uncapped queen cells. If royal jelly misses one can use liquid honey, though less suited.

The grafting tool is an aluminium wire (2 mm. in diametre) with a curved, blunt, well-polished end like a small spade. The end of grafting tool is introduced under the larva which floats on royal jelly and it is raised a little. The larva is transferred into the cup, is placed on the drop of royal jelly and the end of the grafting tool is carefully extracted, slightly pressing the bottom of the cell so that the larva could slide. The frame with transferred larvae is immediately introduced in the nurse colony.

The nurse colony is prepared in the way described above. As many as 30—35 larvae are placed within each and every colony. After the first batch of ripe queen cells are taken the colony is given a second (sometimes a third) batch of grafted cups. Then the colony is given back its queen.

The Bee Research Institute (G. F. Taranov) recommends the following procedure of rearing high-quality queens in the specialized

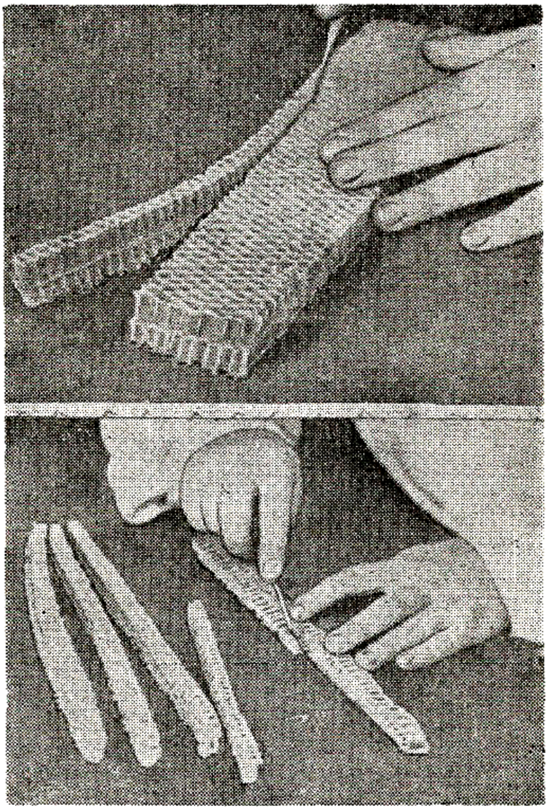


Fig. 45. Cutting up the cells for queen rearing without grafting larvae

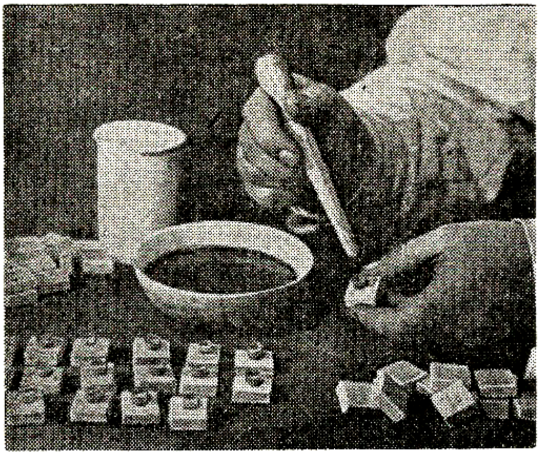


Fig. 46. Preparing queen cell cups

apiaries : 12-hour larvae are transferred on a drop of royal jelly recently taken from queen cells already accepted 12—16 hours before. It is advisable to take royal jelly from the so-called auxiliary nursing colonies (one for every 5—6 basic nursing colonies). The first breeding frame with 24 larvae is placed in a specially-created space in the nurse colony, 6—8 hours after the dequeening. Three days later the nurse colony is given a second breeding frame, two or three brood frames apart. Then, as the queen cells reach maturity, the old rearing frames are taken out and replaced by new ones, with freshly grafted larvae. After the fifth frame with ripe queen cells, the nurse colony is given back its mated queen.

The breeding frames with capped queen cells, taken from the nurse colonies, are put in a thermostat at the temperature of 33—34°C

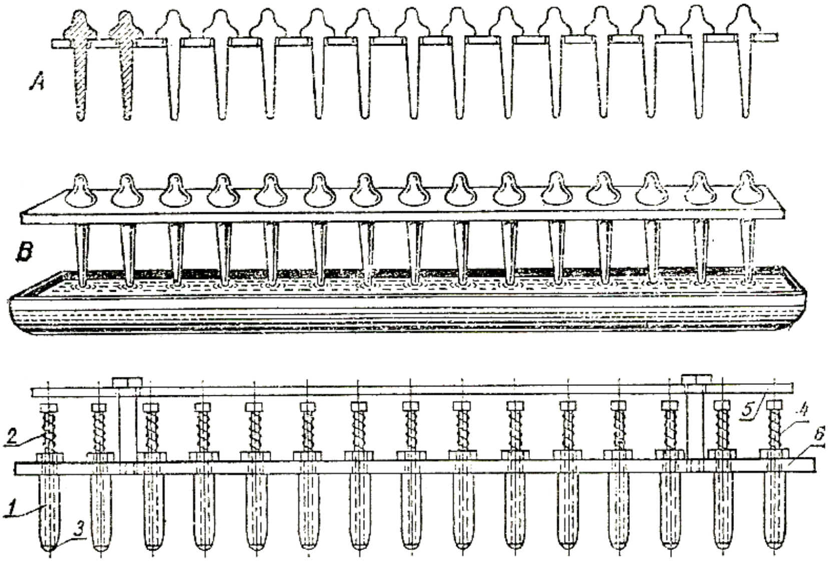


Fig. 47. Upper part : device used to prepare more queen cell cups at once ; A — section view ; B — total view ; Lower part : G. C. Vasiliadi's device used to prepare and fix the queen cells cups

and relative humidity of 70%. If there is no thermostat, the frames with caged queen cells are held in the nests (among brood frames) of some strong colonies: these "incubators" are dequeened colonies.

The young queens are kept in special mating nuclei; three types are in common use: (1) 2—3 standard frame nuclei in a hive body

Fig. 48. Transferring larvae into artificial queen cell cups by means of the grafting tool

divided into four compartments each being a nucleus, with entrances in different parts or a unique nucleus adjacent to a normal colony in a long hive; (2) 3—4 1/2 standard frames nuclei (300 mm. high, 210 mm wide) in a standard hive, separated into six compartments; (3) 1/2

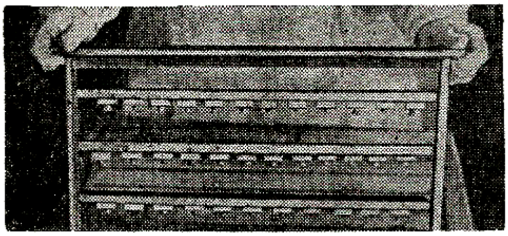


Fig. 49. Breeding frame with queen cell cups containing larvae

standard frame nuclei in a hive box divided into 8 compartments or in long hives with 2—4 compartments each for a 1/2 frame nucleus. From the beginning of spring until the stable warm weather sets in, nuclei of the first two types are used. Later on, young virgin queens are maintained in nuclei with 1/4 of a standard frame (145 × 210 mm). Normal colonies are used at the beginning for building combs and filling in the cells of these frames. The small nuclei are populated with young

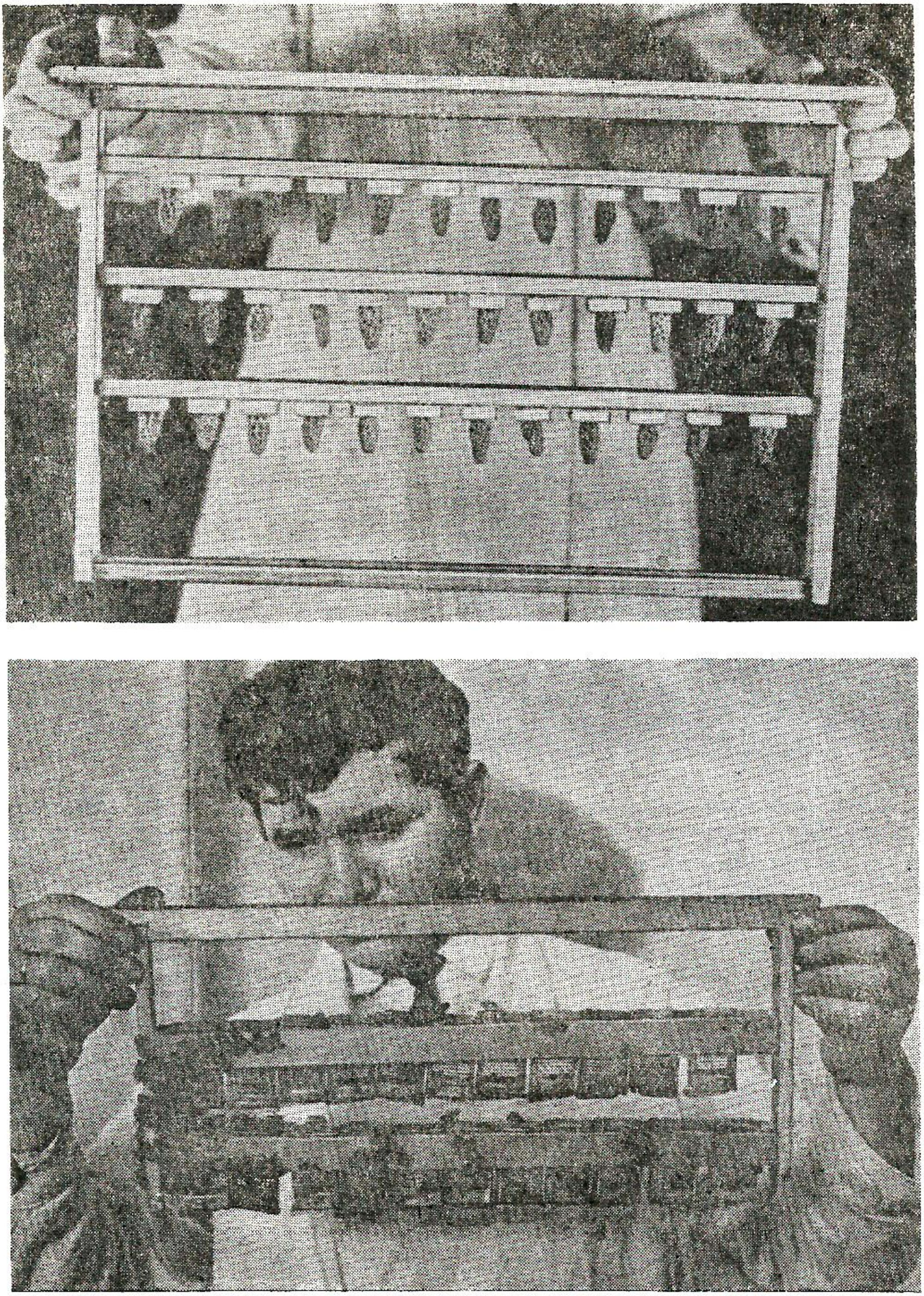


Fig. 50. Upper part : ripe queen cells ; lower part : caged queen cells, in the breeding frame

bees (about 200—250 g) and then they are kept for 24 hours in a cool place.

A ripe queen cell is placed inbetween two combs. After mating, the queen is left for a few days in the nucleus in order to confirm the successful mating and to round off with its first eggs the future population in the nucleus. After removing the mated queen, a new ripe queen cell is introduced into the nucleus.

The experience proved that larger queens are better accepted by bees and better mate with drones than the smaller ones, which considerably heightens the efficiency of the nuclei.

For shipments at great distances the mated queen is placed in a special cage together with 15—20 young bees. The food in such a cage consists of a dense mixture of powder sugar with honey (not honeydew honey). The cage is wrapped with a sheet of transparent celluloid then with a thin plywood cover.

PACKAGE BEES PRODUCTION

The production of package bees has greatly developed in the USA; every year the southern states produce 500,000 bee packages which are sent to Canada and to the northern regions of the country for honey

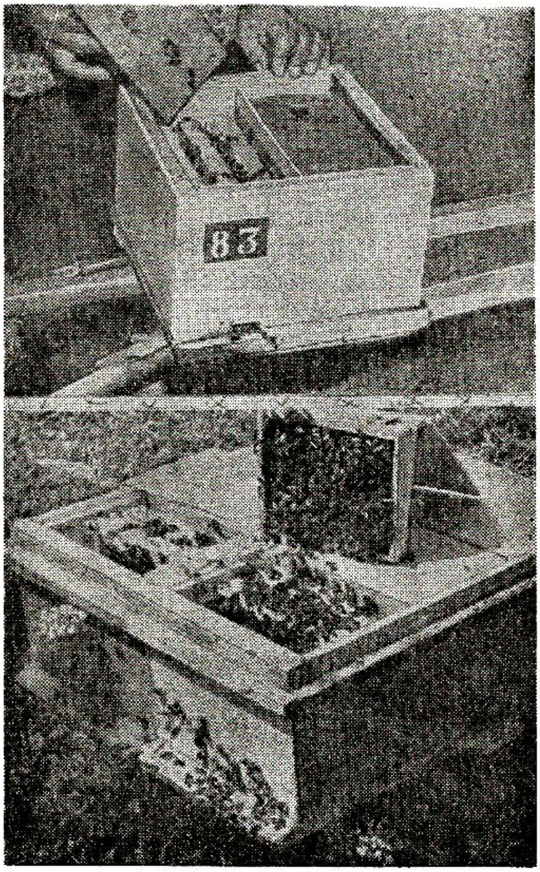


Fig. 51. Upper part: two frames nucleus (1/4 of a standard frame); Lower part: nucleus with several frames (maximum 1/4 from a standard frame — body for half a frame) in an eke of standard hive

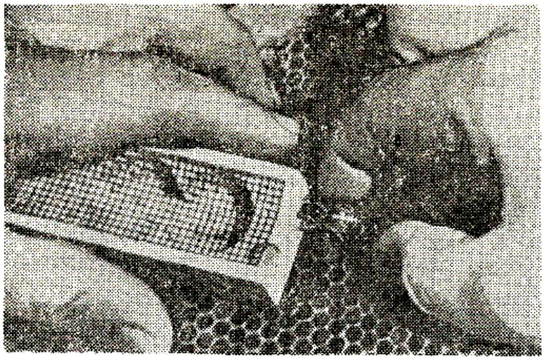


Fig. 52 — Introduction of bees and queen in a transport cage

production, for pollinating purposes and fortifying the existing bee colonies. Production of package bees is closely linked to rearing queens and usually the specialized farms successfully attain both the above-mentioned objectives. An efficient production of package bees started in our country, especially in southern regions, where there are favourable conditions for the early rearing of queens and bees. The queens for package bees are obtained very much like in the apiaries specialized in queen rearing.

In the USA these colonies are dispatched combless. Our bee-keeping nurseries (in Grusiya, regions of Krasnodar and Stavropol, in the ASSR of North Osetia, Central Asia, etc.) prepare package bees on six or four frames. In fact, they are small auxiliary colonies — 1—1.5 kg of bees, 2—3 frames with brood and a mated queen. Each contains 2—2.5 kg of honey.

Package colonies are usually formed in spring although some farms form them in autumn. In this latter case the colonies winter on the spot and in spring, after a first build up, part of the bees and brood are taken for making up packages. The remainder of the colony is given a new queen and after a period of build up, part of its population can be again taken for a new package.

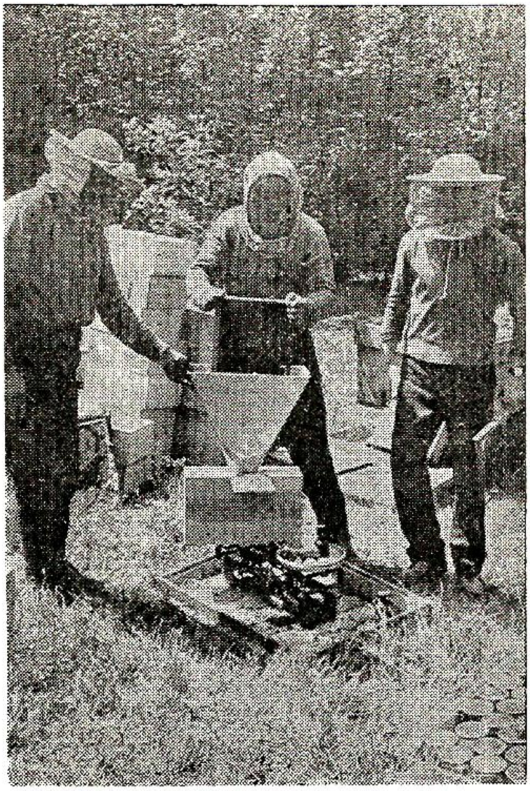
Young and strong bees are selected for packages, preferably on a sunny summer day. Sealed brood is also suitable. The open larvae cannot survive a longer transportation ; besides, for tending such larvae the bees would consume much food and energy.

Light brown combs of good quality are put in the packages. Those of a fairer colour are unresistant to transport, they may be deformed or even broken. Nor better are those of a very dark colour, though resistant. The plywood transport box must be provided with upper and lower frame spacers.

In the middle of the box first are put the frames with brood and queen, then the lighter empty combs and the last the combs with honey. After setting the frames they are fixed in the upper part too. Finally the box must be checked up lest it should have fissures and orifices which may allow for bees' coming out. A specially rigorous check up must be carried on when bees are dispatched by air.

A bee colony on 6 frames, with the box included, weighs 12—14 kg.

Fig. 53. Shaking the bees into a box (without combs) through a special funnel



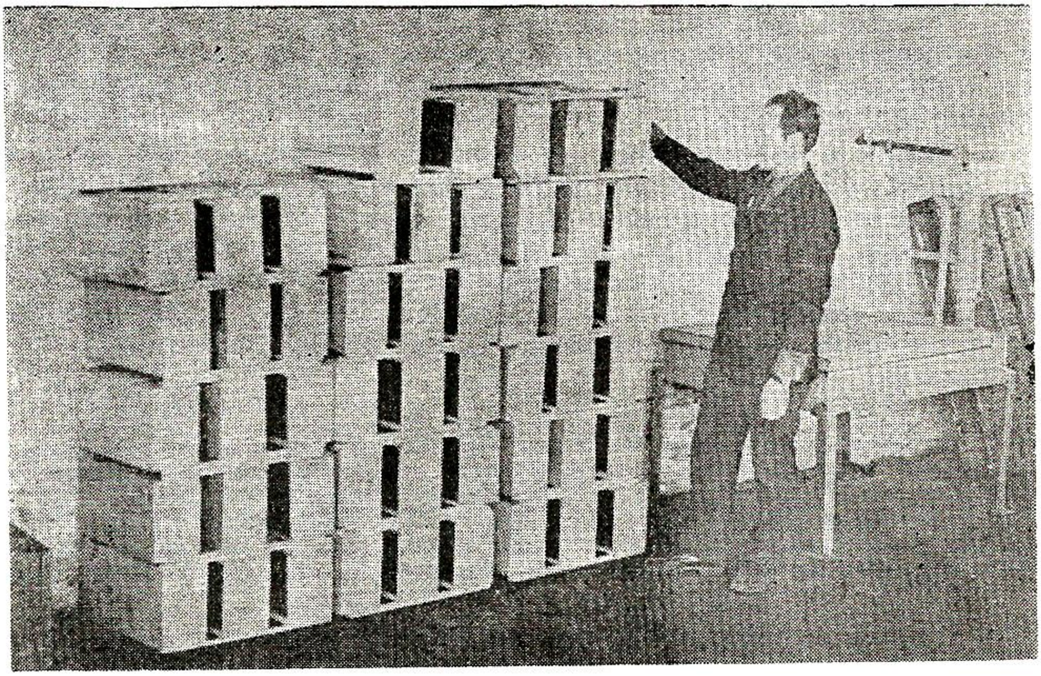


Fig. 54. Packages ready to be shipped

Producing packages without combs is for the time being used on a reduced scale in our nursing apiaries, although it has a number of essential advantages compared to the packages with frames. The transport expenditure of packages without combs is thrice less, because the package colony, the box and the food reserve included weighs 4—4.5 kg. instead of the 12—14 kg of a six-frame package). The food consumption during transport also drops 2—3 times. Besides the cost of a package without frames is less expensive than that of one with six frames. The apiaries providing package bees without combs do not deprive themselves of comb reserve. The risk of transmitting disease agents is avoided too : therefore in the USA the dispatch of packages with combs is forbidden as prophylactic measure.

The production of package bees without combs has broad perspectives especially in using plane as a transport means, which shortens several times the duration of a delivery. The production, transport and installation of package bees without combs require a rigorous organization of work a strict observance of the technical conditions.

A package without combs is made up of 1—2 kg of young bees and a young unmated queen. They are obtained by the well-known methods presented above. In order to prepare bees in due time, strong auxiliary colonies are made up about a week before sending the packages : frames with capped brood and young bees are used. By means of a special funnel the bees of the auxiliary colonies are shaken into transport boxes. If the box is put on a scale, one can shake a determined amount of bees.

Previously, in each box is introduced a young mated queen. confined in a special cage with candy sugar together with 20 accompanying bees. By means of a thin wire the cage is fixed on the middle wall of the package lest it should be balanced on the road. After filling the box with bees, a tin with 60% sugar syrup is placed in the upper round opening of the box.

The tin with syrup must be prepared in advance. They must be air tight. Two orifices (0.5 mm in diametre) are practised at the bottom of the tin so that the syrup might leak as small drops — in no case to pour. For transportation the packages are put together by twos, threes or fours ; they are kept close by means of wood laths ; their network walls should be towards the interior. The bees in the package gather in clusters thus considerably diminishing food consumption during the trip.

According to the data of Beekeeping Department of the "K. A. Timiriazev" Agricultural Academy, a bee package of 1.5 kg. requires during transportation no more than 100—120 g honey a day. If prior their shaking in the transport boxes the bees are obliged to fill their honey sacs, this reserve is enough for four days. The last observation opens up prospects for sending packages without frames and feeder, provided that the duration of the transport does not exceed three days.

The field experiments carried out between 1961—1973 by the Beekeeping Department of the "K. A. Timiriazev" Agricultural Academy showed that the package bees transported for the nectar flows in Siberia and in some northern districts of the RSFSR constitute a large reserve for increasing productions of honey for market. The colonies of package bees can successfully contribute to pollinating farm crops too.

BREEDING BEES

The selection of the original material is highly important for a successful bee breeding. Before approaching this problem we must know the classification and the characteristic features of the main bee races which are interesting for the breeder.

Zoological and apicultural classification of bees. The honey bee belongs to Arthropodes, class of insects, order of *Hymenoptera*, family of *Apidae, Apis*/bee genus. Four species belong to genus Apis. Besides honey bee *(A. mellifera)* it also includes the bee of Central India *(A. indica)*, the giant bee *(A. dorsata)* and the dwarf bee *(A. florea)*. Although the bees of all these species are social insects and live in colonies, the highest development is reached by the honey bees (the instincts of building the nest, of collecting and storing large amounts of food, the large number of individuals in the colony and their morphological diversity, etc.); the honey bee is of the greatest economic interest for the amounts of hive products and the extent of its pollinating service. The honey bee is largely present on all continents. It existed from times immemorial in Europe, Asia and Africa but in the Americas and Australia it has been introduced by man relatively late.

The bee of Central India is spread in Eastern Asia (China, Japan, Korea, India, Far East of the USSR) in wild state. In China, Japan and other countries of Eastern Asia it has been domesticated since oldest times, being nevertheless less useful from the economic point of view than the honey bee. The other two species — the giant and the dwarf bees are to be met only in wild state in India and in the neighbouring islands in the Indian Ocean.

As concerns the development of social instincts — these bees are more primitive than the others, they cannot be domesticated and they have not an important economic value. Honey and wax can be obtained from the nests of the giant bees.

A well-known Russian zoologist and erudite — professor G. A. Kozhevnikov divides the species of honey bees into two subspecies : those having a dark colour *(Apis mellifera mellifera* L.) and the yellow ones *(Apis mellifera fasciata L.)*. According to Kozhevnikov the dark-colour bees subspecies includes the race of Central Europe (of Central Russia), the mountain grey Caucasian and the Madagascar bee ; the yellow subspecies includes the Italian bee, the yellow steppe Caucasian bee, the Cyprus, the Egyptian bees and a group of yellow African bees, little studied. One must recall that the zoological classification is based especially on the morphological indices of the bees and some biological features. Unlike zoological classification, the beekeeping classification relies first and foremost on the figures expressing productivity, prolificness, swarming tendency, resistance to diseases, capacity of adapting to some natural conditions, etc. Morphological features are also taken into account, especially those linked with the productivity or the economic value of the bee colony.

There are not yet industrial races of bees. The few bee populations characterized by high useful economic indices and which are spread on certain areas and adapted to certain natural and nectar flow conditions, may be called *primitive races*. The bees belonging to primitive races, though being mainly the product of long-standing influences of the environment conditions, have felt the consequences of man's activity being kept in artificial hollows, in hives, especially in modern hives. The beekeeper protected the colonies against enemies, modified the feeding and rearing conditions and used the bees according to his economic interests : consciously or not he made selection. The natural selection has contributed to the adaptation of bee colonies to given natural conditions, which increased their economic value too.

The huge variety of natural and economic conditions of our country as well as the fact that in many regions bees live from oldest times, has contributed to springing up valuable native bee races. No other country in the world has enjoyed such variety of local primitive races as the Soviet Union (see colour plate I).

Academician N. I. Vavilov showed that "the local material, subjected for a long time to the action of natural selection and adapted to certain conditions is undoubtedly highly valuable and it must be thoroughly used for selection. This is the conception which must lie at the basis of selection work".

Bee races. The following races may be used as initial material for breeding.

Black forest bee of Central Russia is spread out in our country on large areas of forest and forest-steppe from the Baltic Sea up to Eastern Siberia. It reaches the northernmost limits of practising beekeeping and even it may be met in forest tundra area. It may be also found in many countries of Central and North Europe (Norway, Sweden, Finland, France, Federal Germany, the GDR, Great Britain, etc.). It is adapted to the harsh conditions of the forest area. Under favourable conditions it builds up reaching good physical condition for the main flow (lime tree, fireweed and buckwheat). It has a more intensive nectar collection than other races on lime tree and buckwheat.

The forest bee of Central Russia is more resistant to wintering, to honeydew intoxication and to Nosema disease than other races, especially the southern ones.

The bees of Central Russia start foraging later and come back earlier than the southern ones (the Caucasian bees). They store nectar first in the honey supers and then in the brood chambers. The Central

Russia bees has well developed wax glands and the building instinct too. Their honey capping is white and "dry". During a hive inspection the bees leave the upper bars of the frames. The Central Russian bees are dark-coloured, without yellow bands on the tergites. They are less inclined to robbery than the southern bees but in turn they defend better their nest from robbers. The negative characteristic features of the bees of Central Russia are their aggressiveness and their swarming tendency. Unfortunately in most regions this race is crossed with other ones, especially with southern bees. It was maintained in pure strain in a number of districts in the Bashkir ASSR. In the Burziansk national park a special section has been set up for preservation in pure state and rational breeding of these bees. The import of southern bees to the northern districts and in the forests (the Bashkir ASSR included) is forbidden.

A very wide variation (30—35%) of honey and wax production as well as of live weight of bee colonies and queens' prolificness can be noticed with Central Russian race. The external indices are on the contrary subject to not too great a variability.

The Caucasian mountain grey bee is spread specially in the mountain and forest districts along the chain of the Caucasus Mountains in Grusiya, Adzerbaidjan, Armenia and partially within the limits of Krasnodar region. The Caucasian (or Grusinian) mountain grey bee is best known; it is not only shipped to other regions of the USSR but is also exported. It is very gentle, has the longest proboscis and manifests a slight swarming tendency. Unlike the Central Russian bee its capping is "wet" and dark coloured (the worker bees do not allow for an air layer between honey and the wax cap). When checking the frames, even taking them out the hive, the Grusinian bees keep working without running to the lower lath like the Central Russian bees. They are dark grey, without yellow bands on tergites. The Grusinian mountain grey bee is less resistant to wintering than that of Central Russia. It is more subject to honeydew intoxication and Nosema disease during wintertime. Steps have been taken for preserving the purity of thin race in the mountain areas of Grusiya.

The Caucasian mountain grey bees include some ecotypes, population groups — *megrelian, alhez, imeretin, cartalin,* etc. (in Grusiya) and the *kalakhtapin* in the Adzerbaidjan SSR. The best are the megrelian bees — the worker bees have the longest proboscis which makes them most useful in pollinating red clover seed crops.

As concerns their foraging behaviour, the Caucasian mountain grey bee is more enterprising than that of Central Russia; it is more inclined to robbery but it better defends its nest from the robbers of other colonies. The Caucasian bees are less constant on flowers; they better use the maintenance flow and when it occurs they even limit the queen's egg-laying.

A peculiarity of the Caucasian mountain grey bees is their earlier starting the forage and their later coming back in the evening. In a

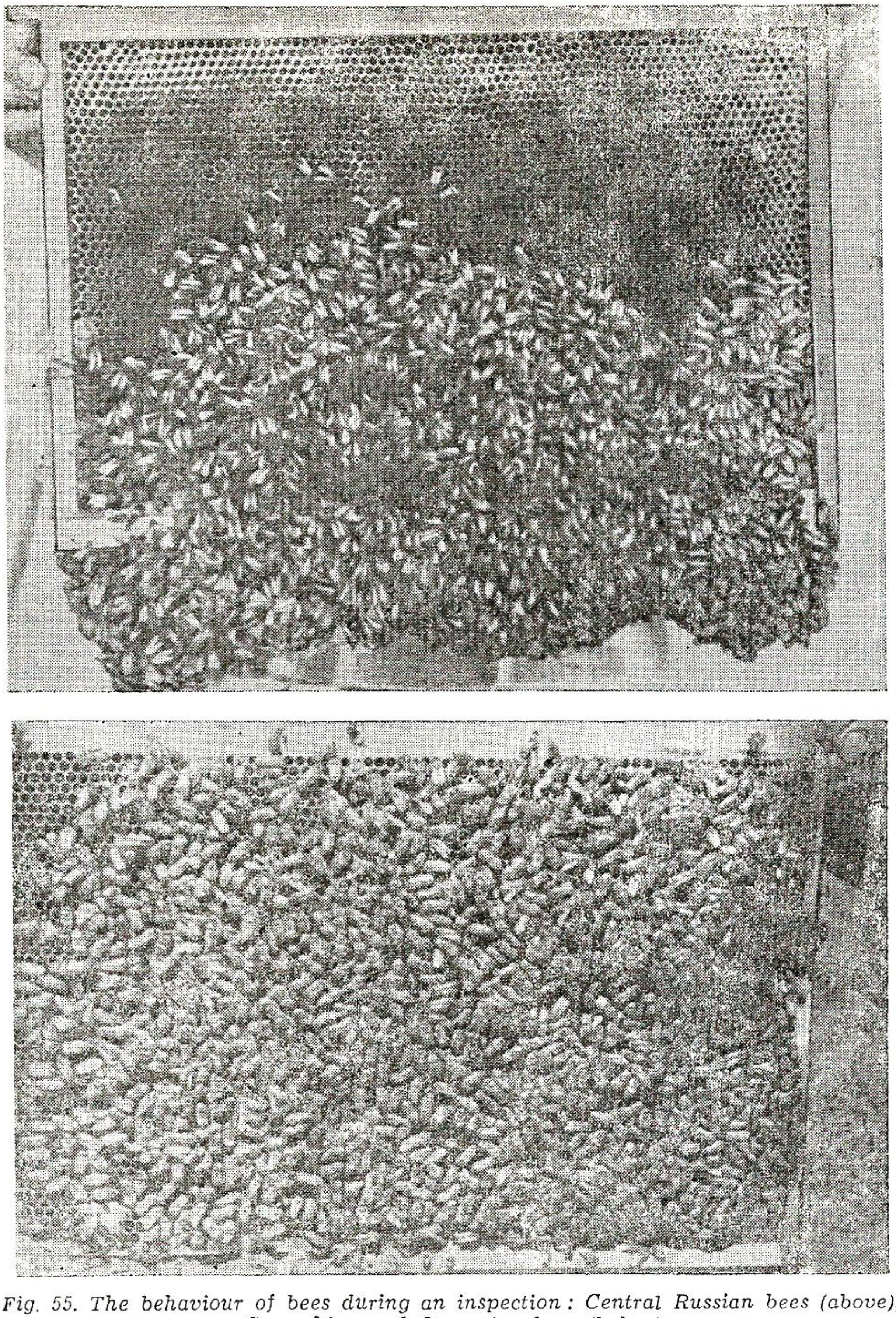


Fig. 55. The behaviour of bees during an inspection: Central Russian bees (above); Carpathian and Caucasian bees (below)

number of districts with poor nectar flows, the Caucasian bees and their hybrids collect 25—30% more honey than the local ones. Taking this into account as well as their lower swarming tendency and their gentleness, their introduction into steppe regions as well as southern forest steppe regions is advisable.

The Far East bee is well adapted to the conditions specific to Primorie region, with an abundant lime-tree nectar flow. It is less aggressive than the Central Russian one and it is not subject to foul brood in the conditions of the Far East; in order to prevent the introduction of foul brood the import of bees of any kind is forbidden to the Far East. This race of bees sprang up on the basis of Central Russian and Ukrainean races (bees brought by settlers coming from the Ukraine and some districts of the RSFSR) with a certain participation of Caucasian and Italian bees. The severe selection which took place under the influence of the long transportations on the sea and ground of the bees and their existence for a century in specific conditions of Primorie led to a bee race which had the characteristic features of the races of Central Russia, the Ukraine and (partly) Caucasian.

The bees of various districts of the Far East are different in colour, behaviour and appearance. Those in the northern region (Habarovsk) are closer to those of Central Russia (dark colour, without yellow bands on the tergites, more resistant to wintering). In the southern districts of Primorie one can find grey bees with very little yellow, quite gentle. The Far East bee shows a strong swarming tendency and a relatively less prolificness of the queens. Surveys of experts of the "K. A. Timiriazev" Agricultural Academy pointed to the high variation in honey production (the Far East) and in queens' egglaying (Primorie) as well as the variation in morphology, greater than with bees of Central Russia and the Caucasus.

The Carniolian bee has been developed on the southern and eastern slopes of the Alps (Craina and Carintia provinces in Austria and Yugoslavia). According to F. Ruttner the area held by these bees includes the middle and lower reach of the Danube, the Romanian Carpathians, Bulgaria up to the Black Sea. In the plain districts their body is coloured in yellow to a certain extent. But the typical Carniolan bee is

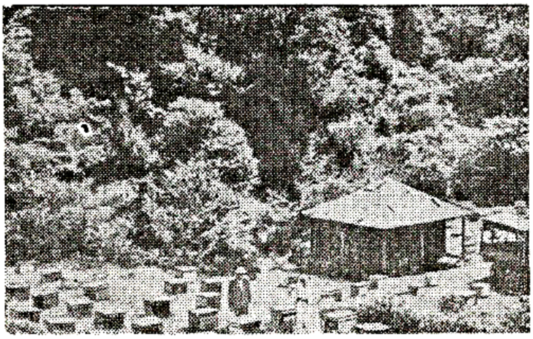


Fig. 56. One of the apiaries of the Chihorotskusk rearing station in the Grusiyan SSR

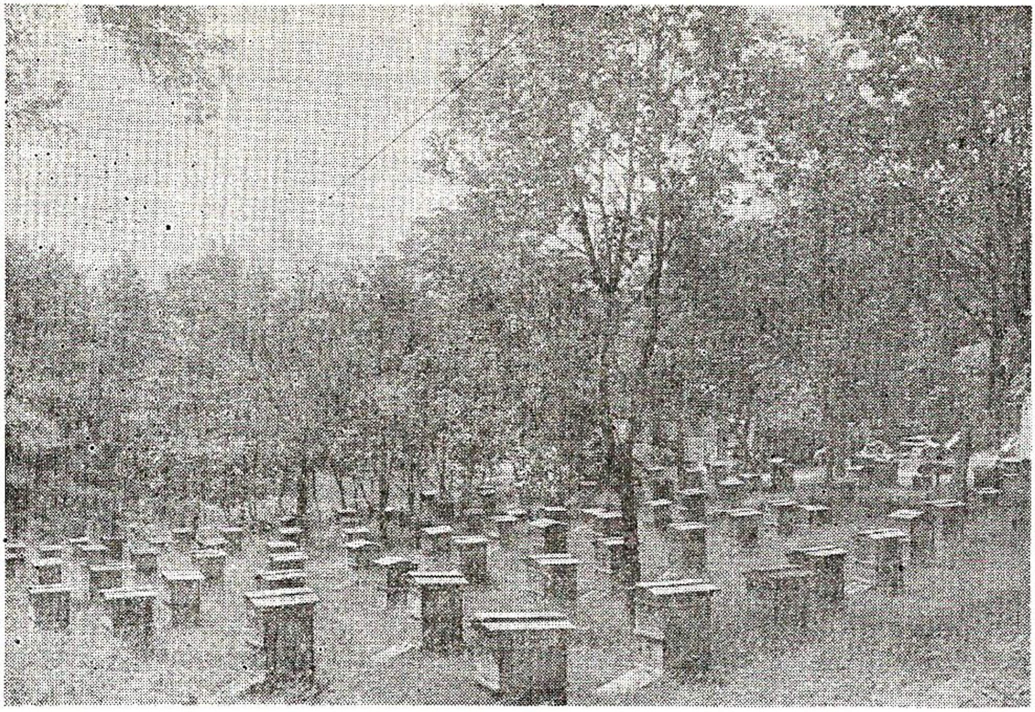


Fig. 57. Apiary with Far East bees in Lozovski district, Primorie

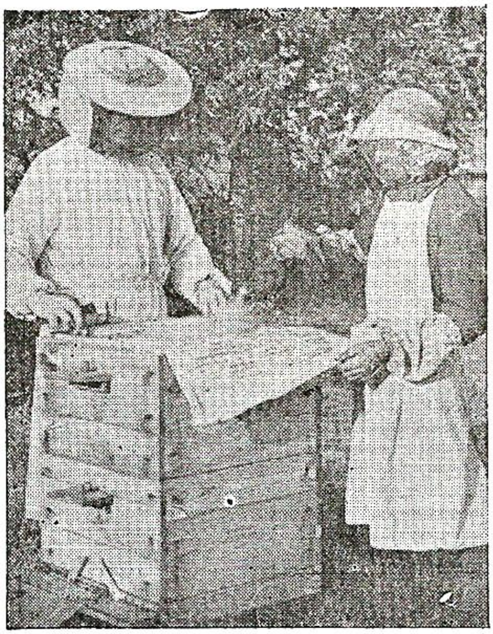


Fig. 58. Inspection of a Central Russian bee colony — with smoker and bee veil

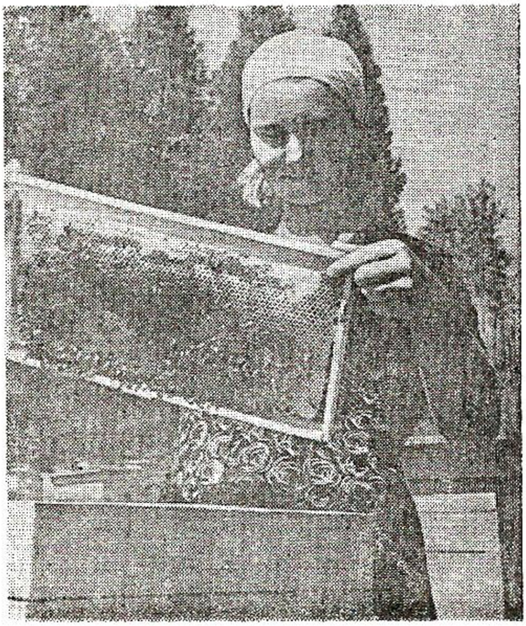


Fig. 59. Inspection of a Carpathian bee colony — without smoker and bee veil

grey, with a characteristic silver stripe down on the posterior end of the second and third tergites.

It is characterized by gentleness, a relatively high prolificness of the queen and an intense build up of the colonies in spring. Many authors mention its well-marked swarming tendency. It is less resistant to wintering than the Central Russian bee.

In the alpine districts of Western Ukraine (trans-Carpathian region and others) neighbouring to the north with the areas held by Carniolan bee, there is to be found the Carpthian bee, which does not differ too much from the former, and which lives under more severe natural conditions. The Carpathian bee is gentler than the Carniolian one and therefore the colonies may be inspected without smoker and bee veil — anytime in the season; the Carpathian queens are characterized by a high oviposition rate: early in the first half of April they lay about 1,000 eggs every 24 hours and by the end of May and the beginning of June about 1,700 eggs.

Unlike the Carniolian bee, the Carpathian bee manifests a low swarming tendency. In the mountain locations no more than 5—6% of the bee colonies swarm. Such colonies may have 8—15 swarming queen cells. In most cases swarming can be prevented by adequate means. Very often, in case of supersedure one can notice the old queen living on good terms with the young one for one month and a half. The colonies of Carpathian bee are characterized by a reduced consumption of food reserves during winter. The flight activity of bees is not highly influenced after taking queens out of colonies. The workers of the Carpathian race gather very little propolis. They are not much disturbed by the beekeeper inspecting the hive. Their honey cappings are "dry".

Following an analytic selection based on genetic-mathematical appreciation of queens in conformity with their descendence the Beekeeping Department of the "K. A. Timiriazev" Agricultural Academy has obtained strains with colonies 35—40% more productive than the original ones (no. 78, no. 77, no. 198, etc.).

Trials in various regions of the country (in Kemerovo, Riazan and Tambov regions in the RSFSR, in the Tartar ASSR, Bielorussian SSR) proved that the colonies of these strains collect by 20—45% more honey than local bees (Carniolan and Caucasian), winter with less losses, are very gentle and manifest a very slight tendency to swarming. For instance, in 1969 at the apiary of the "Riazanskoe Sady" sovkhoze in Riazan region the colonies of Carpathian bees collected 40.6 kg. honey on the average, the Carniolan bees — 34.8 kg., the Caucasian mountain grey bees — 30.8 and the local ones — 28.7 kg. Similar data have been scored in Kemerovo and Tambov regions and in a number of districts in the Bielorussia SSR.

Among further primitive races local importance has the *Ukrainean bee*, spread in the steppe area of the Ukraine, the *Cuban bee* in Krasnodar and Stavropol region and the neighbouring areas, and the yellow bee in the plain districts of Transcaucasia and others. All of them and especially the Cuban and Transcaucasian yellow bees, adapted to warm climate, are less resistant to wintering: they are inclined to swarming and robbery but are not aggressive. From some economic points of view and in terms of biological peculiarities they are inferior to the Carpathian and Caucasian mountain grey bees. Measures have been taken lately in order to replace them with bees belonging to the above-mentioned two races — in Stavropol and Krasnodar regions and in other districts. Meanwhile, steps should be taken for preserving these bees as primary material for the selection work in some districts.

The yellow bee of the Megrinsk mountain district of the Armenian SSR must be also mentioned, which for the time being is not so spread out but which presents a high interest. In terms of appearance as well as biological and economic indices, it resembles very much the famous Italian bees ; it is well adapted to the conditions of dry warm climate, similar to that of Italy. In the future it will be able to be used in the Soviet republics of Central Asia and in other districts with warm climate. The American yellow queens are very prolific and the colony does not restrict their egg-laying at the beginning of the nectar flow. They are less gentle than the Caucasian mountain grey bees. Very much like the Italian bee, its negative characteristic features are the low resistance to wintering and to the incidence of honeydew toxicosis and Nosema disease.

In the countries with a developed beekeeping the largest development has seen the *Italian bee,* which is characterized by the yellow colour of the first and second and partly the third tergites. Besides its place of origin, it has become the basic race in the USA *, Canada, the countries of the Central and Latin America, Australia and New Zealand where it gives large honey yields. Its native land is the northern part of the Apennine peninsula. Some experts suppose that it resulted from a crossing of Egyptian yellow bee with the European black bee. In 1859 it was imported in North America where it has developed to a great extent : a thorough selection led to the so-called Italian golden bee.

Table 10

External characteristic features of worker bees of various races

The characteristic feature	Unity of measure	Central Russian bee in the Bashkir reservation	Caucasian mountain grey bee (megrelian group)	Far-East bee (Primorie)	Carniolan bee	Carpathian bee	Italian bee
Length of proboscis	mm	6.24	7.16	6.40	6.60	6.61	5.51
Length of the fore wing	„	9.35	9.30	9.20	9.41	9.42	9.32
Length of the third tergite	„	2.46	2.25	2.16	2.27	2.28	2.25
Length of the wax plate mirror	„	2.00	2.45	2.41	2.39	2.43	2.45
Width of the wax plate mirror	„	1.62	1.53	1.58	1.67	1.69	1.57
Cubital index	—	1.6—1.7	1.8—2.0	1.7—1.9	2.3—2.5	2.3—2.5	1.7—1.9

* The second place in the USA is held by our Caucasian mountain grey bee, and the third by the Carniolan bee.

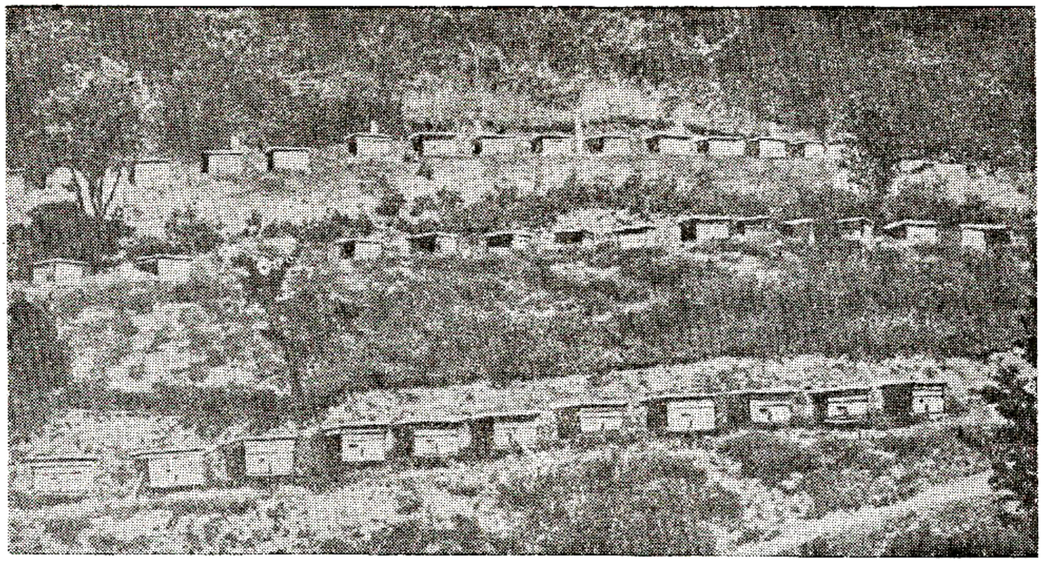


Fig. 69. Apiary in the Carpathian mountains

The valuable peculiarities of the Italian bee are the high prolificness of the queens, the intense build-up colonies, their gentleness (less marked than with Carpathian and Caucasian mountain grey bees). The colonies of Italian bees do not restrict queen's egg-laying when nectar flow starts : therefore they are less adequate in the districts with weak nectar flows. The Italian bees are less resistant to wintering and honeydew toxicosis as well as Nosema disease, than the Central Russian and Carpathian bees.

Choosing the proper race of bees — characterized by high biological and economical performances and at the same time well adapted to a certain area — is very important for increasing beekeepers' efficiency and decreasing the production cost. The most urgent task of research institutions and economic organizations is to undertake a compared study and to test the races existing in various natural and economic areas of the USSR and, on this basis, to establish the most appropriate areas for keeping the different races. Ample experiments with different local and foreign races in various natural zones of our country have been carried into effect in the last few years by the Institute for Bee Research and by a number of experimental stations.

Selection of bees is a sector which lags behind in our husbandry. Although in our country there has been since long a number of valuable races of bees, we still do not have a reproduction stock, the result of a target directed selection work. Actions meant to keep race purity and improve bees methods of mass reproduction and efficient management of bees were paid insufficient attention so far. Many beekeeping farms do not apply even the elementary norms of selection and discarding the bee colonies. Practice shows that an adequate organization of the section work leads to a substantial increase of honey yields in a short time and without large supplementary expenses. The premise is the tremendous variability of honey and wax yields, of honeybees weight, of other economic features and of queens' prolificness within apiaries.

For instance, the coefficient of variability for honey production is 30—40%, for wax production — 25—30%, for quantity of brood and bees in the colony — 20—25%. This means that there are colonies in the same apiary whose honey and wax production may be 3—4 times higher or lower than average indices. The same applies to oviposition.

Even colonies made up of package bees headed by sister-queens may categorically differ as far as build up pattern and honey production are concerned.

An average honey production of 30 kg. per colony of Carpathian bees (combless packages transported from Uzbekistan) was obtained in Siberia in 1973; some colonies collected 48 kg. while others less than 20 kg. The brood pattern in package bee colonies showed that the average egg-laying rate of the queens before the main nectar flow was of about 1,900 eggs/24 hours (the best queens lay 2,900 eggs in 24 hours while the worst — less than 1,000).

Of course, a high productivity of bee colonies can be reached only under good food and management conditions; a highly important role is also played by the hereditary qualities of bee colonies.

The aim of all selection programmes is choosing, improving and breeding the bee colonies and queens possessing valuable hereditary qualities — high honey and wax production, efficiency of pollinating activity, good wintering, low swarming tendency, resistance to disease, etc. The qualitative improvement of the bee colonies in most districts with developed bee-keeping (Far East, Siberia, Ural, Transcaucasia) should be made by mass selection in the big apiaries of sovkhozes and kolkhozes and the selection of valuable local races well adapted to natural conditions and to the particular nectar flows. In some districts the performances of bee colonies may be considerably increased by using F_1 hybrids (of the first generation).

The methods used in general husbandry cannot be applied undiscriminately to the selection work in bee-keeping. It is necessary to take into account the biological peculiarities of honeybees and to make an assessment and selection especially according to economic indices of the bee colony taken as a whole. The qualities of the genitors (queens and drones) can not be appreciated function of the indices of the colony, because they do not gather nectar and pollen and they neither yield any production nor participate in plant pollination.

Unlike other branches of animal breeding, the queens are more important than drones in the selection work. The queen lives for several years and it has a huge number of descendants. Several thousands queens (daughters) can be obtained practically from a queen valuable for the breeder. The rapid maturation of queens and drones plays a great part. These peculiarities of the honey bee are very important for increasing the rate of qualitative improvement of colonies and rapid multiplication of the valuable stock. Finally the possibility to control the food and other colony conditions, especially the possibility to influence them through the nurse bees is highly important in honeybee selection. Some difficulties in the selection work in beekeeping derive from biological peculiarities. It is the free mating of queens and drones, which is difficult to be controlled in common apiaries, as well as the complexity and variety of factors influencing the bees' productivity. That is why the assessment of selection indices is frequently quite exact for both colonies and queens. These shortcomings can be partly done away with thorough organizing special mating stations provided with drones of a well-known origin (see below) and testing queens after their descendants.

Rearing Methods in Beekeeping. Parallel with improving bees' feeding and management conditions each and every apiary must carry on a selection work. A careful breeding work allows for higher honey yields and improvements with respect to the efficiency of the branch; likewise, the possibility to introduce improvement management technics and better beekeeping programs.

Beekeeping with high-capacity multiple-storey hives (with two or three boxes) requires among other things prolific queens and strong colonies; gentle bees with low swarming tendency largely contribute to raising the colony's productivity and the beekeeper's efficiency; team work may better prove its efficiency in apiaries with non-swarming bees.

The different regions of our country are characterized by a wide range of natural and nectar flow conditions as well as of bee races. Only one method of selection cannot be applied. Various methods of rearing and breeding bees can be applied function of zonal peculiarities, management techniques, volume of the apiaries and their specialization.

In areas where the valuable bee races are native, well adapted to local conditions (the bee of Central Russia, the Caucasian mountain grey, the Carpathian and the Far East bees), the main concern of breeding must be the preservation or race purity (the analytic selection) using mass and individual selection with queen's appreciation after descendants. The problem of protecting, improving and rationally using the best local races should be solved as soon as possible.

Unlike the analytic selection, the selection requires bees of two or more races, all contributing with their valuable qualities (high resistance to wintering of the Central Russian bee, long proboscis and low swarming tendency of the Caucasian mountain grey bee, etc.).

Parallel with pure race breeding, the commercial crosses of bees belonging to various races can be efficient. As it was demonstrated by experiments at the Institute of Bee Research the first generation of hybrids Caucasian × local bees and Far East × local bees distinguished themselves by a productivity bigger than 20—40% in a number of districts of the country. Nonetheless commercial crossing must be carried into effect under a severe control. One must take into account that the productivity of hybrid colonies in the second — and all the more in the third and future generations — suddenly decreases. In most cases the inter-strain hybrids are more rational, warrant the preservation of the purity of race. Such inter-strain hybrids are largely used in the USA: very popular are the inter-strain bee hybrids of Italian ("Starline") and of Caucasian mountain grey ("Midnite") bees.

In countries which have valuable native bees (Italy, Austria, Yugoslavia, Bulgaria, Romania, France, etc.) the beekeepers are mainly preoccupied with breeding the pure local race.

In the last few years a number of countries have tried to replace their local bees by imported ones. With this aim in view GDR and Federal Germany largely reproduce their Carniolan bee.

For the various districts of our country the Technical-Scientific Council of the RSFSR Ministry of Agriculture recommended the following guide-lines for the selection work in bee-keeping.

1. *Improvement of local bees of pure breed by mass or individual selection* — in the regions of Krasnoiarsk, Primorsk and Habarov, Amur, Arhanghelsk, Cheliabin, Chitin, Irkuts, Kirov, Kostroma, Kurgan, Perm, Sahalin, Sverdlov, Tiumen, Tomsk. Vologda, in the Bashkir, Bureat, Tuvin and Udmurt Autonomous Soviet Socialist Republics, in the Transcaucasian Republics, the districts of Western Ukraine, the forest zone of Bielorussia, East Khazakhstan and some mountain districts in the Central Asian Republics.

2. *Improvement of pure breed of local bees by mass or individual selection or by commercial crossing of the local bees with Far-East bees* in the regions of Altai, Kemerovo, Novosibirsk and Omsk.

3. *Improvement of pure breed of local bees by mass or individual selection or by commercial crossing — under severe control of local bees with Caucasian mountain grey bees* — in the regions of Belgorod, Briansk, Gorikovo, Iaroslav, Svanov, Kaliningrad, Kalinin, Kaluga, Kuibyshev, Kursk, Leningrad, Lipets, Moskow, Novgorod, Orenburg, Orlov, Penza, Pskov, Riazan, Saratov, Smolensk, Tambov, Tula, Ulyanov, Vladimir, Volgograd, Voronezh, in the Mari, Moldavian, Chiuvashan and Tartar Autonomous Soviet Socialist Republics.

4. *Improvement of pure breed of local bees or Grusinian mountain grey bees by means of mass individual selection or their commercial crossing* in the region of Krasnodar and Stavropol, Rostov, in the Daghestan, Kabardino-Balkar, North Osetia and Chechen-Ingush Autonomous Soviet Socialist Republics.

In the areas allowing for commercial crossing the preservation of a compact massif of local bees is necessary on the territory of at least two or three neighbouring districts in order to further the process of their improvement by means of pure race breeding; the other districts will be supplied with improved local queens as initial material for obtaining F_1 hybrids *.

Mass selection of bees is the simplest form of selection and the most accessible for common apiaries. It can be efficient thanks to the mass character and the possibility of being applied to a large number of apiaries and bee colonies. Mass selection as well as any other form of selection work can yield good results only under best food and management conditions.

In order to carry out successfully the selection work, it is necessary :

1) To set up optimum breeding and developing conditions for the bee colonies, paying a special deal of attention to queens and drones ;

2) To preserve the individual character in developing bee colonies; to restrict bees' migration ; to restrict displacements of bees and brood from one colony to another ;

3) To keep data on the situation of production and control in apiaries, to register the origin of queens and bee colonies ; to estimate the main economic indices of the colonies ;

4) To make selection within an as large as possible number of bee colonies, taking into account the fact that the more comprehensive the selection basis the surer the evidence of best colonies ;

5) To study the peculiarities of local natural conditions and the character of the nectar flow — they have a decisive importance for the development and productivity of bee colonies.

The appreciation and selection within mass selection is made according to the sum of economic indices : honey and wax production, strength of bee colonies and prolificness of queens ; resistance to wintering, swarming tendency, health condition of bee colonies and adaptation to nectar flow conditions typical to the given locality.

Honey production can be appreciated according to the quantity of honey collected by the colony during the season and the honey left to bees as food reserve. This is the gross production of the colony. The amount of honey may be determined by different means. The simplest, and however, the most approximative, is the assessment with the naked eye; a full comb (435×300 mm), capped by bees contains about 4 kg of honey. The amount of honey may be more exactly assessed by weighing every frame taken separately (if it contains only honey) and by deducing from the gross weight the weight of the frame and empty comb (about 500 g. for a comb of 435×300 mm). In this case the use of spring balance is recommended.

Likewise the quantity of honey collected may be determined weighing all combs of a bee colony before and after extracting honey.

The wax production of the bee colony can be determined by the number of combs built on the foundations during the whole season.

The strength of the colony (honeybee intervals) and prolificness (number of brood combs — open and capped) can be determined three times during the season : during summer season, before the main flow and during autumn check up.

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* The Institute for Bee Research and its experimental stations have accumulated much material on whose basis the new recommendations for the main directions of selection work in apiculture and the plan of distributing races per districts will be drawn up.

Resistance to wintering is appreciated according to the amount of food consumed in winter by the bee colony on the whole and calculated per interval of wintered bees too, the quantity of dead bees and the degree of dirtying the hive with faeces (the five-point scale). We can make use of the data of inspections made in autumn and spring.

The health condition of the bee colonies is determined at the periodical inspection of their nests, of capped and uncapped brood and of mature bees. The sick colonies cannot be used for multiplication even if they distinguished by honey yield or other indices.

The swarming tendency of bee colonies is appreciated after the absence of swarming condition.

For choosing the best adapted colonies to local conditions one must take into account only those colonies which had high honey yields under conditions typical for the respective locality.

Attention must be paid to indices attesting the relation of bees to the race which is reared: the colour of the tergites, the way honey is capped, behaviour when the nest is checked up, external morphology indices.

In conformity to the above-mentioned indices the bee colonies of the apiary are to be divided into groups by the end of the season. The first group must include no less than 8—10 colonies — the best in terms of resistance to wintering, strength, development, health, honey and wax production, swarming tendency — all perfectly corresponding to local, pure breed. The second, larger group, includes common colonies, which scored average performances. The third group (no more than 10—15% of the total number of bee colonies of the apiary) is made up of the less productive colonies, less resistant to wintering, those who were ill or had a weak build up.

The colonies of the first group are used for queen and drone rearing. Within the colonies of the second group the queens are replaced with younger ones, reared in the colonies of the first group. Besides, the colonies of the second group can supply bees to make up auxiliary colonies, headed by queens selected from the first group daughters.

The colonies of the third group must be destroyed: 4 or 5 of the best colonies of the first group are used as mother-colonies. No matter how many mated queens obtained in the respective apiary, the beekeeper must have no less than 5—6 drone-rearing colonies: a smaller number cannot warrant a sufficient number of drones for mating queens. The closer to the respective apiary are the neighbouring ones, the more urgent is the need to set up the drone-rearing colonies and to stimulate them to produce an as large as possible number of drones. As a result, in all probability the queens will be mated by drones of a certain origin.

Mother-colonies must not be closely related to the drone-rearing colonies because this would inevitably lead to lower viability and productivity. In order to avoid such negative consequences in breeding at every 2—3 years the beekeeper has to make a mutual exchange of the best queens in his selection apiaries.

Mass selection can be applied in any sovkhoze and kolkhoze apiary and this is precisely its advantage. Nevertheless it does not yield the same results as the thorough selection work with queens' tasting according to their origin.

Selection on bee lines. Such a selection, more thorough as compared to mass selection, must be practised in the best apiaries, in the large farms of sovkhozes and kolkhozes, coupled with large-scale queen building. The compulsory conditions for this activity being efficient are abundant honey flows, good food reserves, optimum management conditions (large reserves of good combs, high-capacity hives, etc.) and queens and drones reared in very good colonies.

A rigorous selection work require good evidence for all colonies of the apiary. The bee colonies can be appreciated only by knowing their condition in spring, before the main flow and before wintering (the number of bees and the amount of brood, the gross honey and commodity honey yield, the number of combs they built, the number of combs with bees and brood taken for auxiliary colonies or with other aims in view).

Very much like mass selection, the thorough strain (line) selection starts with the best colonies in point of productivity and biological peculiarities. The main index of the value of the colony is its gross honey production. Besides, worthy of mention are also the wax production (the number of combs built on foundations), the queen's prolificness (its consequences are the strength of the colony, the amount of brood in spring and before the main flow), the absence of swarming tendency, the type of wintering, the bees gentleness.

The best colonies (rated by the above indices and of their queen) are called "elite". Practice demonstrates that sometimes a colony or a queen with outstanding performances fail to transmit their valuable qualities to the progeny. The value of the elite-stock and the heritability coefficient of some qualities increase under the following condition :

1. if not only one colony but a whole group of sister-colonies (descending from the same queen) distinguish themselves in point of productivity ;

2. if not only the queen (or the colony) are remarkable, but their forerunners too (mother, grandmother) ;

3. if the elite colony scored very good results not only one year, but several years running.

Part of the best "elite" colonies are used for obtaining larvae for rearing queens, while another part for obtaining drones. A few colonies are used for queen rearing (nursing colonies).

Many beekeepers sometimes consider any high yielding colony as useful for work. It is not correct because the "elite" colonies are assessed as such upon external indices, the causes of their high productivity are not clearly set off (valuable hereditary qualities or provisional, random circumstances such as drifting contributing to the production of the colony under observation, hidden robbery, etc.). The fact is known that F_1 hybrid colonies yield a high production and among them there are colonies with bumper results ; nevertheless in the second and the following generations the hybrid bees' productivity suddenly drops. A principle in husbandry says that a pure-breed animal is characterized by a high productivity but not all highly-productive animals are pure-breed. This principle is also valuable for beekeeping.

Valuable in point of selection are those queens with bumper results whose descendants yield better results than usual colonies. These are colonies with bumper results, apt for improving. Nevertheless, there are cases when the descendants of an "elite" colony yield weaker productions than common colonies. That means that the respective queen had not valuable hereditary qualities.

The breeding qualities of "elite" queens can be more exactly determined by their testing according to descendants.

Testing queens according to their descendance is the most important stage of the selection work in bee-keeping. With this aim in view, according to the dimensions of the farm and the queen-breeding plan, one must choose 3 out of 6 best colonies.

Testing the queens by their descendants requires a group of sister-queens to be reared from each "elite"; the larger this group the more exact the appreciation will be. Within large apiaries, with a well-organized activity of queen rearing, each and every queen is supposed to produce 100—120 daughter queens. Within apiaries which have not yet the necessary technical basis, a smaller number is enough (25—30 daughter queens). In this case the test will be less relevant.

For levelling the drones' influence upon the queens' descendants, the daughters of all "elite" queens which are tested must be mated with a certain drone population. With this aim in view the best is to organize an isolated mating station, sheltered from wind, where there are no apiaries on a radius of 5—6 km. As many as 5—10 strong drone-rearing colonies must be located in such a place in which there are many drones and nuclei with unmated queens. If there is not an isolated mating station, the daughters of the "elite" queens are mated in a common apiary, where a permanent group of drone-rearing colonies should exist. Within the other colonies the drones' development is limited by usual means.

For appreciating the elite queens one must compare the respective groups of daughters among them and to the common queens. Groups of bee colonies equal in terms of quantity and quality are made up and the daughters of elite queen are introduced into the colonies of each group. Such colonies can be auxiliary colonies made up at the same time with common groups in which old queens are replaced by "elite" daughters to be tested. The number of the groups in each apiary and the number of bee colonies in each group depend on the sizes of the beekeeping farm and on its separate apiaries, on the number of tested elite queens and on the number of daughters reared from each of them.

If for instance one tests four elite queens (100 daughters each) 500 colonies are necessary. 400 of which are headed by elite daughters while 100 by common queens. The testing work may be organized in four apiaries. Each apiary must have 5 groups made up of 25 colonies. The bee colonies of the first group are headed by daughters of elite queen A; the second group by daughters of elite queen B; the third group — by daughters of elite queen C and the fuorth group — by daughters of elite queen D while the fifth group by common queens. In not too large farms one can organize testing of fewer queens (2—3), on a smaller number of daughters, distributing them at one or two apiaries.

Mother colonies

Isolated mating station

Conventional signs

offspring no. 104

" " 88

" " 78

" " 48

" " 41

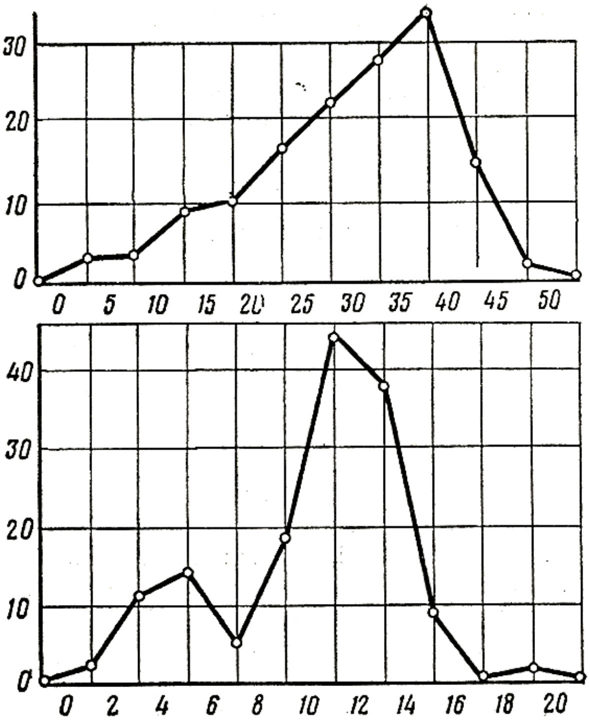
All daughter queens to be compared ought to be reared in strong and highly productive nursing colonies under equal conditions (the same method of obtaining larvae, formation of nursing colonies, tending the mated queens, etc.). The feeding conditions and management of the bee colonies in the groups which must be compared should be similar too.

Final conclusions on the productivity of colonies headed by daughters of the elite queens under test can be drawn only the next year, because in the first year only bees descending from the old queen work. The prolificness of the daughter queens can be appreciated also in the first year of testing, especially if the queens were introduced in the hive in spring, before the main flow. There is a direct relation between the queens' prolificness (the amount of brood and the strength of the colony) and the honey yield of the colony. As a rule, the more brood and bees in a colony before the main flow the larger the gross honey yield. Therefore, early in the first year of testing one can make a previous estimation of queens which are tested according to the fecundity of their daughters. The final appreciation can be made only the next year according to honey production.

On the basis of records during the controls, the average production of the colonies is calculated for each group with daughters of an elite queen and with control groups (with common queens). The elite queens are classified as followed on the basis of comparisons in terms of average honey yield: the honeybee colonies of each group among them and with the colonies of each apiary and with the average production of all apiaries. The elite queens whose daughters were characterized by a low productivity should be discarded as negative elements, since they are not valuable for the selection work. The queens wh se daughters distinguished by the highest productivity as compared to common queens and to daughter queens of the other elite queens, have high selection qualities. These are the elements of improving with valuable hereditary qualities productivity and, most important, they transmit their qualities to the descendants.. These queens can lay the bases of highly-productive lines.

Fig. 61. Variability of honey and wax production in Carpathian bee colonies (brought as combless packages) in Siberia ("Lysinskii" beekeeping sovkhoze, Kemerovo region, 1973):

above: on the abscissa: honey production (kg) — $n = 140$; lim $= 3.9 — 48.0$; $M \pm m = 30 \pm 0.84$; $Cv\% = 33.18$; on the ordinate: number of colonies. Below: on the abscissa: combs built (pieces); on the ordinate: number of colonies; $n = 140$; lim $= 1 — 19$; $M \pm m = 10.50 \pm 0.29$; $Cv\% = 33.14$.



An example of efficiency of selection work with testing elite queens after their offspring can be the first experiments of selecting bees in a number of kolkhozes in the regions of Stavropol and Krasnodar, undertaken by the author of the book as early as before the war. At the apiary of the "Leninfeld" kolkhoze (Stav-

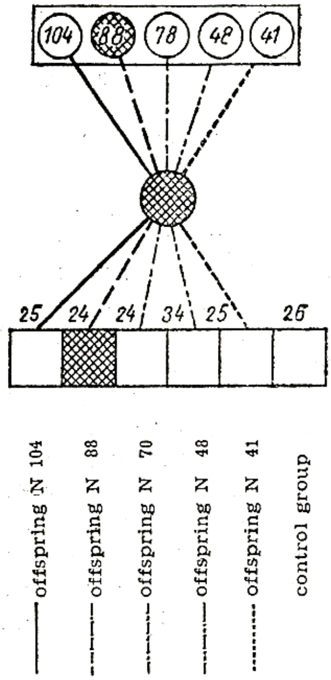
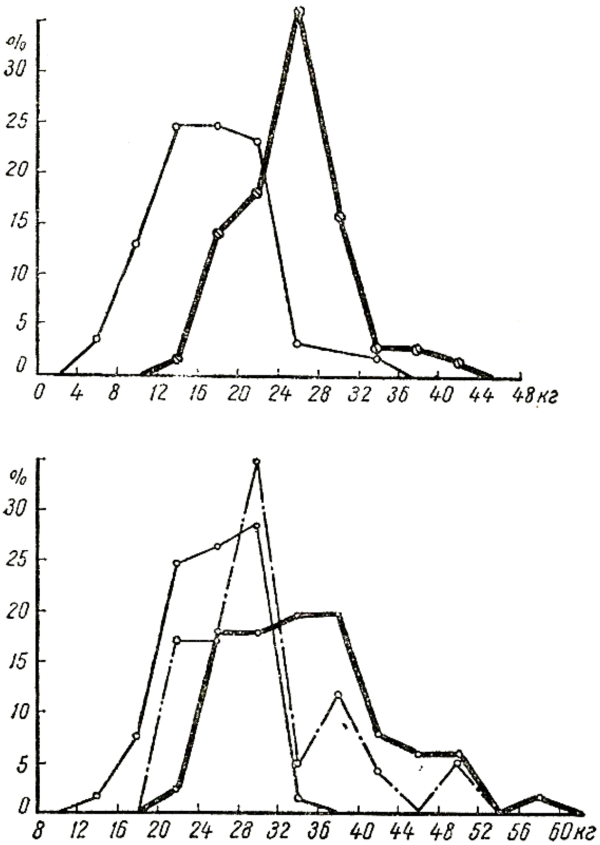


Fig. 62. Distribution of the elite queens daughters per apiaries for testing after offspring

Fig. 63. Production of the off-spring of elite queen no. 65, no. 57 and the control group



ropol region) the queens no. 65 and 57 were tested after their offspring. The colony with queen no. 65 produced 125 kg. of honey in the first year and 118 kg. in the second year. Highly productive were also the predecessors of this queen as well as its sisters. As many as 400 daughters were reared from queen no. 65, 110 of which were used in the tests. Concurrently the queen no. 57 was also tested. The colonies with queens which were daughters of queen no. 65 gathered by 45% more honey than the colonies of the control group (headed by common queens). The daughters of the elite queen no. 57 rose the productivity of the colony by 20%. More brood and bees have been recorded in the colonies with queens — daughters of elite queens. It is interesting to note that the offspring of elite queen no. 65 gathered more honey not only per colony but per 1 kg. of living weight of bees too. In the next year the best colonies in all terms of build up and production, in all apiaries of the kolkhoze, were descendants of the strain no. 65.

Similar data were obtained by the Beekeeping Department of the "K. A. Timiriazev" Agricultural Sciences Academy with individual selection of bees from the Far East in the apiaries in the Primorsk region, of the Carpathian bees in the Ukrainean SSR, of Caucasian mountain grey bees in Stavropol region and of Central Russian bees in the apiaries of Bashkir reservation. Five queens were selected and tested after their offspring in the region of Primorsk. Centralized data on the egg-laying of the daughter-queens and the productivity of bee colonies of various strains are presented below.

Besides one cannot lose sight of the fact that in all apiaries the best colonies in terms of basical indices are the descendants of the elite queen no. 188 (5 M strain). Therefore one can assert that the difference of productivity (see table no. 10) is conditioned by genotypical factors and that elite no. 188 — the founder of 5 M

Table 11

Queens' egglaying and honey production in bee colonies of Far East at various strains

Strains	Average honey production (kg)	Egg-laying	Number of ovarioles in the queen's ovary
1 M	61.77±4.60	1.200±51	293.4± 7.10
2 M	59.90±4.10	1.238±24	289 ±10.0
3 M	52.7 ±4.24	1.106±52	259.3± 8.9
5 M	75.8 ±2.42	1.486±46	298.5± 7.6
control group	50.2 ±3.92	986±29	261.0±11.1

strain constituted an improving factor. The presence of a great number of highly productive descendants makes surer the conclusion.

Year 1967 saw the testing of four of the best daughters of the founder of 5 M strain and the colonies proved productive. Thus, the founder of 5 M strain (queen no. 188) permanently transmitted the hereditary qualities not only to its daughters but also to its granddaughters.

The Carpathian queen no. 78, tested after off-spring distinguished by the same valuable qualities. Its daughters laid 1702 eggs on the average in 24 hours as compared to 1103 eggs in the colonies of the control group. The bee colonies of this strain surpassed as concerns honey production the bee colonies of the control group by 35—40%.

In the 1972—1973 period, following the individual selection of Caucasian mountain grey bees, with estimation of queens after their off-spring in the "Kislovodski" kolkhoze in the Stavropol region, the Apicultural Department of the "K. A. Timiriazev" Agricultural Sciences Academy, kept for breeding the strains 8 and 155 which proved an increased prolificness of queens, by 25%. The bee colonies with the queens of the strain 8 collected on the average 30.8±8 kg. honey and the colonies of strain 155 only 21.1±9 kg. in 1973. The difference of 9.6 kg. is statistically significant.

Inter-strain hybrids of bees. The well-known "Dadant" American firm produces "Starline" — inter-strain hybrids between the Italian bee and the Caucasian mountain grey bee which are largely used in the USA.

The Apicultural Department of the "K. A. Timiriazev" Agricultural Sciences Academy developed and tested in the conditions of production the method to obtain in-bred and outbred hybrids of lines of Far East bees and Carpathian bees. Inbred lines of the first, the second and the third generations are obtained following artificial insemination of queens with sperm of brother-drones. Then the queens of an inbred line are mated with the drones of the second line of this kind. Close inbreeding leads to a decrease of weight of the queens and bees, as well as of their viability; crossing of individuals of different inbred lines leads to heterosis, which results in an increase by 20—25% of queens' egg-laying and the production of their c lony. Thus the purity of bee race is preserved, at the same time using the phenomenon of heterosis.

Any selection method using the estimation of queens after their offspring cannot be successful unless it is accompanied by controlled

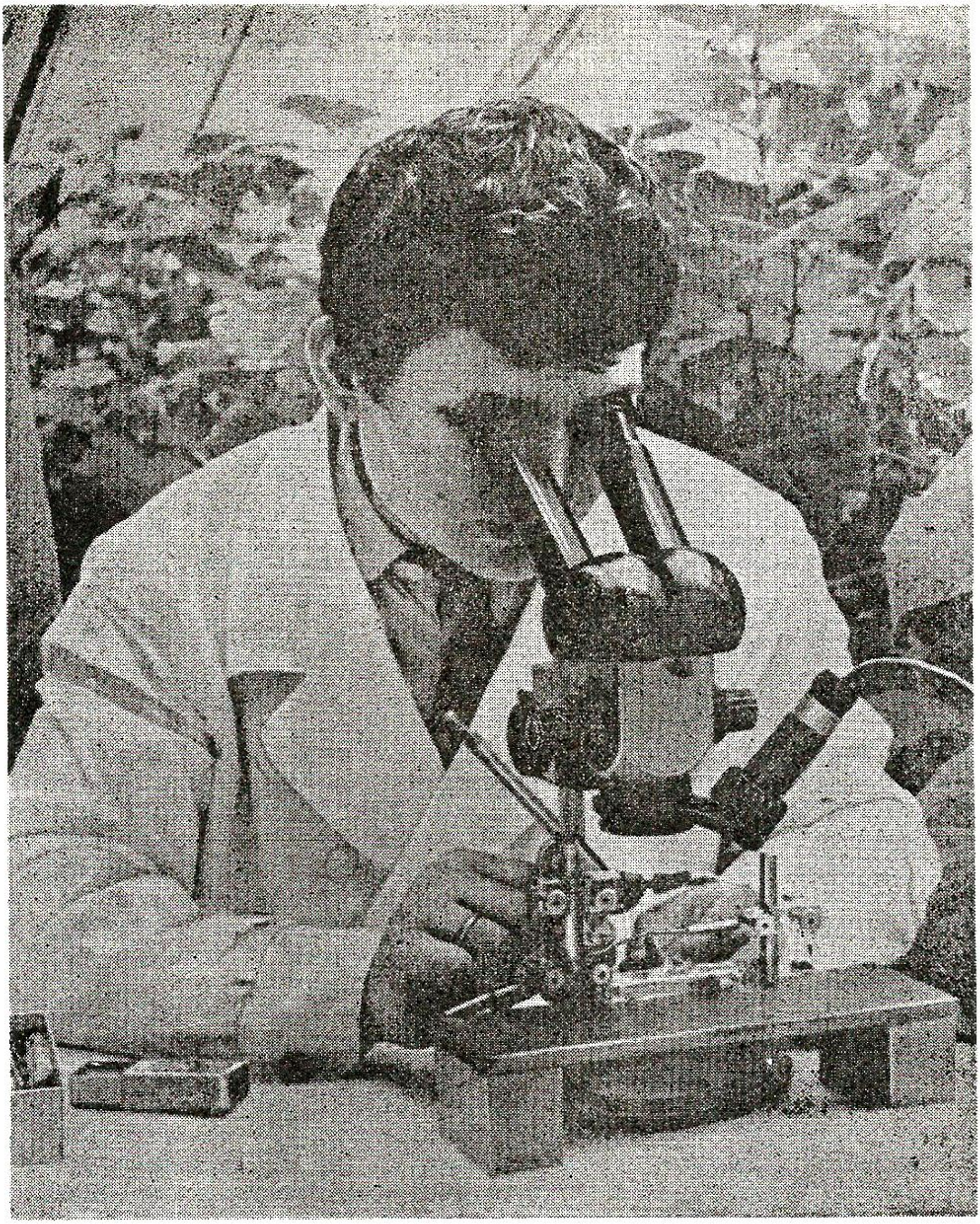


Fig. 64. Artificial insemination of the queen

rearing of drones in strong and highly-productive colonies. Of similar importance are records keeping and discarding of queens. First the queens are discarded in the stage of queen cells by removing all under-sized queen cells; secondly — when they are still unmated. The fact was demonstrated that the larger the queen, the better its ovaries are

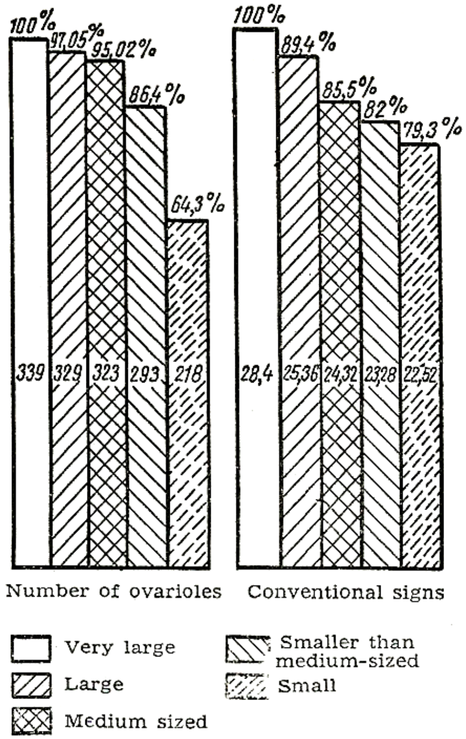


Fig. 65. Influence of queen's size on its prolificness and the production of the colony

developed and the higher its prolificness and production of the colony. Therefore before introducing the queens in the nuclei one can discard the small and under-developed ones. The queens of average sizes may be left and used for other purposes.

The largest and best developed queens must be utilized for selection. It is necessary to multiply by all means the queens which proved to have improvement factors, and their best daughters, to obtain from them as many queens, drones and new colonies as possible. The breeding work is continued within the best lines.

In order to prevent the negative influence of inbreeding, several highly-productive lines must be created with the aim of subsequent new inter-line crossing (queens belonging to a line, drones — to another and the nursing colonies — to a third one). In each line, new elite queens are set off and tested by their offspring. The off-spring of the queens which proved to have improvement factors can be used as breeding material for raising the production of colonies in the neighbouring apiaries of the respective bee-keeping farm.

Following a systematic selection which lasted a few years, practiced by crossing between Central Russian bee and the Caucasian mountain grey bee, the Institute of Apicultural Research obtained an ecotype named "Oka", part of whose lines have the valuable qualities of the initial races and distinguish themselves by a 25—30% higher yields. The testing of bees belonging to this group is now made under production apiary conditions.

The thorough and systematic selection work, practised within the large specialized apicultural farms, testing queens after their offspring and setting up lines — that is how new highly productive groups of races and bee races can be obtained.

PREPARING BEE COLONIES FOR NECTAR FLOW

In most districts of our country the period of the main nectar flow — when the bees collect the most important amount of marketable honey — is relatively short (about 3—4 weeks). The profitableness of the apiary often depends on the way in which the beekeeper knew how to prepare his colonies for this nectar flow. It is important to help the colonies so that they reach their best form at the beginning of the nectar flow and or of the pollinating period of the main farm crops. This depends first and foremost on the food and the quantity of good nest combs and honey combs existing in the hive. Very important is also the quality of the queen. Finally, conditions must be created for the expression of instincts which stimulate nectar collecting and the inhibition of instincts which hinder nectar collection.

Measures taken before the main nectar flow alone are not enough. All apiarists' activities all the year round must be devoted to one and the same aim : to meet the main flow with strong colonies, apt for work, with a sufficient reserve of combs to store honey. The preparation for honey collection must start in the autumn of the preceding year since only well-prepared colonies — strong and well wintered — can develop successfully in spring and effectively take advantage of the honey flow. This problem must focuss a great deal of attention after wintering : supporting the spring build up, building foundation combs, new auxiliary colonies, preventing natural swarming.

A correct preparation of the colonies for the main nectar flow and its fuller utilization requires some data upon the period, duration and intensity of the nectar flows to be in places where apiaries are or can be conveyed.

In the districts with early main flow, the period is very short between the end of wintering and the beginning of the main flow, which does not allow for sophisticated or long-term techniques. In these conditions the wintering of strong colonies is highly important ; securing the apiaries with mated queens to be introduced in the colonies early in spring is also a good support.

In the districts with late nectar flows (buckwheat and sunflower for instance) which start 2.5—3 months after the end of wintering there is enough time to build up strong colonies on the account of auxiliary colonies which are formed with young queens, emerged in spring. In 6—7 weeks such auxiliary colonies can rear 2—3 generations of bees, which can be used for nectar flow concurrently with the bees reared in basic colonies. In localities with short but intense nectar flow (lime tree, for instance) highly important is to build up a strong colony for the be-

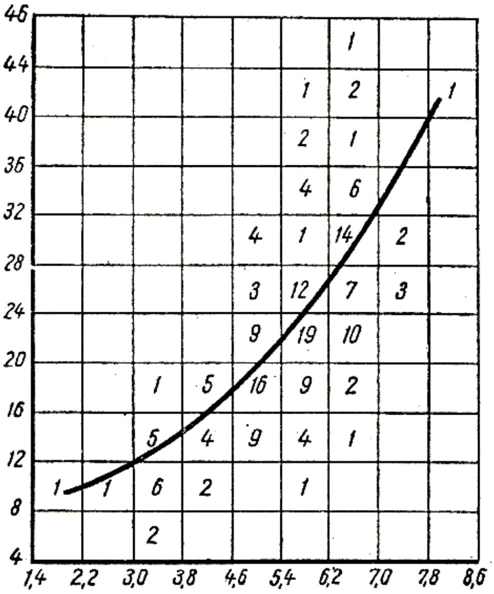


Fig. 66. Correlation between the strength (live weight) of the bee colony and honey production (r 6.687 ± 0.039).

On the ordinate : honey yield (Kg)
On the abscissa : live weight (Kg)

ginning of the flow (up to 6—7 kg. and more — of bees) with the aim of having their food secured and their producing more marketable honey. Under these conditions it is important to build strong colonies in autumn, to fortify bees in spring and to use temporary auxiliary colonies and to prevent swarming in due time.

In the conditions of a lasting but not too abundant nectar flow it is advisable to form strong colonies and to take measures for limiting the queen's egg-laying when the nectar flow starts. As a consequence the bees will spare energy and food for rearing the brood and they will gather more honey. If in a given area there are two not too abundant nectar flows, it is not advisable to limit the queen's egg-laying, since the bees reared during the first flow can be used for the second one.

The mention should be made that the type and character of a nectar flow are not permanent even in one and the same place ; they largely vary according to economic, weather and other conditions. The character of the nectar flow can suddenly modify according to the changes in the pattern of melliferous crops the dimensions of areas under these crops and the management techniques of nectariferous crops, temperature and humidity, rainfall, etc.

Huge possibilities for controlling the forage pattern offers the migratory beekeeping, which permits utilization of nectar flows on the massifs of melliferous plants in various areas or districts. Therefore, taking into consideration the type of nectar flow in the respective place and the possibility of using other ones, one cannot prepare the colonies only for the local nectar flow. The work of feeding, multiplying and keeping bees must proceed in such a way that during the season one could use various types of nectar flow and with this aim in view one can permanently have in the apiary strong colonies.

The average of keeping strong colonies. Both research and practice have demonstrated that with any type of nectar flow, strong colonies gather more nectar per unit of live weight. As it has already been mentioned above, a direct correlation has been established between the strength of the colony and the nectar collection. Within strong colonies, in which the most favourable food and temperature conditions can be met, best quality bees are reared: they are large, with a long proboscis and a honey sac larger than with bees in medium and weak colonies. The bees reared in strong colonies can bring a larger amount of nectar and pollen; the summer bees have a longer life; a relatively greater number of them fly out of the hive for collecting nectar (Tables 11 and 12).

Table 12

The number of bees coming from strong and weak colonies (data supplied by "K. A. Timiriazev" Agricultural Sciences Academy

Hours of observation	Bees which came in two minutes			
	Total		Calculated per 1 kg. of bees	
	in strong colonies	in weak colonies	in strong colonies	in weak colonies
9—10	114	69	48	40
13—14	111	39	36	28
16—17	110	55	32	32

Table 13

Dependence of weight of pollen pellets on the strength of the colony

Date of observation	Average weight of pollen pellets (mg)	
	with strong colonies	with weak colonies
May, 2	15.72	11.04
May, 18	21.46	14.70
June, 2	20.82	13.55

Strong bee colonies have great advantages also in pollinating farm crops and fruit-trees which blossom early in spring. Finally, strong colonies consume less food by far per living weight; the expenditure for their maintenance are less than for the maintenance of medium and especially weak colonies.

At preparing colonies for a flow it is necessary to take into account the biological peculiarities of the bees.

It is common knowledge that the Caucasian mountain grey bees, even in the event of a more reduced flow (1—1.5 kg) start immediately to collect nectar and limit the queens' egg-laying. Therefore with such kind of bees it is not necessary to resort to special measures for limiting the queen's egg-laying. The Caucasian mountain grey and the Carpathian bees are less prone to swarming and when preparing them for nectar flow fewer measures are needed against swarming than with bees of Kuban or Central Russia.

Caucasian bees lived in wild state in grottos where the nest could not be expanded vertically. They were for a long time kept in primitive long hives in hollow trees. Therefore for the Caucasian bees the horizontal hives are most appropriate. On the other hand, the forest bees lived in woods and hollow trees and they could expand their nests vertically. When they were moved into hives they preserved their tendency to expand their nest vertically. Therefore, because of this biological peculiarity, it is better to keep the forest bees in hives with two or more bodies.

Caucasian bees do not enter the honey super lest they filled the lower part of the hive whereas the bees of Central Russia store the food in the upper part even when the hive is empty. These things must be taken into account on the whole management of the colonies and their preparing for the nectar flow.

Preparing bee colonies in hives of various types for the nectar flows. The vertical hive with 12 frames and honey super is the most common in our country. Its volume is too little for creating strong colonies and storing large honey reserves. Nevertheless many beekeepers yield great productions with these hives, providing they observe the necessary conditions of management and multiplication of colonies.

It is enough to recall the name of A. I. Demko, Hero of Socialist Labour, who obtained 165 kg. honey on the average per colony kept in such hives and that of apiarist D. J. Naichucov, who in the severe conditions of Tomsk region obtained an average production of 78 kg, honey with hives with 12 frames and honey super for a few years.

For removing the above-mentioned shortcomings of the hives with 12 frames, the frontranking farms use more than one honey super; the honey super may be replaced by a second body (also of 12 frames, like the hive) and 1—2 super honey chambers. The second body can be replaced by two honey supers united to each other in which one can place 12 standard frames. This method is mentioned as keeping bees in hives with two bodies.

Keeping bees in hives with two bodies is largely spread in Far East, Ural and other districts of the country with abundant nectar flows. The apiaries with a great number of bee colonies have yielded great honey productions using the method mentioned above.

As a matter of fact in 1973 the "Iuzhnyi" beekeeping sovkhoze (Primorsk region) yielded 113.7 kg. honey on the average from 2,732 colonies in hives with two bodies. Better indices were obtained by frontranking apiaries in this farm and others. For instance M. K. Moskalets ("Iuzhnyi" sovkhoze) yielded 155.5 kg. of honey and 1.17 kg. wax from each of the 144 colonies. Besides, he set up 70 new colonies. For these results he was awarded the "Red Flag of Labour" order. The beekeeper of the experimental station of Primorsk, V. A. Butovets obtained 151.1 kg. on the average from each bee colony.

At maintaining bees in hives with two bodies the frontranking beekeepers build the colonies for nectar flow as follows. They finish bees' wintering early, using special holders made of thermo-insulating material. The main inspection starts when the weather becomes warmer. After this inspection it is very important to disturb no more the colonies. During the period of spring build up the hives should have not less than 3—4 combs with honey and 2—3 combs with bee-bread. For supplementary development of bees, auxiliary colies (auxiliary queens) are used for the nectar flow. They are made up in the second body of the strong colonies, separated by a full crown board. During the season the total number of auxiliary colonies may reach up to 80% of the total number of bee colonies. At the beginning the beekeeper should place 3—4 combs of sealed brood, young bees and mature queen cells within auxiliary colonies. After queens' mating the auxiliary colonies will be fortified with another 2—3 combs of mature brood and young bees. The temporary auxiliary colonies should be united with the basic colonies when the main melliferous crop blossoms (for instance lime tree). With this aim in view the separating plywood crown board is removed and the best queen is kept in the colony. After unification strong colonies are obtained, 6—7 kg (and even more), which use well the abundant lime-tree nectar flow. Before the beginning of the main nectar flow at lime tree the combs with sealed brood in the lower body are moved in the upper body and the combs with uncapped brood from the upper to the lower body. The third body is added to the hives with exceptionally strong colonies. This is made to create more room for storing nectar in the upper body.

Some beekeepers in certain districts keep the colonies in two bodies, without supplementing them with bees from the auxiliary colonies (auxiliary queens) in the period of nectar flow. When in the 12-frame hive the colony will fortify so that the bees should occupy 11—12 intervals and 8—9 combs with brood to be in the nest, a second body or two honey supers are added. Three or four combs with honey and bee-bread as well as three or four combs with mature brood are put in the second body. The frames with food reserves are placed at the edges of the second body, the brood is in the middle and among them one should also put 1—2 frames with empty or foundation combs. The frames taken out from the lower body are replaced with reserve empty combs as well as foundation combs and the hive is so organized as to avoid its dismounting until the end of the main flow. In step with developing colony, foundation or empty combs are added to the second body.

Sometimes it is advisable to leave 7—8 frames in the lower body and then, shortly after colony's fortification, to move from the upper body to the lower one the combs which were built. Nevertheless, these movements entail supplementary labour expenditure and therefore they are not economical.

When kept in two bodies, thanks to the bigger volume of the hive the colony rears more brood and bees. The result is strong colonies for the main flow, apt to gather by 25—30% more honey than in the hives with 12 frames and honey super. Likewise, it is also in the hives with two bodies, that bees are less inclined to swarm.

A number of beekeeping state farms in the Primorsk region approached to commercial scale honey production, with maintaining colonies in hives with two bodies according to the method developed by the Institute for Bee Research.

Keeping bees in long hives has been spread in the southern districts of the RSFSR, in the Ukraine, Central Asia and Caucasus. The volume of these hives is bigger by far than the 12-comb hives, which permits to obtain stronger colonies for the nectar flow. In the event of a not too abundant but lasting nectar flow it is advisable to increase the volume of the hives alternating foundation combs with the built combs. A roomy nest can be thus created for queen's laying eggs, building new combs, nectar collecting as well as for building strong colonies for the nectar flow. For sparing work it is advisable not to expand the nest gradually (by 1—2 frames) but at once. With this aim in view the frames should be moved to one end of the hive, as far as possible from the main entrance and in the space thus created one must place 5—6 or more frames at a time with empty or foundation combs. Expanding the hive nest in only one step — as suggested by the Institute of Apiculture (G. F. Buharev) — drops sensibly the labour expenditure for taking care of the colonies. Besides, this method contributes to a certain extent to inhibiting the swarming instinct.

In order to build strong colonies in long hives, an auxiliary colony should be placed in a completely separate sector of the hive for a while. Before the main nectar flow the division board is removed and a strong colony is thus set up which takes most advantage of the nectar flow. In autumn and winter the available space in the hive can shelter a nucleus for spare queens' wintering. Many breeding farms use the space available in the long hive separating it for temporary nuclei to keep the young virgin queens before mating and also for setting up auxiliary colonies, which are sold as package bees.

Keeping the bee colonies and preparing them for the nectar flow in such hives entail a great volume of manpower, since beekeepers generally expand the nest, completing the food reserves, extract honey, etc. with each frame. Nonetheless the greatest opportunities for raising labour efficiency and increasing the number of colonies kept by one beekeeper are offered by bee-keeping practised in multiple-storeyed hives.

Keeping Bees in multiple-storey hives is extensively practised in the USA, Canda and other countries. In the last few years it has been massively introduced in a number of districts in this country.

In many districts in Caucasia, Transcaucasia, and Far East one can see multiple-storey hives with 435×230 mm frames ; but the management technique differs from the conventional one. Our beekeeper does not handle whole bodies but still individual frames, squandering manpower and taking no advantage of this method.

At present, large-scale testing of the efficiency of maintaining bee colonies in multiple-storey hives is practised in apiaries. The production of such hives is going to grow.

The greatest share of the manpower is held by preparatory operations (such as embedding foundations in frames, preparing the bodies and honey supers for expanding the nest, etc.) in the process of correctly organizing the management of a colony. The above-mentioned operations are carried out pre-eminently in winter or in the respites between the periods of intense work. Such operations could be done in the same manner by beekeeper working with hives of other types too : this will contribute to an important increase of efficiency in the beekeeper's labour. At such an organization of labour the beekeeper's work is more even distributed all-the-year-round, and in the period of bee colonies' intense activity he can deal only with caring bees proper. Such difficult operations as dismantling hives and detailed inspection of combs, repeatedly expanding the hive with individual frames, fixing up frames and preparing hives before migratory beekeeping, detailed controls and preparing the hives for wintering are done away with when colonies are kept in multiple-storey hives. The inspection of the bees' colonies is simpler — without even dismantling the hive. In order to determine the strength of the colony, the presence of the brood, of food reserves, building of hives it is enough to raise a little the body and to scrutinize the hive from the top or the bottom without taking out frames. The dismantling of the hive may be compulsory in certain cases, when noting the abnormal state of the colony (diseases, the queen's death, etc.).

A wrong opinion about the utilization of honey supers connected with keeping bees in multiple-storey hives may be met in beekeeping literature. The commercial beekeeping farms in the USA, Canada, Argentina and Australia largely use such supers for marketable honey production, which facilitates uncapping of combs and honey extraction. Under these conditions the hives are generally made up of two bodies with brood and a few supers.

The set of bees' upkeeping operations in multiple-storey hives may be summarized as such : the end of winter, changing bodies among them with concomitant cleaning of the floor boards, extracting honey and preparing bees for wintering. All the above mentioned operations are carried out without dismantling the hive, the individual frames are not handled as such but in units.

As a rule, the colonies winter in two bodies. After this they are taken out of the cellar when warm weather sets in, the bodies are shifted; the upper one is put on the clean floorboard of the hive and the lower one is superposed on the top. Then the colonies should not be disturbed for two or three weeks and in the meantime the frames and bodies for expanding the nest are prepared. The necessity of expanding the hives is determined after inspecting a few colonies. Because the future development of the colony for the main flow, the possibility to form new colonies and to prevent swarming largely depend on the timely carrying out of these operation, the expansion of the hive must not be postponed. The expansion of the hive can be made with a hive body — previously filled in with foundation combs alternating with empty combs — which is placed between the first two bodies or on top of the second one. The first variant is highly efficient for preventing swarming and stimulating the biuld up of the colonies. Before the main nectar flow, bodies for honey storing are placed on the bodies with brood.

A compulsory condition of maintaining bees in multiple storey hives is the utilization of frames with permanent Hoffmann spaces which ensure the immobility of combs during transports and inspections cf hives. Thanks to these frames the bodies can be easily reversed at an inspection and they can even be put on earth on any side without damaging combs and/or killing bees. Bee colonies in hives with frames provided with permanent spacers are always ready for transports and the beekeeper is spared the difficult operation of fixing up frames.

Multiple storey hives are very fit for sheltering auxiliary colonies which are placed in the upper body, separated from the rest of the hive by a full crown board. Taking out this crown board before the main flow and putting together bees of the auxiliary colony with bees of the basic one, a strong colony can be set up which efficiently takes advantage of the main flow.

Fig. 67. Formation of auxiliary colony in the honey super of the multiple-storey hive

For extracting honey, the filled-in combs in the multiple-storey hives are gathered all at once, at the end of the main flow after the ripening of honey (provided the apiary should dispose of a sufficient number of combs).

Preparation for wintering colonies kept in multiple-storey hives is simplified because taking out supplementary frames and regrouping the others are not necessary when the hive is mount. The colony winters in two bodies and the upper one is the store for the main food reserves.

Taking advantage of the main flow. Until the main flow the apiarist must ensure the colonies with a sufficient reserve of combs for storing nectar and its processing into honey. This problem is as important as for obtaining large honey productions with bees kept in hives of any type. Honey supers are used for storing honey in the 12 frame hives. They must be placed before the nest is completely crowded, preferably one or two weeks before the main flow. Besides the frames with empty combs the honey supers should also include foundation combs to be built by the bees. In step with filling the first honey super a second and sometimes a third one are placed over the hives with strong colonies. Each new honey super is placed under the preceding one. The timely introduction of supers increases the volume of the nest and contributes to calming down the swarming impulse. Lest the queen should lay eggs in the combs of the supers some beekeepers provide them with 10 shallow frames instead of 12: the bees prolong the cell walls and the cells become so deep that the queen stops laying eggs in them.

In the conditions of an intense flow sometimes the necessity arises of placing honey supers — or the third body when bees are kept in hives with two bodies. These supers or special lower bodies with frames for honey sections are put for production of honey in combs.

In order to use the maximum number of bees for nectar collection, various methods of limiting queen's egg-laying were developed.

Limiting queen's egg-laying during the main flow aims at liberating bees from the obligation of tending larvae and keeping them free for collecting nectar. As a rule the bees reared during the nectar flow do not participate in collecting nectar and their overwhelming majority do not reach wintering period. Special experiments showed that in a dequeened colony, the bees' collecting activity (during the main nectar flow) decreases. Therefore it is necessary to have a queen but only little uncapped brood. At an intense nectar flow, even the bees limit the queen's oviposition, filling with nectar any free cell. The Caucasian mountain grey bees do the same even under the conditions of a relatively poor nectar flow. With the aim of limiting egg-laying some beekeepers replace the old queens with queen cells or virgin queens just before the nectar flow. During the nectar flow the new queen mates with drones so that the egg-laying is resumed by the end of the nectar flow. The bees which have been reared after the nectar flow overwinter very well. The egg-laying can be temporarily limited by placing the queen under a small lid of net. Beekeeper I. P. Filatov has suggested a simplified method of replacing the queens, which does not require the complicated operation of finding the old queen. During an abundant nectar flow a mature queen cell is placed between two upper bars of frames, in the middle of the nest or of the honey super. The acceptation of the young queen, emerged from this queen cell, is controlled after two or three days: if the queen has emerged (a fact proved by the round orifice at the lower extremity of the queen cell) in 75 per cent of the cases the young queen is accepted and the old one killed.

The young queen starts laying eggs over 10—12 days. During the same period the egg-laying in the colony is interrupted and the amount of brood diminishes.

The method of limiting egg-laying by means of a queen excluder in one or two lower bodies of the multiple-storey hive is largely used abroad.

The limiting of egg-laying is imperiously necessary when package bees are used for honey forage (followed by bees' killing) especially with Kuban bees.

The experiments of "K. A. Timiriazev" Academy of Agricultural Sciences and of some sovkhozes in utilizing southern package bees for honey production in Siberia showed that the nectar collecting by the bees of Kuban increases by 30—40% when the queen's egg-laying is limited. This method proves less efficient with Caucasian mountain grey bees (see table 13).

Table 13

Effect of limiting the queen's egg-laying on the productivity of Caucasian mountain grey bees (Krasnodar region)

Group of colonies	Average honey production per colony			
	free egg-laying		limited egg-laying	
	kg.	%	kg.	%
Colonies of package bees with 5 frames	32.0	100	36.6	114.3
Colonies of package bees without combs	22.6	100	25.3	111.7

The limitation of queen's egg-laying when package bees are used for nectar collecting favours the final killing of bees, since by the end of the nectar flow the combs are free from brood.

Honey collection and extraction. Before taking honey from colonies the beekeeper must ensure the bees with high-quality food for the winter-spring period. It must be prepared in the first half of the main flow because during the intensive blossoming of the main honey crops in most districts of the country the bees gather better quality honey, more suited for the colonies' wintering. At the end of the nectar period the bees often collect honeydew, unfitted as food for winter.

It is simpler to prepare flower honey of a good quality for wintering in hives with only one body (hives with several or two bodies or long hives). Until the appearance of honeydew flow, about 6—7 frames with capped flower honey are taken off from such hives and are temporarily stored. By the end of the flow and when honey with a certain content of honeydew is extracted, the combs with flower honey are replaced in the hives to serve as winter food for colonies.

When bees are kept in 12-comb hives with supers for storing food reserves, some strong colonies can be provided with two honey supers containing full size, nest combs. When these combs are filled with flower honey they shall be taken and used for bees' wintering. One can take the combs filled with flower honey from the body of the hives of the Caucasian mountain grey bees because, unlike the bees of Central Russia, they store it from the beginning in hives and not in super chambers. In the districts where there is not a honeydew flow in summer and autumn, the food reserves for winter are prepared by the end of the main flow.

When the apiary avails of a sufficient reserve of combs for storing and processing nectar, *the filled in combs should be taken out for extraction at the end of the main flow* so that honey should be allowed to get mature. If the apiary was not supplied with a sufficient amount of combs, in the conditions of an intense nectar flow, the combs with honey should be taken out during the main flow and after extracting honey they ought to be again placed in the hives for a new filling in. Anyhow unripe honey should not be taken out. The mark of ripening is capping of honey cells. One must choose for extraction only combs which have one third of the cells capped.

When honey frames are taken off labour expenditure sensibly drops and the bees are less disturbed if the Porter bee escape is employed. Its functional device is made up of a system of two weak springs through which the bees can pass only one way without making a too great effort. Then the tips of the springs join with each other hampering the bees to make their way back. The bee escape is mounted in the crown board made out of a thin board. Its sides are fixed up in laths. The crown-board with the bee-escape is placed between ekes and the body or between the upper body and the brood nest. The bee escape must be installed in the morning. The worker bee fly in the field during the whole day but they cannot return to the super : the next day there will be no bees in that part of the hive, which will allow for an easy removal of the honey supers.

The commercial beekeepers in the USA and other countries use pure crystallized carbolic acid in aqueous solution (50%) for removing bees. On a wood bar of the same sizes as the upper part of the hive body (4—5 cm thick) the beekeeper fixes 3—4 layers of well stretched gauze and on top a black cloth or a thin black sheet. The gauze is imbued with carbolic acid and the frame is introduced into the hive above the honey super or hive body ; bees would readily pass into the lower part of the hive setting free the honey super or hive body. It is recommended to have 6—8 such crown boards at hand. Until bee escapes are fixed to all hives, the beekeeper can take out the supers and honey chambers — free of bees, from the first hives to which bee escapes had been fixed. This method of driving bees out is successfully used with multiple-storey hives. If bee escapes are not available, honey frames are taken out of the super and the bees on them are shaken off or softly brushed away (or with a goose feather).

It is better for honey combs to be taken out the hives by the end of the day, when the flight of the bees is less intensive. Thus the activity of the colony is less disturbed and robbery is prevented — in the flowless periods. If honey frames are extracted during the nectar flow, the combs taken out must be replaced by empty combs.

Honey is extracted in a room where no bee can reach. When it is cold, the room has to be warmed, otherwise honey is more difficult to be extracted. Before starting extraction, it is necessary to thoroughly wash and dry the centrifugal extractor, to fix it on the ground, and to prepare the table or any other device for uncapping combs, the containers for bottling honey, etc. Before introducing combs into the centrifugal extractor, they are uncapped with knife immersed in hot water. Two

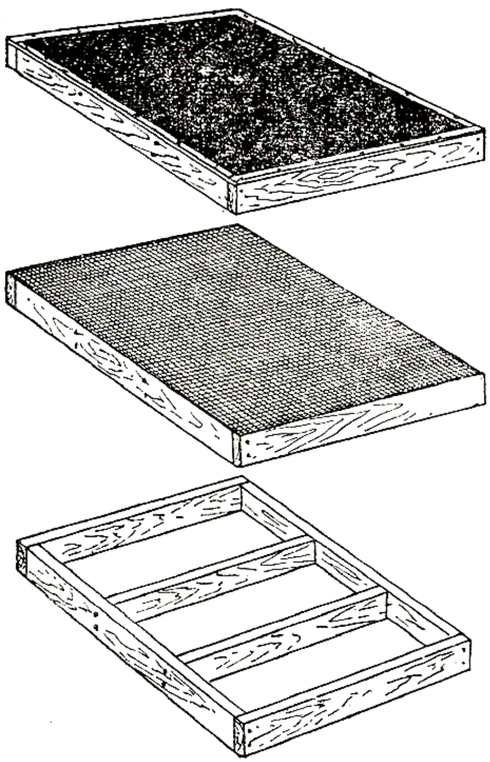


Fig. 68. Crown board with bee escape for removing bees from the upper supers of the hive by means of carbolic acid :
Bottom — the wood structure of the crown board ; in the middle — after application of a few gauze layers ; top — with black cloth

knives must be available for each operator ; while uncapping with one, the other is kept into hot water. This uneasy operation is much facilitated by using steam and power heated knives. The caps separated from honey are melt to obtain wax. They produce high-quality wax, most suitable for manufacturing comb foundation.

The uncapped combs are immediately introduced into the extractor baskets, vertically, being tangential to the spinning axis. To avoid breakage of combs, the extractor is first set to operate slowly with the speed being then gradually increased. When the honey on one side of combs is extracted, the combs are reversed to have the honey on the other side extracted. Then combs are reversed once again for all the honey to be extracted. In radial extractors (where combs are supported, without combs, radially) honey is extracted from both sides concomitantly. In large-scale operations, comb uncapping and honey extraction must be performed at a central plant, adequately equipped for this purpose.

It is better to mount the extracting equipment in vans which are driven to the apiary location for extracting the honey on the spot. In the large commercial apiaries in the USA, where honey harvesting and extraction are the most difficult operations, requiring much highly efficiency, electrically-driven plant is used.

The health requirements with respect to processing foodstuffs must be observed when extracting honey ; clean white overalls and well washed containers — with no smell and clean processing equipment.

The bulk of the refuse material should be removed by settling prior to straining honey through a filter attached to the outlet of the extractor. Then honey is pumped or let to flow down into settling tanks. In a few days, the small impurities (wax particles, bee remains, and other material) and the scum with pollen particles rises on top and are skimmed. The honey is packed in 1-quintal drums in perfectly clean milk cans or lime wood small barrels of various capacity.

Barrels made of trembling poplar, oak-tree and coniferae timber are not advisable because they lend a specific small to honey.

Honey must be stored in a dry room, preferably at a temperature up to 10°C and a relative humidity of 60—70%. Honey easily picks up other smells. Therefore other products with stong smell (sauerkraut, sardines) must not be stored in the same room with honey. The immature honey (over 20% moisture) should be stored in a dry and warm room, in open containers to favour the evaporation of the extra moisture before packing it.

Before sale, packing firms bottle honey in small containers : glass jars, of 200 to 500 g. and more, paraffin-lined cartons, etc.

Production of Comb Honey. Beekeeping farms of kolkhozes and sovkhozes do not produce comb honey ; only amateur beekeepers supply comb honey. Cut-comb honey and section honey in enticing packages is a delicacy. In addition to being attractive and fine looking, section honey better preserves its natural aroma, because part of the aromatic substances, enzymes and vitamins are destroyed during the processing of honey for liquid packs, especially when incorrectly heating it before bottling. It is desirable to extend comb honey and section honey production, especially in the areas with large towns, in the neighbourhood.

The simplest method of producing comb honey is to use supers with good, light coloured combs ; they can be placed not only in 12-frame hives but also in twin and multiple-storey hives. The combs filled with honey and fully capped are taken out by the end of the nectar flow and comb honey can be sold. One of the disadvantages of these frames is their relatively high weight (almost 2 kgs) which make them difficult to sell.

Chunk honey (pieces of comb placed in glass jars of 0.5—1.0 l with the jars being then filled with light-colour extracted honey) is very popular in the USA. But the finest dainty is considered to be the comb honey in wooden sections, packed in card board cases with cellophane window.

The sections are made of soft wood essences (the best is lime tree) of 105×105 mm to hold of 400 g honey. The laths are 2 mm thick and 35—40 mm broad (if there are slits in the upper and lower parts to allow bees to pass), and 25 mm (when no slit is provided for). These sections, provided with comb foundation, are mounted by fours in special frames (105×420 mm inside sizes) and are put into a special super of suitable size.

Sections well filled with honey can be only obtained from strong colonies, with an abundant nectar flow being available. The best for the production of section honey are the multiple-storey hives. The supers with comb sections should be put above the top body before the beginning of the main flow ; the sections with capped comb are taken out after the nectar flow is over. The sections obtained from middle Russian bees or Carpathian bees, with snow-white cappings, have the most attractive appearance. Propolis must be removed from the wooden sections, and then honey sections are packed in cardboard cases wrapped in cellophane.

MOVING BEES IN MIGRATORY BEEKEEPING AND POLLINATING FARM CROPS

Migratory beekeeping is an important means of raising the productivity of apiaries and of intensive practice. It does not require large expenditure for special equipment, and those for transport are fully covered by the income derived from the extra-honey obtained and from the higher yield of farm crops. Moving bees to various flows helps bee colonies to become strong in spring, before the main nectar flow, and store food for wintering ; it is necessary for more efficiently exploiting the main nectar flow and for pollinating the entomophilous farm crops. Here are several examples of good results obtained.

At the honey production apiary of Eisk 3,100 bee colonies were moved to forests in the submountainous zone. They produced 24 kg. on the average of marketable honey per season. The colonies left at the stationary apiaries did not yield any marketable honey, hardly managing to collect food stores.

It is only constant moving of hives first to the forests in the submountainous zone and then to the abundant honey flows provided by farm crops — blossoming in various periods coriander, sun flower etc. — which enables the sovkhoze of Kislovodsk and other sovkhozes specialized in beekeeping to obtain high performances in queen breeding and package bee production.

At the experimental station of fruit-tree and shurbs at Berdsk, of the Production Direction of Iskitim (Novosibirsk region) an average of 55.3 kg. of honey was obtained every season from 160 colonies moved to the forest flow as compared to only 26.6 kg. in the stationary apiaries of the kolkhozes and sovkhozes of the same Direction. The bumper crops of the sovkohzes and beekeeping farms in the Far East are mostly due to constant and planned moving of colonies to the bee pastures in flower.

In the last few years, the migratory beekeeping has been extensively practised at long distances — several thousand kilometres. Many commercial beekeepers in the Northern USA (Dakota — Montana) keep their colonies to forage the local flow and then carry them by truck to the Southern states (Texas, Georgia, Florida, California), to the citrus flow and for rearing early queens as well as for producing package bees. The Mexican firm "Miel Carlota" also practises migratory beekeeping. In this country, numerous farms in Krasnodar and Stavropol regions have, in the last few years, moved their bee colonies to Siberia and to the Northern districts of the RSFSR for foraging the rich honey sources available in the forests there.

The "Mikhailovsky Pereval" sovkhoze, Ghelendzhik district, Krasnodar region, obtained 20.5 tons of honey from 694 bee colonies moved to forage in Krasnoiarsk region. Beekeeper V. F. Koshevets obtained an average of 63.1 kg 43.2 kg of which marketable honey) from 120 colonies. The great distance entailed expenditures of 23.7 thousand roubles while the income stood at 39.1 thousand roubles. The production cost of one quintal of Siberian honey stood at 114 roubles, as against 147 roubles in Eastern Siberia, and 227 roubles in North Caucasus.

The best method of management when moving bees to long distances to various flows and for pollinating farm crops is to use package bees. It also has broad prospects for more-extended package bee production.

The most widely used and at the same time the simplest method of moving bee colonies to short and medium distances (from 5—10 km to a few hundreds of km) is to use trucks. Where roads are broken, tractor trailers are used.

Bee colonies must be prepared so that when trucks come they should be loaded at once. The operation must be performed carefully especially when colonies have much brood and bees and it is very hot. Heavy frames with honey and newly-built combs must be taken out of the hive. If the hives are not provided with permanent frame spacers, wood pieces (with 12×15 cm section and 120—150 mm long) should be

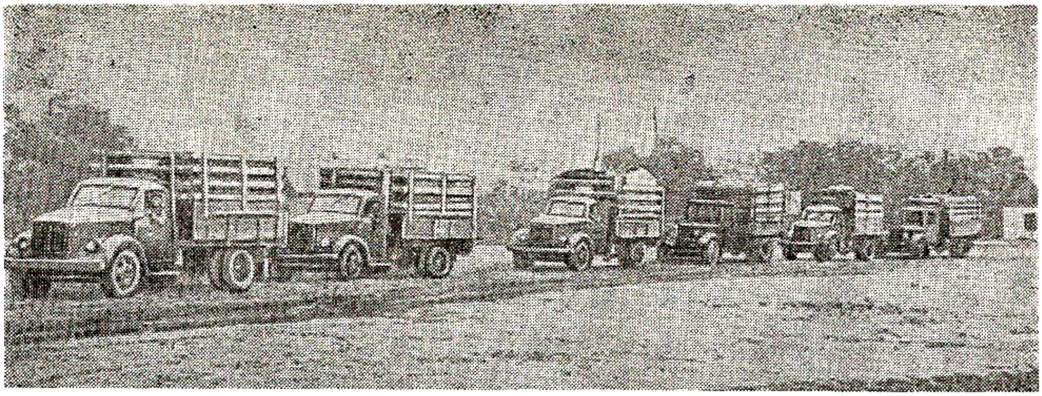


Fig. 69. Moving bee colonies by truck in hives

introduced between frames. If the brood nest of the hive is entirely occupied by bees, for providing more room in the hive, the beekeeper must add one more super or hive body (preferably with empty combs); on top, it must be covered with wire cloth mounted in a wood frame, or with sack cloth. If the hive covers provide for room above the frames and are supplied with a ventilation device, there is no need of the empty super and metal cloth.

All the component parts of the hive are fixed by means of buckles or strappers lest they should be displaced during loading or transportation. When bees cease flying, before loading the hives, all entrances should be well closed. The main entrances must not be covered with wire cloth because bees, seeking to come out of the hive, get aggitated and plug the entrance causing extra losses. The hives are placed transversally into the truck, in several rows and must be well fastened with ropes. Function of the capacity of the hives, the tonnage of the truck and the room available in it, 25—30 up to 50—60 colonies can be loaded.

It is better for bees to be transported by night or early in the morning (to short distances). On bad, cold weather, when bees do not come out of the hive, colonies can be transported during the day too.

The new location must be prepared previously. After having arrived at the new location and having distributed the hives, they can be opened. If there are not landmarks (trees, isolated bushes) bees can enter other hives. As a rule the bees of the colonies placed in the rear enter the hives in the fore rows. This happens more rarely if the hives are sited in the new location in the same order, as previously to the transportation or if the number of rows on the new location is reduced. Manpower can be considerably saved if one uses mechanical loading means or loading-unloading devices.

Over long distances bees may be also transported by train, by plane and by ship. By train the bees are carried in refrigerator vans (if it is warm), in waggons for animal conveyance, freight cars and on open platforms (over not too long distances).

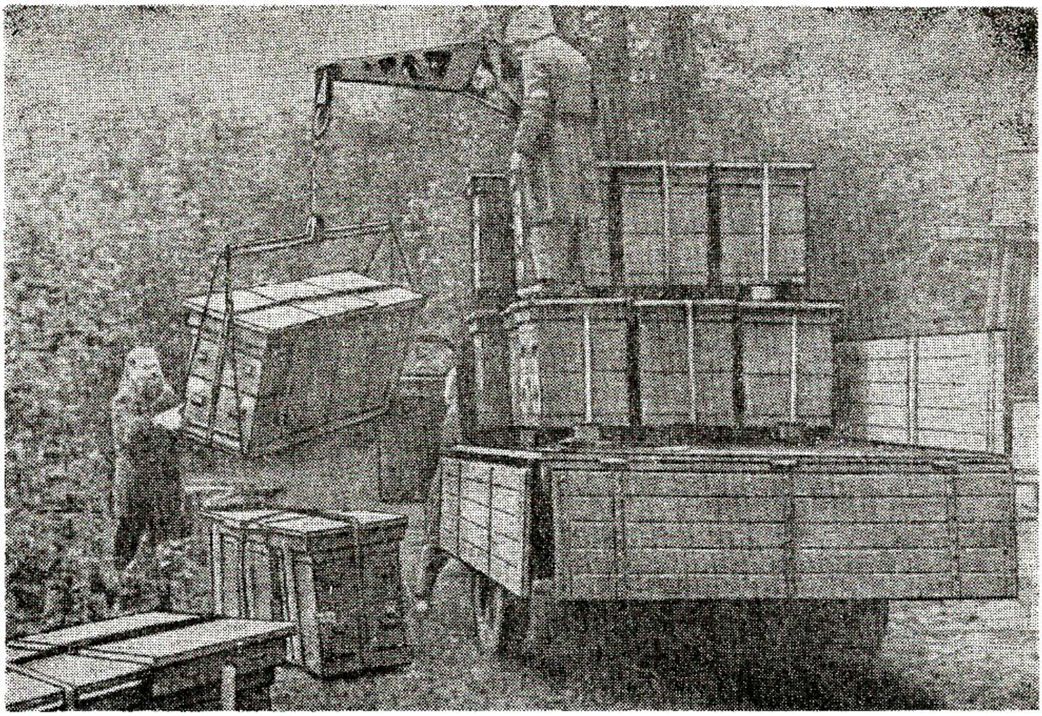


Fig. 70. Mechanical hive loading

Preparation of bees for transportation by train is similar to that for lorry. In the waggon, frames must be placed parallel with the direction of the move of the train (along the waggon). About 75—100 colonies can be placed in a four axled waggon, according to the sizes of the hives.

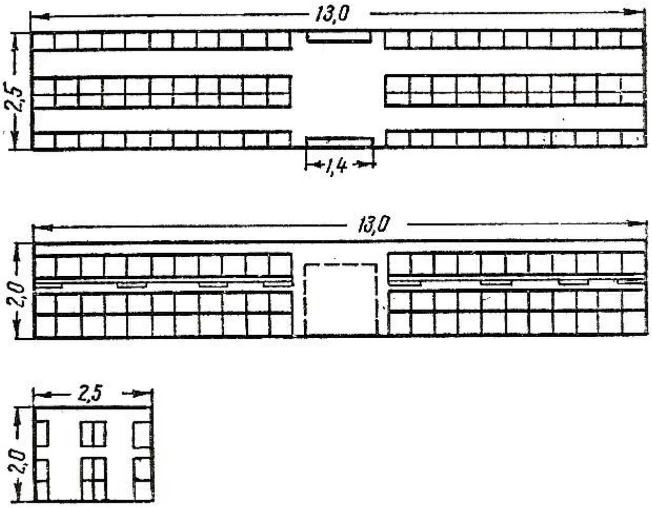


Fig. 71. Scheme of distribution of six-frame packs in the waggon (size in m).

Large-scale tests made of various transport methods in Krasnodar and Stavropol regions, in Siberia and the northern districts of the RSFSR showed that it is not advisable to carry bees in hives over so long distances. As a rule the unsealed brood and a great number of bees die during a long transportation.

It is better to transport bee colonies in light cases of plywood. Early in spring one can use common freight cars being much less expensive. Almost 300 6-frame colonies in cases can be placed in a four-axle waggon. The cases are ranged in three or four rows and enough place is left for the attendant accompanying them.

It is better for the bee colonies to be transported by plane. Thus fewer bees and less brood die and transportation takes a shorter time.

Thus cases loaded into special planes in the previous evening can reach Kirov by next morning (in 7 hours), while from Krasnodar to Achinsk (Krasnoiarsk region) in a little more than two days. Planes of AH-12 type can take almost 200 cases with six frames and over 500 combless cases.

The combless colonies in packs bear best the transportation by plane and the fares are thrice less as compared with the six-comb packs. The charges for bees' transportation by plane have lately dropped by

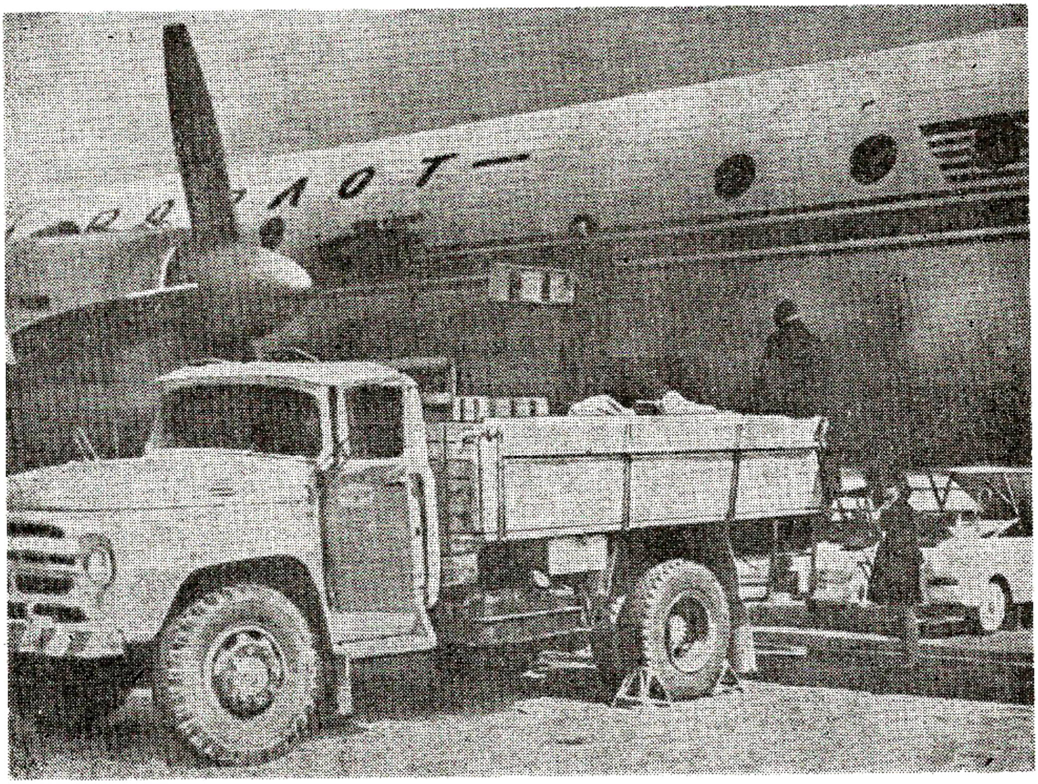


Fig. 72. Loading combless colonies in cases into the plane for their transportation from the south to Siberia for the nectar flow.

50% (being similar with that for agricultural produce), which opens broad prospects for extensively using aviation to support beekeeping.

The fact must be noted that for raising the material incentive of workers transporting bees to various nectar flows and for pollinating farm crops, sovkhozes and other state farms can pay the beekeeper and their aids as well as other people working within apiaries during the migratory bee-keeping period 40% higher wages.

WINTERING OF BEES

The period of winter rest and the results of wintering are highly important for the life of the bee colony. The development of the colony and its productivity during the next season largely depend on how bees have overwintered. That is why the apicultural season starts with the preparation of the colony for wintering.

Preparation of bees for wintering. It starts already in summer. It is necessary to prepare strong colonies made up of physiologically young bees which are not worn out by nectar collecting and brood rearing, and which must be abundantly supplied with high-quality food. It is also very important to provide for good external conditions in order to ensure a successful wintering.

The strength of the colony before wintering has the same import as the strength during the nectar flow. When wintering in bee houses, in packed hives covered with snow, strong colonies consume per unit of fresh weight (for 1 kg of bees) less food than the weak ones (See table 14).

Table 14

Consumption of food stores per 1 kg. of fresh weight of bees

Method of wintering	Average consumption of food (in kg) per 1 kg. of bees — per groups of bees with weight in kg: 1.0	1.5	2.0	2.5	on the average for all groups of colonies
packed hives	9.54	8.39	6.38	4.90	7.90
under snow	9.67	8.78	7.99	5.74	8.42
in bee houses	9.56	8.77	6.42	4.22	7.74

In strong colonies, in the inactive period, before the appearance of brood, the temperature must be lower and even almost +15°C; by the end of wintering, when brood appears the temperature in the nest rises to 34—35°C; with weak colonies it is higher in the cluster and it is subject to great oscillations; by the end of wintering it is lower not surpassing 32—33°C. The ratio between the area of producing warmth in the cluster of wintering colonies as compared the whole mass of bees is lower in the strong colonies than in weaker ones.

That is why, strong colonies consume less food and energy for maintaining temperature in the nest at a certain level.

In addition to temperature, highly important for bees' wintering is the composition of the air in the nest. During wintering within the cluster of the bee colony the content of carbon dioxide increases up to 4—5% while the content of oxygen decreases down to 17—18% (usually the proportions of carbon dioxide and of oxygen in the atmosphere are 0.03% and 21% respectively).

At a lower content of oxygen and a higher concentration of carbon dioxide in the nest during the winter inactive period, the combustion processes in bee bodies slow down, and the metabolism as well as the consumption of food decrease. Relevant research has shown that in strong colonies the concentration of carbon dioxide within the wintering cluster is higher than with medium and weak colonies. In colonies of the same strength, more carbon dioxide and less oxygen can exist in the interior of the cluster in the northern races, more resistant to wintering (Bashkir, middle Russian) than in southern ones (Caucasian, Italian, Indian).

The physiological condition of bees is also highly important for a good wintering of the colonies. The bees which participated in nectar flow collection until late in autumn, do not survive as a rule until spring. Also short-lived are the bees which had reared brood till late in autumn and processed a large quantity of sugar syrup for completing food stores.

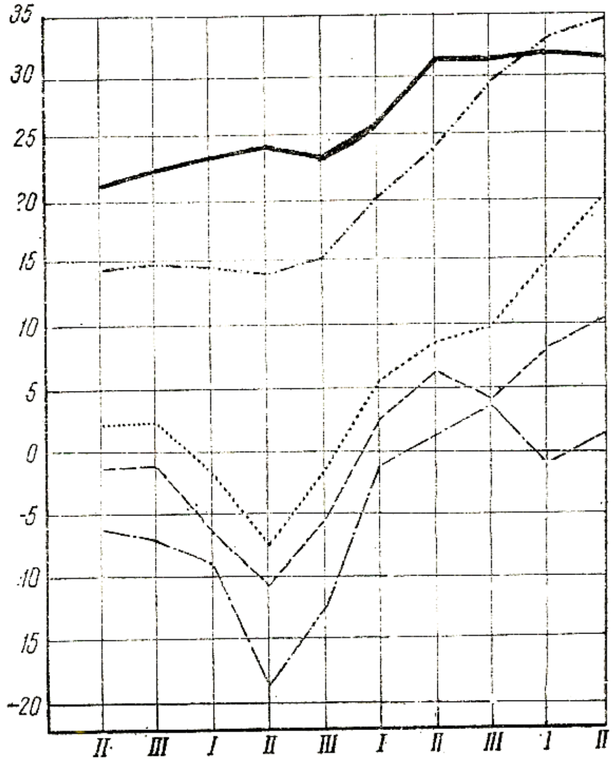


Fig. 73. Temperature in a strong and weak colony in winter.

2250 g family
. . . . . t° on the hive bottom
— . . — t° in the cluster
950 g family
— — — t° on the hive bottom
——— t° in the cluster
— . — t° environment

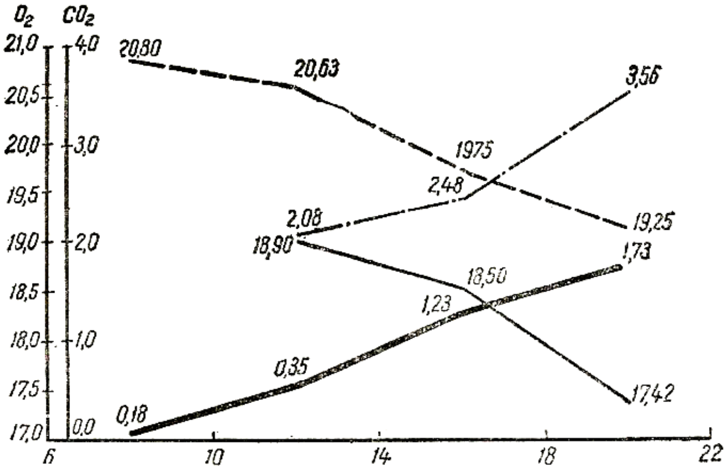


Fig. 74. Composition of air in the nest of bees of various strength during winter.

On the abscissa : number of bees in a family (thousand)
On the ordinate : content of O_2 and CO_2 (%)
——— Central Russian bees (O_2 content in the nest)
— · · · — Central Russian bees (CO_2 content in the nest)
— — — — Caucasian bees (O_2 content in the nest)
——— Caucasian bees (CO_2 content in the nest)

The young bees which emerged late bear wintering with difficulty too. Although they have neither collected nectar nor have processed food, nor have reared brood, they had not sufficient time to fly before the start of winter.

According to the data reported by the apicultural experimental station in the Ukraine, in the conditions of forest-steppe bees emerged from eggs laid by the queen at the end of August and the beginning of September, i.e. the end of the nectar flow resisted better to wintering. As many as 60% of the bees emerged from eggs laid until July 20, which participated in foraging, died in wintertime. A high death-rate (almost 30%) was also recorded with bees reared late in autumn (the end of September and the beginning of October) and which did not come to fly before the installation of hives in the bee house.

In order to rear large numbers of young bees for wintering, it is important for colonies to have young and prolific queens, abundant food stores, good combs for egg laying and an efficient warming system when cold sets in. The late maintenance nectar flow largely contributes to rearing bees in autumn. Therefore, if there are not bee pastures in the vicinity of apiaries which flower late, it is necessary to move bees to other late flows for strengthening the colonies before wintering, such as buckwheat and white mustard, heather, meadows or low banks and islands liable to be flooded, to cotton and kenaf, hibiscus crops as well as to alpine pasture lands. If no such possibility exists, a part of the food stores can be replaced by sugar syrup (especially where honey-dew flows are available) for stimulating queens egg-laying in the periods without nectar flow. The colonies must be fed on supplementary sugar syrup, to provide for the necessary food stores and to replace the honeydew honey immediately after the flow is over. Queen's egg-laying and the number of young bees reared in the colony towards winter increases and the sugar syrup will be processed by old queens which participated in foraging the nectar flow — and not by the young ones, which are going to winter.

The colonies must have young queens in order to overwinter successfully. By the end of nectar flow they lay more eggs and their egg-laying lasts longer than that of old queens. Especially good from this point of view are the queens emerged by the end of nectar flow.

The experiments carried out at the apiaries in the Ukraine (V. A. Nestervodski) showed that in autumn the colonies with one-year old queens have by 193% more brood than the colonies with three-year old queens, and by 69% than those with two-year old queens. For a successful wintering not only the age of the queen is important but also their quality. According to data reported by the "K. A. Timiriazev" Academy of Agricultural Sciences (I. N. Kotova) the viability of large, well-developed queens is higher than that of small queens: they are more resistant to Nosema disease, live longer, and their prolificacy in spring is higher.

For rearing more young bees for winter, many experienced apiarists temporarily use auxiliary colonies, made up by the end of nectar flow. The bees reared in such colonies are united with normal colonies, the old queens being discarded. Use of temporarily auxiliary colonies for obtaining strong colonies before wintering is highly indicated in the districts with early spring nectar flow for which strong colonies are needed early in spring. Such colonies will be more efficient in pollinating fruit-trees which blossom early. If the basic colonies had young and productive queens, the auxiliary colony may be left to winter independently.

Storage of extra queens is largely practised by experienced apiarists for bringing to normal condition queenless colonies in spring and forming support colonies and new colonies early in spring and stregthening old ones before the nectar flow. As a rule 15 spare queens are to be found at an apiary of 100—150 colonies. They are kept in nuclei. The best is to form such nuclei with the frames available in the beekeeping farm. Three small colonies with spare queens can be placed, if necessary, in the brood nest of a 12-frame hive, divided by blink walls into three parts each with its entrance. In such a hive, close to the normal colony, a small space for 2—3-frame nucleus can be delimited. This is easier to be done in long hives, where a nucleus with queen can winter nearby the normal colony, partly on the account of the warmth produced by the strong neighbouring colony.

The larger the number of bees in the hive the less food is consumed per unit of living weight. A high death-rate of bees and queens is recorded in nuclei, especially when winter lasts long. Therefore, in autumn some apiarists form strong support colonies with young, highly performing queens, at the end of the nectar flow instead of preserving spare queens in nuclei.

These colonies overwinter better and in spring they are used for package bees or for increasing the number of bees in other colonies for the main flow. Towards the winter such colonies must contain 1—1.5 kg bees and 8—9 kg honey, while the nuclei — 0.6—0.8 kg bees and 6—7 kg food stores. In northern districts with long winters the colonies must have more bees as well as a greater amount of food in store. In southern districts colonies can have fewer bees and less food stores.

Numerous attempts have been made to reduce food consumption and the number of bees for storing productive queens throughout winter with the view of having young and cheap queens in spring. In the USA this demand has been met by the apiaries in the southern states specialized in producing mated queens and package bees early in spring (March-April). Our queen-breeding apiaries do not meet yet the huge requirements of early queens. Most of the relatively small number of queens produced by them are sold in June and July. Therefore, concomitantly with raising the production of early mated queens in the southern districts in this country, methods must be developed for maintaining queens during winter, with minimum consumption of bee supplies and labour.

Attempts of maintaining queens in half-depth hive bodies failed. Since the bees must consume much food for maintaining the necessary temperature, they wear themselves out very fast and they do not resist until the end of winter, with the queen usually dying the last. A few years ago the Romanian scientists proposed a method of storing queens outside the cluster of the colony, in small cages together with 50—60 worker bees. During winter, worker bees in the cage are replaced with other ones every 3—4 weeks. This method, with some changes is tested at the Apiculture Department of the "K. A. Timiriazev" Academy of Agricultural Sciences and the Georgian Experimental Apicultural Station. In the future this method is envisaged to be used in the farms in the southern districts in this country where winter is short. The food necessary is only 150—200 g. Food is necessary for maintaining one queen and only 100—150 g bees.

One must not lose sight of the fact that the large-scale application of queens' maintaining outside the cluster of the bee colony requires severe measures to be taken for preventing Nosema disease. An efficient meant to control Nosema disease is Fumidil B which diminishes several times the possibility of bees and queens getting Nosema disease.

Preparation of colonies for wintering is made after the nectar flow is over, when the queens cease egg-laying and almost all brood had emerged. Until then the honeydew honey must be replaced by flower honey of good quality or sugar syrup and the extra frames which are not occupied by bees must be taken out. Function of the duration of winter and of the strength of the colony, when brood nests are contracted they are left no less than 15—17 kg of honey in the steppe area and in the southern districts, and at least 18—20 kg of honey in the forest and alpine zones. For completing food stores in spring (after bees are taken out of the wintering houses or after the first inspection of colonies which had wintered in the open) at least 8—10 kg of honey must be also available in each colony, in frames outside the nest.

The nests must be supplied extra frames with combs at least half filled with capped honey (each frame must have minimum 2 kg of honey).

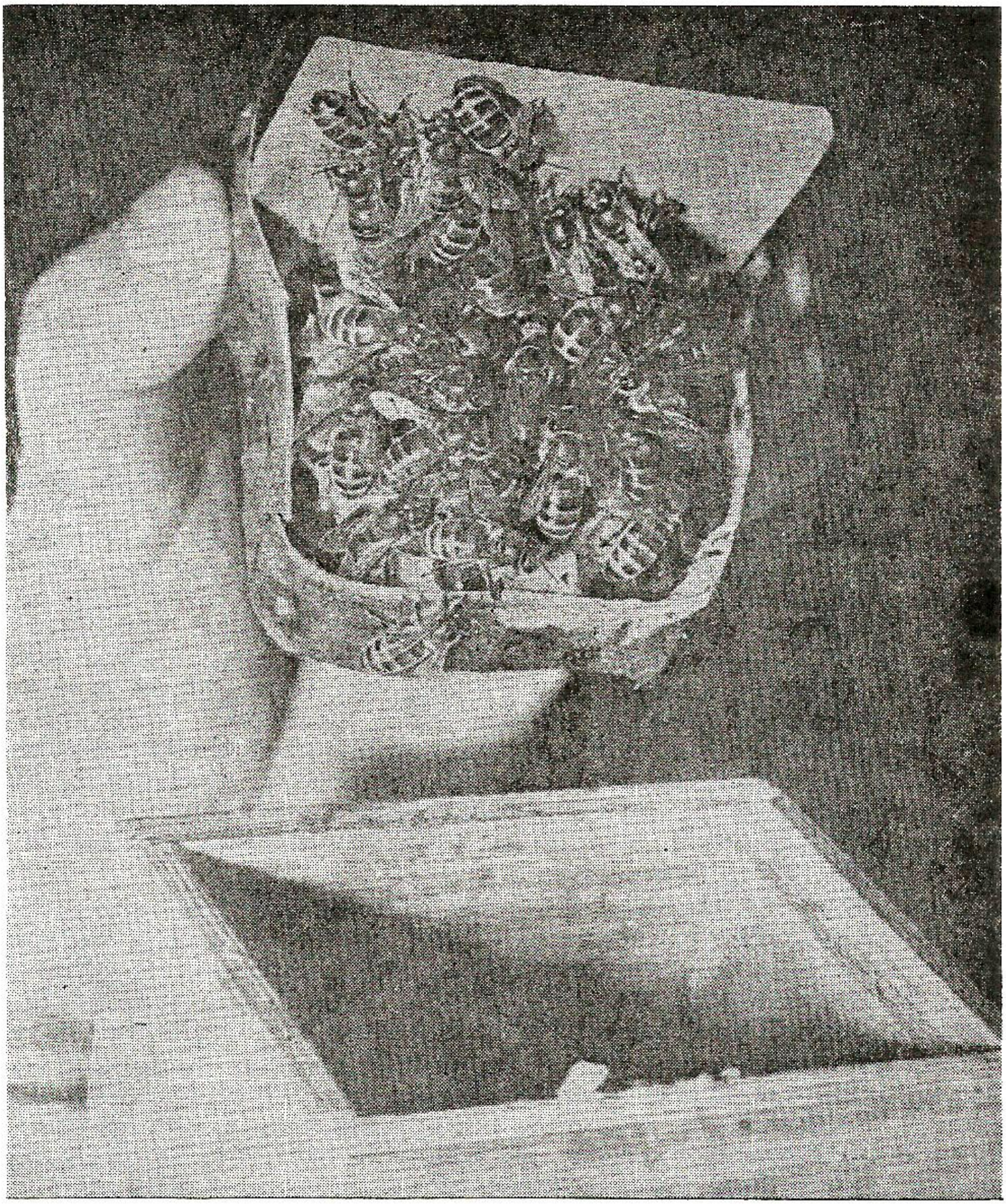


Fig. 75. Cage with small comb for wintering queens outside the cluster of the bee colony.

All frames containing too little honey shall be taken out of the hive. If during the main nectar flow the frames with flower honey stores were taken out, they must be now put back into hives.

The nests must have as many combs as bees can cover. Strong colonies cover as a rule 9—10 standard frames or about 16—18 frames in multiple-storey hives. No empty combs or with too little honey must be left in the centre of the nest. The heavy frames, full of honey, and almost entirely capped, must be put at the extremity of the nest. It is better to overwinter bees in multiple-storey hives. Strong colonies will winter in two bodies of such hives, with winter stores being in the top super.

When food stores are insufficient or the honeydew honey has to be replaced, the bees are fed on concentrated sugar syrup (2/3 sugar and 1/3 water). A great amount of supplementary food must be administered as long as bees are active. Before starting feeding all extra frames are taken out of the hive leaving only those necessary for wintering. In autumn, until the bees are introduced into the bee house the nest must be well protected. The main entrance must be reduced and metallic grids should be attached, to prevent access of mice ; it is important to take every measure to prevent robbery when bees winter in the open ; special care must be taken in providing for hive insulation.

Function of local conditions bees may be wintered in bee houses or in the open. Experience showed that in the conditions of a good preparation of bee colonies for wintering bees winter in the open just as well as (in some places even better) in bee houses. When wintering bees in the open, expenses for building shelters are saved as well as the labour necessary for the difficult operation of transportation of hives from the apiary and back ; moreover, in many areas the rate of bees' survival, development and production is higher. In addition to the southern districts of this country with short and mild winters (the Caucasus, Central Asia, the southern districts of the RSFSR, the Ukrainean SSR and the Baltic republics) where bees usually winter in the open, many apiaries in Ural, Siberia and north-western districts of the RSFSR where winters are long and heavy successfully use this wintering method.

Wintering in open air is largely practised in the USA and Canada. This method has been more and more popular of late. By its very nature, the bee colony is adapted to wintering in the open. Even today, in the forests of Ural and in the northern districts, wild bees perfectly resist to severe winters with —50°C frosts. After domestication of bees, man would house bees in cellars protecting them from cold and robbers. Many beekeepers in favour of bees' wintering in bee houses support this idea with one more argument : wintering in the open requires larger food stores. This may be true for the districts with very severe and long winters. Even in this case, 2—3 kg of extra food consumed during winter in the open are fully compensated by the better development of colonies in spring and by their higher productivity.

The problem of the way of wintering must be solved by each and every bee-keeping farm taking into account the local natural economic conditions.

Wintering in bee houses. In the conditions of severe winters and of the eixstence of good shelters, meeting the bees' biological requirements, they may be wintered indoors.

After the preparation of hives, one must move them into bee houses as soon as possible. Advantage must be taken of the bees' last cleansing flights in order to start wintering with as little as possible faeces in their gut. In many areas, a colder period may be followed up by warm days when bees can undertake cleansing flights. In such cases, the bees already moved into bee houses are deprived of the possibility of relieving their guts ; also, because of the high temperature in the shelter they become aggitated which bear negatively upon their wintering.

Bees must be moved into bee houses after the cold, preferably dry weather has well set in, to avoid bringing of wet hives into the room. In the northern districts, such a weather sets in at the beginning of November, whereas in the southern areas — 10—20 days later. Moving hives into the bee house must be made so as to disturb the bees the least possible, and to last for one or two days only. The hives with bees are placed on shelves, the heavier (viz. the stronger) colonies on those at the bottom where the temperature is lower, and the light colonies and nuclei on the upper ones where it is warmer. When a proper temperature and humidity is provided for in bee houses, hives are placed without covers and quilts. After bees calm down, the upper and lower entrances are opened. Penetration of cold air contributes to making up a well-knit cluster of bees and to increasing the concentration of carbon dioxide within the nest. Likewise, a good ventilation is necessary to remove the humidity from the nests. With strong colonies, to improve the ventilation of the nest, it is advisable to take aside part of the covering cloth or one of the marginal lath of the inner cover.

In the bee house temperature must be maintained at 0°—2°C. When humidity is higher, the temperature can raise up to +4°C. Decrease of temperature below 0° does not influence substantially the results of wintering ; great temperature oscillations are, however, not recommended. More dangerous are higher temperatures (5—7°C) which cause bees' aggitation and increase the death-rate. The relative humidity of the atmosphere in the wintering room must range between 75—80%. High humidity is detrimental since hives will become too damp, the moisture content in honey increases, and the combs will be covered by mould ; all this can be conducive to a high death-rate, even to destruction of the colony. Too dry an atmosphere can also be damaging since bees become aggitated and thirsty, and sometimes honey may crystallize.

For measuring air temperature and humidity a thermometer (or better two should be provided for in the bee house : one at the upper and lower level of the shelves respectively) and a hygrometre ; the temperature and humidity of the atmosphere can be thus adjusted in the room by diminishing the light opening of the adductive and evacuation channels or by intensifying the ventilation of the room. By the end of winter, the temperature in the bee house should be just as hign as to be controllable by adjusting ventilation alone. For this, the bow-windows may be opened, and the openings to the platform at night. If all this is not helpful, barrels with ice must be brought into the bee house.

When the air is too dry, the floor of the room must be sprinkled with water or wet sacks must be hung in hooks. Thus, the ventilation intensifies in the hive ; the aggitated bees are given water.

Day-light must not penetrate into the wintering room. In order to be able to inspect bees and the measuring devices in the room red coloured bulbs are used. Where electric power is not available a common lantern provided with a red filter should be used.

When colonies are properly prepared for wintering (observing all requirements) and the optimum temperature and humidity are maintained in the bee house, one must not disturb bees with too frequent inspections. One or two visits a month suffice for checking thermometer and hygrometer, and the condition of colonies. In case of a good wintering, bees are quiet and silent. If certain colonies are aggitated, the cause must be found out and removed. By the end of wintering, bee colonies must be inspected more often. During this period, brood appears, the temperature in the hive rises, the food consumption increases, and a more intense ventilation is necessary.

In case of colonies having been improperly prepared for wintering, they must be given a helping hand as soon as possible. If spots of diarrhoea appear, bees must be left out on cleansing flight before the due period (see page 130). Whether the food stores are insufficient they should be completed by introducing 1—2 combs with honey into the hive.

Wintering Bees in the Open. When wintering in the open, bees can undertake cleansing flights late in autumn and early in spring, while the colonies in bee houses are deprived of this possibility.

Studies carried out by the "Agricultural Department" of the "K. A. Timiriazev" Academy of Agricultural Sciences of various wintering methods of middle Russia and mountain grey Caucasian bees in Moscow, Yaroslavsk and Vologodsk regions have shown that the bees which wintered in the open develop faster in spring, rear a larger number of bees, and get Nosema diseased more seldom. The colonies which winter in the open consume more food (by 1—2 kg. than in case of indoor wintering). This is due to the fact that they start the build up earlier in spring and rear more brood which accounts for the consumption of large amounts of food stores.

The local middle Russian bees which wintered in packed hives at the experimental demonstration apiaries of ASAT had by 36.6% more brood in spring; likewise, they collected by 24.1% more honey than the control colonies which wintered indoors. In this case, the honey consumption was 10.88 kg. honey per colony, while the colonies which wintered indoors consumed 9.59 kg. as compared to 11.8 kg. necessary for clnies which wintered under snow. It is highly important to provide for the wintering in the open of the mountain grey Caucasian bees and of their hybrids brought into the northern regions of the country (Table 15).

Table 15

Results of various methods of wintering of mountain grey Caucasian bees in Yaroslavl region (the "Druzhba" didactic farm "K. A. Timiriazev" academy)

Wintering method	Packed hives	Under snow	Indoors
Number of colonies	18	18	18
Food consumption (kg./col)	11.2	14.3	13.9
Faeces (mg)	29.5	31.8	37.5
Ill of Nosema disease (%)	22.5	27.7	33.3

For open-air wintering bees are prepared almost similarly as for indoor wintering. Under severer conditions, special attention must be paid to food stores and to insulation of hives, because inspection of colonies and correction of improper conditions is difficult before spring comes. There are several methods of wintering bees in the open.

In southern districts with short and mild winters, where the bees can undertake cleansing flights till November and in spring early in March, the nests are contracted and thoroughly insulated for wintering; hives are left in their places, without being packed at the outside too.

A good place for locating hives for winter times is an orchard with wind protection belts around it; in zones with mild winters and much snow (the Baltic republics, the Western Ukraine, etc.) colonies winter successfully under snow, which insulates them and protects them from great temperature variations and from wind. Hives are placed on low stands. entrances are protected by a sloping strip of wood least it should be blocked by snow, and snow (in 0.5—0.7 m thick layer) is amassed around hives. When spring begins and snow thaws it is removed from the top of the hives. When bees winter in double-walled, insulated hives, no snow around hives in necessary any longer.

In such hives colonies have been wintering very well for several years, even under the severe conditions of Emelianovsk district, Krasnoiarsk region (the apiary of "The XXIInd Congress" kolkhoze with over 600 colonies).

In zones with severe conditions, when bees are wintered in single-walled hives, they are packed at the outside, and protected from wind. Corrugated board and rubber sheets are used for this purpose in the USA and Canada. There bees are wintered in multiple-storey hives in two boxes. Hives are covered with rubber sheet so that the ends of the sheet protrude 15—20 cm. over the hive. The space between the sheet and the walls of the hive are filled insulating material (withered leaves, shavings, straw); the thickness of the insulating layer of the sides of the hive is of 12—15 cm, while on the top of 18—20 cm. Then the upper edges of the sheet are bent, covered with a sheet of the same material and tied closely with a string. In order to allow the air to penetrate into the hive and the bees to fly, two lathes are nailed at the upper entrance of the second body, in which an orifice at the level of the entrance is provided for. It is through this orifice that bees come out late in autumn and early in spring for cleansing flight.

Wintering of bees in packed hives is successfully practised in many districts with cold winters: it is better to pack two or four hives together. Packing of four hives is better as it saves material and assures optimum temperature. It is apropriate when hives are placed in groups in the apiary. Before frosts come four hives with colonies are packed together, their entrances facing oposite directions; to this end protecting pannels — made of cheap building material (boards, twig weavings, etc.) — are placed on all sides of hives as well as tops and under the bottom boards.

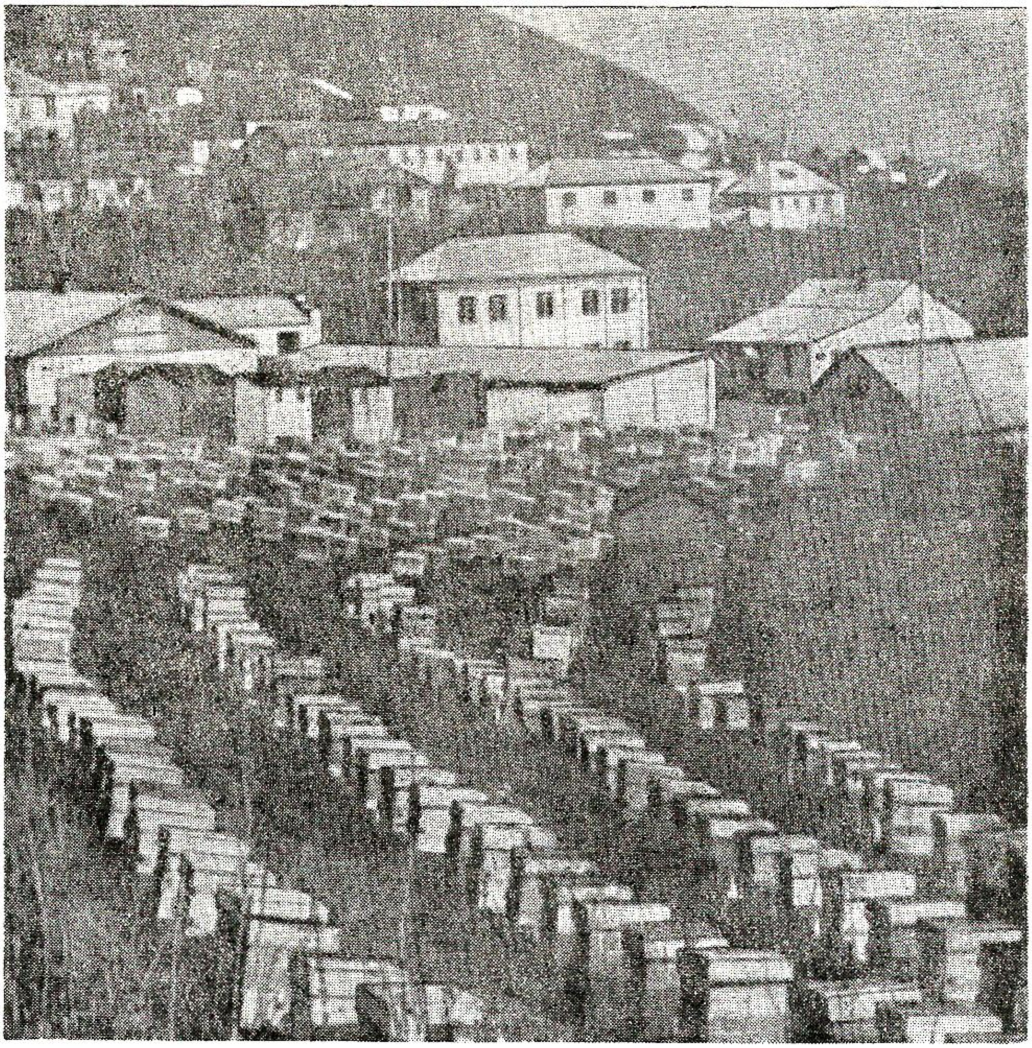


Fig. 76. Wintering of bees in the open without extra insulation (Central farm of the "Kislovodskii" sovkhoze)

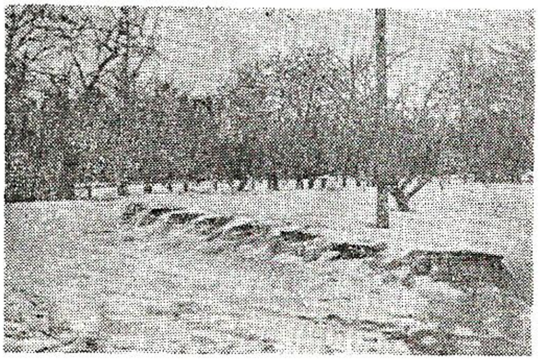


Fig. 77. Wintering of bees in the open, under the snow

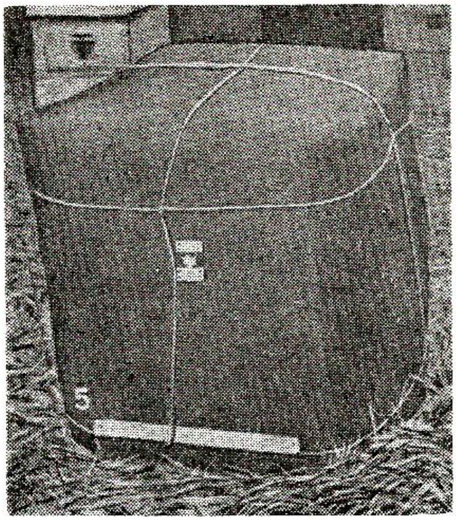


Fig. 78. External packing with ruberoid

Between the bottom board, walls and cover of the hive and the protecting pannel a space is left which is filled with insulating material (withered leaves, moss, shavings, boon or sawdust). The thickness of the insulating layer between the walls of the hive and the pannels must

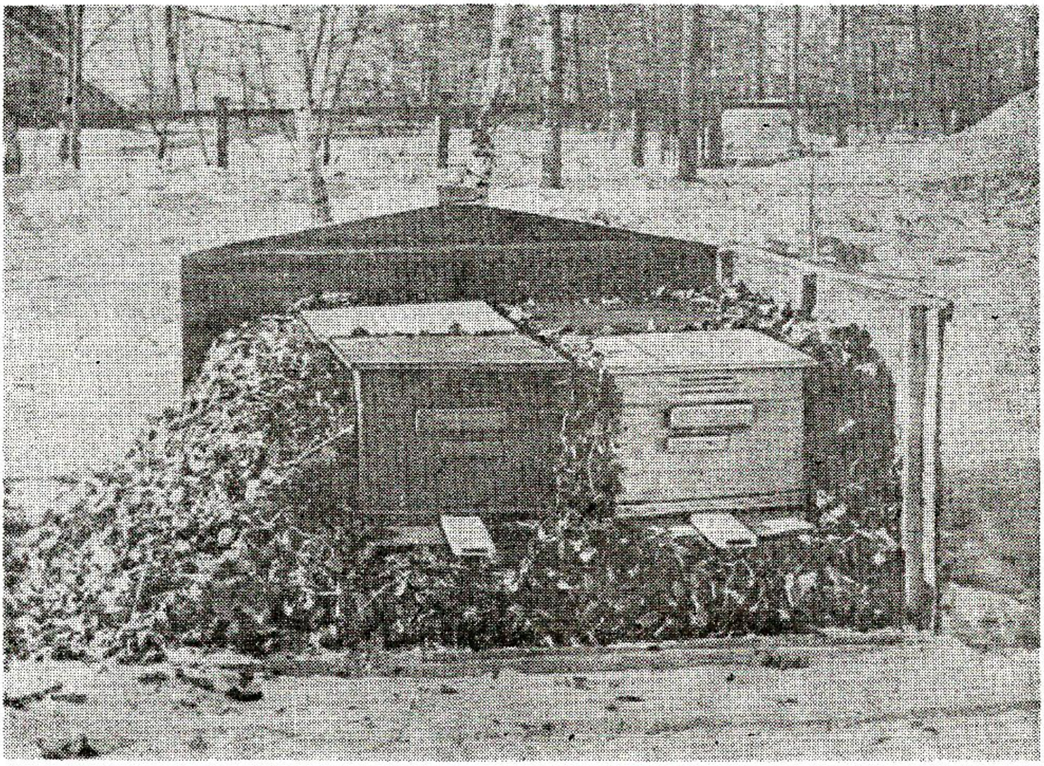


Fig. 79. Wintering of bees in packed hives

be of 15—20 cm, and of that between neighbouring hives — of about 10 cm. Starting with the hive entrance, 8—10 mm high and 150—200 mm wide small channels are practised, which lead to the outside.

To protect the hives against mice it is recommended to lay a needle leaves under the lower layer of the insulating material, and the outer ends of the corridors to be supplied with metal grids.

When several hives are packed together taking out packings in spring is not an urgent problem since the colonies warm each other and are well protected from the outside temperature variations.

The first spring checking of the colonies can be made by removing the external pannel and the layer of the insulating material only during the inspection, the pack being taken out when warm weather comes. Thus the colonies develop under good conditions in spring. The protecting pannels can be used in summer for building wind protecting fences and sheds, and whether they are of wood boards — for shelters when colonies are moved to various flows. In autumn they will be again used for packing hives.

POLLINATION OF FARM CROPS BY BEES

The results obtained by many researchers in this country and abroad, as well as the long experience of large sovkhozes and kolkhozes are evidence of the tremendous economic importance of beekeeping in increasing the yield of entomophilous crops, improvement of fruit and seed quality and in raising the vitality of subsequent plant generations.

In our country, the large-scale pollination of red clover seed crops was undertaken by the well-known agronomist I. N. Klingen in 1910. These experiments demonstrated the high efficiency of the pollination by bees of clover crops in Orlovsk region. Later on, studies carried for a long time by the professors of the "K. A. Timiriazev" Academy of Agricultural Sciences (P. N. Veprikov, A. F. Gubin, etc.), the reasearchers of the Bee Research Institute (G. A. Rozov, G. M. Soloviov, G. V. Kopelkiewski, E. G. Ponomariova, G. A. Skrebtsova, etc.) as well as other Soviet and foreign scientists have shown the great role played by honey bees in increasing production and improving the quality of seeds, fruit (and fibres) of sun-flower, buckwheat, cotton, sugar-beet and fodder legumes, berries and fruit trees, and subtropical cultures, leguminous plants, pumpkins and medicinal plants.

In pages 4—7 the importance and economic efficiency of pollination by bees of entomophilous crops is discussed. One must note that the importance of crossed pollination of entomophilous crops rises very much in step with the intensification and specialization of farm production, and with ever larger areas under single crops.

These methods result in higher yields per hectare, increased labour productivity and lower production costs. A rational, planned pollination of farm crops by bees is an important help towards efficiency of such methods. Use of fertilizers and chemical weedkillers in agriculture has an important influence on the efficiency of pollination by bees of entomophilous crops, because improved growing and developing conditions of entomophilous crops will result in more flowers and secretion of a larger amount of nectar — which also means more bee forage.

The extensive use and perfection of methods of phytopharmaceutical control of plant diseases and pests cause mass killing of wild pollinating insects (bumble-bees, solitary bees, etc.) and consequently the role of honey bees in pollinating plants increases. Special measures are however necessary to be taken for protecting honey bees from possible poisoning with such drugs.

Pollination by bees can play an important part in improving hereditary qualities of entomophilous plants, of seed crops, especially of hybrid cotton seed, fodder, leguminous crops, etc.

BIOLOGICAL APPROACH

By experiments made with 57 plant species Charles Darwin showed the superiority of crossed pollination as compared to self-pollination. This superiority was maintained in subsequent generations.

The same conclusions were reached by the top representatives of the Russian biological science K. A. Timiriazev and I. V. Michurin. They have also provided for the materialistic substantiation of the phenomenon. The higher vitality and seed and fruit yield as well improved quality is possible only when flowers are pollinated with a larger amount of pollen of various qualities and with selective fertilization.

In his work "Interesting Aspects of the Influence of the Reproductive Stock on the Qualities of their Hybrids" I. V. Michurin wrote that each expert in plant hybridation must take into account that the descendants of naturally crossed pollinated plants are relatively more viable, provided each parent plant can freely choose the fittest pollen for its reproductive organs — either airborne or brought by insects from a rather large number of varieties of plants which cannot be always expected from hybrid saplings obtained by artificial, viz. forced crossing...".

The various means of crossed pollination played a very important part in the evolution and formation of plant species, in the development and biological progress of high forms — angiosperms or flower plants. And a preponderant part was played by insects.

The English paleobotanist D. G. Scott pointed out that when angiosperms evolved all af a sudden in the Cretaceous period — as we are inclined to think it — the whole appearance of the Earth changed and flowers similar to those which we know today occured everywhere. This significant change in the plant kingdom, long ago is almost as important as man's evolving for the animal kingdom, and it depended largely on the simultaneous development of superior insects". Such superior insects, thanks to which the superior plants, with flowers, developed were the earliest ancestors of wasp-type bees turned to feeding brood with nectar and pollen.

With superior plants the flower is the reproductive organ. The main parts of the flower are the pistil (female organ) and stamens (male organs). The transfer of pollen from the male organs to the stigma of the pistil is called pollination. After pollination, the pollen on the stigma of the pistil germinate, the pollen tube reaches the cavity of the ovary after passing through the gynodium. Then one of the two spermatozoa merges with the nucleus of the oosphere and fecundation takes place resulting in the zygote which in its turn becomes the embryo. The second spermatozoon in the pollen tube merges with the nucleus of the central cell of the embryo sac. As a consequence the endosperm develops, which accumulates nutritive substances used during the future development of the embryo. This is the double fertilization. (discovered by S. G. Nevashin in 1898).

Plant Pollination. The first plants which appeared on the earth in early geological periods developed in water, which led to plant pollination. At present, water pollination occurs in a few species only, such as *Elodea canadensis* and *Valisneria spiralis*. The flowers of these plants blossom under water and then rise to the surface. The male flowers part with the floral peduncle and are floated to the female flowers. The plants pollinated via water are called hydrophilous plants.

A great progress in the development of plants was their transition to land and pollination by means of wind. The anemophilous plants include gymnosperms (the coniferae which are living fossils of plants of long ago) and a considerable number of species of higher angiosperm plants (rye, maize and other cereals, sedge, reed, brich-hazel-nut-, poplar-, oak-trees etc.).

Most higher plants are pollinated by animals (the zoophilous plants). Some species living in the tropics are pollinated by small humming birds (the ornitophilous plants). The great majority of flower plant species are pollinated by insects. Almost 80% of the higher plant species are entomophilous, while 20% are pollinated by wind. The entomophily is a better form of pollination providing for greatest possibilities of selective fertilization.

The anemophilous plants usually have modest flowers, without a lively-coloured corolla.

In order to achieve crossed pollination by means of wind they must produce a large amount of light pollen, consuming for this numerous highly nutritional substances. In the period of blossoming of pine- and hazel-nut-trees, of rye and of other anemophilous plants, the atmosphere is full of pollen grains. A large amount of pollen is wasted and only a small part is accidentally carried to the stigmas, by the wind.

Insect-pollination is safer and more economical. The insects take the pollen directly from the male organs of some flowers and carry it into the female ones. For this, insects visit a large number of plants; pollen different genetically produced by plants in various conditions sticks to their bodies; this mixture of pollen grains is carried to the stigma of the pistil, securing the best conditions for selective fertilization.

No means of pollination is however constant. In step with changing plant growth conditions, the methods of pollination also change. Some plant species are in an "intermediary" condition between the wind and insect pollination. Charles Darwin exemplifies this condition with rhubarb *(Rheum rhaponticum)* — having a light and unsticky pollen which is carried by wind; at the same time, the rhubarb flowers are visited by insects which thus perform cross-pollination. The same applies to vine, oak-, willow-tree, hamp and other species.

A number of species which had previously been entomophilous have adapted themselves to wind pollination because of the lack of

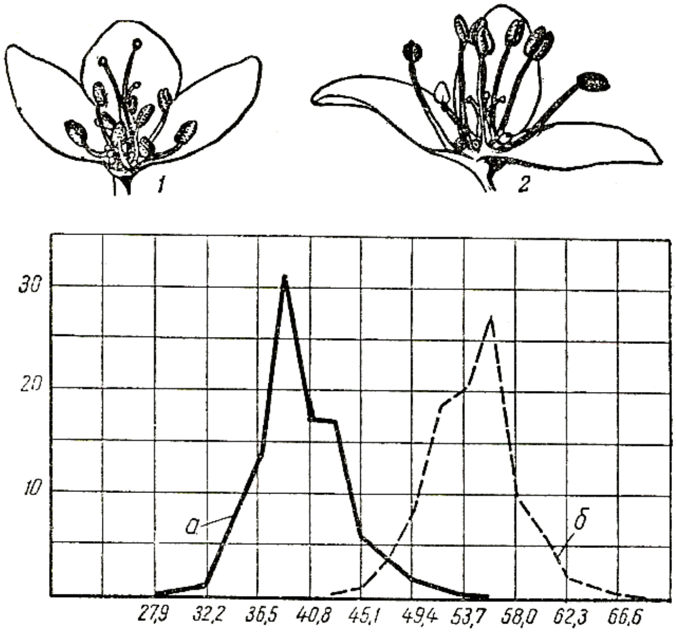


Fig. 80 Heterostyly in buckwheat flowers :
1 — flowers with long style (the pollen grains on it are small) and 2 — flowers with short style (greater pollen grains). On the graph — variability of the pollen grain dimensions in long style (a) and short style (b) flowers

pollinating insects in their native region. According to Acad. V. L. Komarov, this category includes the graminaceae whose lively coloured flowers — formerly pollinated by insects — have turned during their evolution into colourless ears, adapted to wind pollination.

The scarcity of entomofauna determined the appearance of self-pollination with a number of species with flower plants which had obviously been adapted to insect pollination. A telling example of this change is the pollination of peas *(Pisum sativum* L.*)*, whose flowers have a lively-coloured corolla and secrete nectar. With them, self-pollination takes place before blooming ; as a rule, they are not visited by insects. Charles Darwin, after having studied peas for 13 years, noticed honey bees and bumble bees on its flowers only three times. Darwin asserted that this would not necessarily lead to the conclusion that in the origin country the same variant behaved in the same manner. And, indeed, subsequent studies demonstrated that in alpine districts of Asia, peas are pollinated by bumble bees. A similar transition to self-pollination because of the lack of insects has taken place in lentil, beans and other leguminous plant species. These are however exceptions from the general process of pollination development — from more primitive self-pollination to various forms of cross-pollination, of which insect pollination is the most efficient, biologically and economically).

Adaptation of plants to cross pollination. During their development in close relation to the higher insects, plants have developed a number of characteristics enabling their adaptation to cross-pollination, gradually retrieving from self-pollination. Here are the most important ones :

1. Separation of male from the female reproduction organs. This is best represented in the dioecious plants ; male

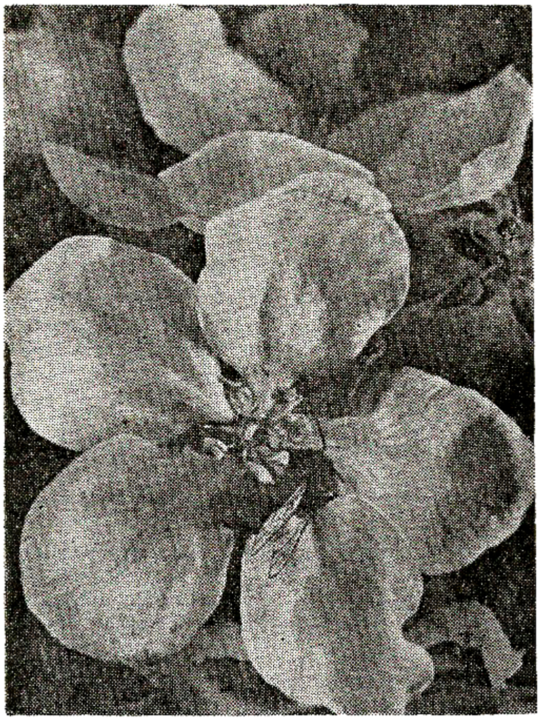


Fig. 81 — Apple-tree flower. The female organs grow mature first (proterogyny)

flowers with stamens exist on some plants whereas on others — only female pistillate flowers (willow-tree, hemp). In monoecious plants flowers are unisexual (they have either stamens or pistil) but both kinds would develop on one and the same plant (cucumber, pumpkin, oak-tree etc.). Separation of the reproduction organs of flowers also appears in hermaphrodite flowers (as in buckwheat): in the flowers of some plants the stamens are longer and the pistil shorter, while in other flowers, vice-versa. With some flowers, the anthers are as tall as the stigmas of other flowers. Such a position of the reproduction organs of the flowers was called "heterostyly". Worthy of mention is the fact that in the anthers of short stamens a finer pollen is to be found which, as a rule, is not capable of fertilization because the short germinating pollen tube cannot reach the ovary.

2. M a t u r i t y a t d i f f e r e n t d a t e s o f f e m a l e a n d m a l e o r g a n s in hermaphrodite plants, which hampers self-pollination. In some cases the anthers become mature first and then the stigmas, as sun-flower, fire-weed, gooseberry and geranium (proterandry). The mature anthers break, the pollen in them spreads out or is collected by insects. When the stigmas grow mature, the respective flower no longer had pollen. Pollination is performed with pollen from other flowers of the same plant or of other plants.

With a series of plants (apple- and pear-tree, plantain) the stigma gets mature faster (protagyny). The pollination is made with pollen from other flowers before the maturation of its own pollen.

3. Physiological incompatibility. Although in many plants the female and male organ grow mature at the same time, self-pollination does not take place when the pollen reaches the pistil. And this because in reaching the stigma its own pollen does not germinate or germinates slower than the pollen coming from other flowers (as for clover and other fodder plants). This phenomenon is called *self-sterility*. In some species, the pollen germinates neither on the stigma of its own flower nor on the stigma of other flowers belonging to the same plant. And, with a series of fruit-tree and berry varieties (apple-trees, pear-trees, raspberry etc.) the pollen does not even germinate on the stigma of other plants of the same variety, and cross-pollination is possible only between different varieties, sometimes only between certain varieties.

A number of adaptive features have developed in relation to cross-pollination by insects. First and foremost is the nectar secretion, which attracts insects, being a source of food. Then, they produce a less finer pollen than the anemophilous plants : it can be easily collected by bees which make up pellets and carry them to the nest for rearing brood and feeding the other bees. The flowers of entomophilous species are bigger and easier perceived, as a rule, than those of the anemophilous plants. Small flowers usually make up large inflorescences, visible from great distances. Likewise, with some species (for instance sun-flower and other compositae), part of the peripheral florets on the head have no reproductive functions, their role being to attract insects by the vivid colour of their petals. It is interesting that the flowers of most antomophilous species are so coloured as to be remarked by insects — yellow, dark blue, which reflect the ultraviolet rays (which the insects easily perceive). On the contrary, many ornitophilous plants have red flowers — which insects do not distinguish, but which are well perceived by the birds.

The flower scent — especially of those whose petal colour is not vivid (lime-tree, some umbelliferous plants etc.) — is also very important in attracting insects.

Role of Various Insects in Plant Pollination. During the evolution of entomophilous plants, the major role has been played by the various representatives of Hymenoptera, *Apis* in particular. The latter have permanently been major factors in cross-pollination of farm crops. Not all insects visiting flowers for nectar are useful for cross-pollination too. For instance, some beetles and bugs feeding on nectar with pleasure, prove more damaging than useful to plants.

A very unimportant part in pollination is played by butterflies (some of them are even damaging), golden and parasitary wasps and the wasps with short proboscis. Among the wild representatives of entomofauna an essential part in pollination is played by bumble bees, solitary bees, some species of wasps and flies. Moreover, each and every of the above-mentioned groups are interesting for the pollination of certain plant species. For instance, the bumble bees with long proboscis pollinate the red clover more successfully than other insects. Some solitary bees are well adapted to visit and pollinate alfalfa. Flies pollinate well the carrot seed plots. Nevertheless the number of wild insects suddenly changes in different years and their populations suddenly decrease when tilling field ways, fallow lands or when drug control of plant pests and diseases is applied on. Under present conditions in the areas with intensive agriculture their role as pollinating agents is practically null and void of any importance.

The main part in pollinating entomophilous crops is played by honey bees; their evolution and way of living best adapted them to the process of their development for fulfilling this function. They live in colonies. Their number during the flowering period of the main honey plants can reach a few tens of thousands. For feeding themselves, rearing brood and ensuring food reserves, the bee colony collects over two quintals of nectar and 20—25 kg of pollen during the blossoming period of entomophilous plants. To collect such an amount of nectar the bees of each colony must visit over 500 million flowers, each of them containing 0.5 mg of nectar.

Almost as many visits are necessary for gathering pollen. Thus, during a season a strong colony visits over one thousand million flowers. No other species of insects can be compared to honey bees as concerns the volume of pollinating activity. The problem does not consist in quantitative indices alone. It is also important that honey bees winter in large colonies. In spring, when the number of wild pollinators suddenly drops (in bumble bee colonies for instance only the queen survives) the honey bee colonies can use in nectar and pollen collecting a strong group of 10,000 worker bees whose number increases daily in step with greater numbers of plants in bloom.

Whereas the majority of solitary bees are monotrophic insects (visit only the flowers of plants belonging to the same genus or species), or oligotrophic ones (visit the flowers of a series of species of the same family), the honey bee is a polytrophic insect. It collects the nectar and pollen from all entomophilous species accessible to it, no matter what family, genus and species it belongs to. In this case the bees rapidly switch the large areas under honey crops still at their blossoming, i.e. in the period when flowers need pollination. In order to fill its honey sac during one flight alone, a bee must visit up to 80—150 flowers depending on nectar production of plants. The same number of flowers must be visited by a bee to collect pollen and make it pellets. Two pellets weighing 15—20 mg contain over three million pollen grains. The hairy body of the bee retains some pollen grains of various origin, which during visiting flowers reach the stigma. Each flower is visited several times by bees during its lifetime. It ensures the best conditions for selective pollination and that is why in intensive agriculture a rational organization of pollinating entomophilous plants by bees is necessary for higher and improved productions at lower cost prices.

METHODS OF INCREASING THE EFFICIENCY OF POLLINATING ENTOMOPHILOUS CROPS BY BEES

Pollination of entomophilous crops by bees is one of the most important means within the complex of advanced agrotehnical measures of plant cultivation. The efficiency of this measure depends on the other agrotechnical elements equally important. The normally fertilized ovules can develop normally and set high-quality seeds only on condition that plants should be ensured a sufficient amount of nutritive substances, which is only possible under good conditions. Otherwise the efficiency of pollination of crops by bees suddenly decreases (even down to zero) since the normal feeding of the fertilized ovules is troubled. A slacking down in the development of fruit set, their falling (in trees and fruit trees), their withering (in buckwheat) or their shaking down (in alfalfa and other leguminous plants) — all this was often noted on entomophilous crop plantations which were treated with fertilizers in an inadequate way, stiffled by weeds and damaged by various pests. The fact was established that the crop increase following the pollination of cultures by bees is greater in step with better conditions of plant growing and developing and higher agrotechnical level. For increasing the efficiency of pollination, a very important role is played by the preparation of strong bee colonies at the beginning of the massive blossoming of the main entomophilous crops. Preparation of strong colonies for pollinating entomophilous crops is also necessary and it is carried out in much the same way as in the case of preparation for the main flow.

The pollination service requires populous colonies, with prolific queens and a great amount of brood in various stages. When the target species secretes little or little accessible nectar (for instance red clover), the colonies must rear much unsealed brood : feeding this brood requires an intensive foraging activity.

Moving the bees close to the antomophilous crops is one of the most important measures for improving the efficiency of pollination, because the intensity of plants' visiting by bees decreases as the colonies are more distant.

According to data provided by Professor A. F. Gubin the number of bees on the red clover seed plots decreases on the average by 3.7% with every 100 m distance from the apiary. At a 2.7 km distance from the apiary bees no longer visit the red clover as a rule. The same occurs with the pollination of other crops.

Very suddenly drops the number of bees in case of moving off apiaries from blossomed orchards early in spring, when weather is still cold. As a rule, the nearer the apiary to the orchards the less the amount of energy and food spent by the pollinating bees. The technique for bees' preparation and transportation for pollination is the same as in the case of migratory bee-keeping.

Hive location besides the target crops depends on the size and species of the crop. For facilitating the work of the aparist, hives are usually sited within one and the same place. In this case the hives must be distributed in such a manner as the most entomophilous crop plots should be located at maximum 500—700 m while the orchard at 200—500 m. In case of small and relatively compact plots (up to 50—75 ha) it is better to place the apiary in the middle of the respective field. On large areas — long but narrow — two or more such apiaries can be located, at a distance separating them of at least 1—1.4 km (in the orchard, 0.4—0.5 km). With two or several apiaries one may often organize the so-called "junction pollination".

The junction pollination is organized on relatively large areas to provide a more or less uniform visiting of flowers all over the entire area which is going to be pollinated. Every corner of the plot ought to be provided with an apiary : the usual decrease in number of bees of an apiary towards the centre of the field is so compensated by bees coming from another apiary. The frequency of bee visits for plant in the given area between the two apiaries will be almost even.

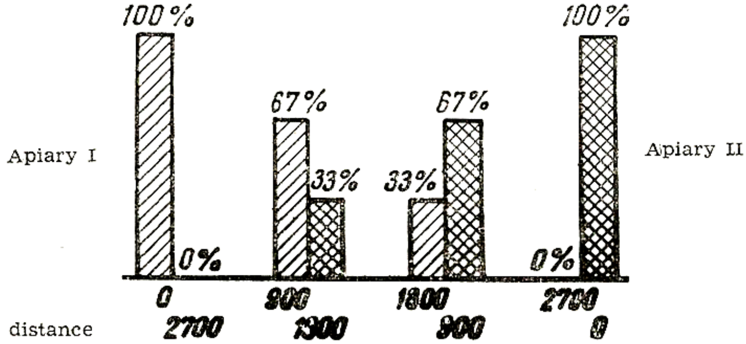


Fig. 82 — Junction pollination according to A. F. Gubin

Nonetheless, the general effect of pollination will increase if the apiaries are not located just adjacent to the target field but 400—500 m of the centre. One must take into account that the bees in each and every apiary do not only fly to each other but also visit the flowers round the apiary. In case of such a location the distance between the apiaries diminishes by 800—1,000 m and the bees of the former apiary visit the closest plots on the left while those of the latter one the right plots. As a consequence, the average distance between apiaries and plots of pollinated plants ought to be considerably diminished, thus increasing the general effect of pollination.

In case of simultaneous blossoming of several nectar species, bees usually visit all species within their flight radius, but with different intensity. As a rule, most bees collect nectar from those plants which secrete more nectar and which at the same time are accessible to bees. In the period of full blossoming of lime-tree or buckwheat most bees start collecting the nectar of these plants ; however, a small number of bees go on visiting other plants yielding less nectar. An abundant nectar flow at a major honey plant results in higher vitaltiy of the bees and a stimulation of their flying energy and induces a better visiting of plants with poorer nectar secretion.

Red clover for instance has a very weak nectar flow and is less visited by bees than lime tree and buckwheat. If bees meet only red clover fields, the vitality of the colonies, the queens' prolificness as well as the brood quantity and the number of foraging worker bees decrease; the number of visits to red clover flowers decreases. If besides the red clover fields there are some major nectar sources too, the bees' vitality increases and as a consequence the number of visits on the red clover flowers.

Things are much the same with pollinating cucumbers in greenhouses. If bees are given the opportunity to work greenhouse crops for collecting nectar and pollen, the colonies develop better, which is equal to more frequent visits on cucumber flowers and implicitly to a better pollination. This is due to the fact that various groups of bees in every colony visit certain plants and even a certain plot, and if from time to time they receive supplementary food under the form of nectar and pollen, they go on visiting the given plot while the rest collect from other crops and plots. This more or less constant link of a group to a certain plot or certain branches of a blossomed tree was demonstrated by S. Sigh et al. in special surveys.

One may notice a certain specialization according to which bees working for instance sunflower will, as a rule, avoid the flowers of other species. In the case of an abundant nectar flow this "specialization" can last for a long time. It is profitable for the colony because a uniform and constant pattern of collecting nectar and pollen from one and the same species is more efficient than visiting plants of different species. This specialization results in more efficient cross-pollination too. However, bees have no strict preferences in visiting certain plant species. Charles Darwin, early in his time, noted the simultaneous visitis of bees on various species. Most often the honey bees visit two species and seldom three. This transition from one species to another during nectar and pollen foraging is called "flower migration". Dropping in the intensity of nectar flow usually causes a bees' migration to another source, which proves th versatile behaviour of the bee colonies. The bees' capacity to migrate from one plant to another (flower migration) is used for inducing more frequent visits on some crops such as red clover for instance.

Number of colonies required and size of pollinizer apiary depend on the biological peculiarities and the acreage of the respective crop, as well as on the strength and condition of the bee colony. Full assertion of the selective fertilization and of maximum seed set require several visits to each flower. Special surveys have demonstrated that red clover flowers require at least two visits, sun-flower 8—10, buckwheat 6—8, strawberry 11—15, cucumber 15—20, pumpkin 20—30 visits. Knowing the approximative number of flowers per unit area and the number of necessary visits, one can determine the number of bees necessary for pollinating one hectare under a certain crop.

Suppose that 2 million flowers which need 8 bees' visits grow mature daily on an area of 1 ha under sun-flower. Bees must visit one day no less than 16 million flowers. During the period of sun-flower blossoming each and every bee can undertake 12 flights. If each sun flower floret contains 0.5 mg nectar, the bee must visit 90 florets at one flight for filling its honey sac; thus it will have to visit 1,080 florets during its 12 daily flights. Therefore, 16 million visits to sun-flower can be made by 15,000 foraging bees.

One may consider that almost half of the worker bees of a colony are foraging bees, dealing with nectar and pollen collection. If the sun-flower massive crops are supplied with strong colonies (about 6 kg on the average) each of these colonies can ensure the pollination of 2 ha under sun-flower. Weaker colonies (about 3 kg on the average) hardly manage to pollinate one hectare. If an entomophilous crop holds a small area the number of colonies per unit area should increase. It is highly important especially for plants which are more seldom visited by bees (red clover, alfalfa).

The number of bee colonies necessary for pollinating an entomophilous crop and for honey production should be higher if the crops are to be found at a wider distance than 0.5 km or if the bee colonies are weak. Under the conditions of advanced agricultural techniques conducive to a larger number of flowers and an abundant nectar flow more bees per area unit are necessary for a good pollination and best use of the main flow. Under poor agricultural technical conditions and a poor nectar flow the number of active colonies may diminish.

For pollinating one hectare of entomophilous crop the following number of colonies must be ensured :

fruit-trees and berries	2 —3 colonies
vegetables and pumpkin	0.3—0.5 colonies
buckwheat	2 —3 colonies
sun-flower	0.5—1 colonies
cotton	0.5—1 colonies
seed fodder leguminous (clover, alfalfa)	1.0—1.5 colonies
seed esparset and melilot	3 —4 colonies

Some entomophilous crops are hardly visited by bees because their flowers secrete a small amount of nectar or the structure of flowers (red clover, alfalfa) makes nectar collection difficult. More often than not the necessity arises to move bees from one crop to another. On the basis of the study undertaken by N. P. Pavlov about reflexes, professor A. F. Gubin has worked out a system of bees' directioning towards certain melliferous plants or of their moving from some flowers to others, which was called bees' training.

Training of bees with scents is accomplished bu means of elaborating the conditioned reflex for the aroma of flowers of certain plants. With this aim in view bees are fed on sugar syrup having the aroma of the flowers to which we intend to orient the bees. Receiving food with a well-determined aroma, the bees search flowers with the same smell, gather the nectar secreted by them at the same time pollinating them. The steadfastness of the conditioned reflex asks for a systematic feeding ; to this effect bees must be fed daily on scented sugar syrup along the entire period of blossoming of the melliferous crop.

Training must start at the beginning of plant blossoming. The sugar syrup is prepared in the preceding evening (the proportion 1 kg sugar : 1 l water). Sugar is dissolved in boiled water and is left to cool down the temperature of freshly-milked milk. Then the corollas of the target flowers are added; after 5—6 hours the syrup gets the flowers' aroma and it can be given to the colonies in the common feeders (150 g—200 g per colony). The colonies are fed early in the morning before the flight. This feeding goes until the end of mass flourishing of the pollinated crop. The next day and the following ones the dose of food may be halved.

Bees' training by means of smell has a satisfactory effect on condition that the apiary should closely neighbour the massive pollinated crop, because bees' feeding in the hive mobilizes them to search the source of food nearby.

Thus, within the experiments under taken by I. I. Firsov of training bees to visit red clover, as many as 608 bees foraged on the first 100 sq.m next to the apiary, 397 on the same area placed at 350 m from the apiary and only 249 bees at 700 m from the apiary.

Bees' training for foraging a certain plot aims at inducing bees to visit the plants on a determined area, far from the apiary as a rule. Late professor A. F. Gubin proposed the method of using strong scents and attracting the bees. In case of feeding bees on syrup having the red clover aroma, a small amount (about 2—3 drops) of essential oils (anise, mint) is added. When many bees are gathered at the feeder they are moved, with the feeder, in the clover field. When the scented syrup is consumed, the feeders oper: the bees — their honey sac full of syrup — will come back to the hives where they will recruit other bees to visit the feeders.

The specific scent of the anise or mint oil helps bees to locate the feeders. Essential oils must be supplementary added in the feeder for 2—3 days. In the meantime the bees start intensely visiting not only the feeders but also the clover flowers on the respective area. The feeders are then taken off but the bees in the hive are further fed on clover syrup.

Bees can also be directed to a target crop by means of a screen reflecting UV rays or painted in colours easily perceivable by bees (dark blue, yellow). Food is first supplied against this screen nearby the apiary; then screen and feeders are gradually moved towards the target plot. As a consequence, a conditioned reflex in addition to the visual stimuli develops in bees; if sufficient strengthening food is supplied, the visits to the target plot get more frequent. Comparative surveys have demonstrated that bees' training is preferable to moving them, since bees are better "persuaded" by feeders. With the aim of directing bees towards the target plot it is not necessary to supply food in hives; supplementary feeding in the field is made 2—3 times.

Bees' training to a certain plot can be used by hybrid seed growers, especially when the target plot is of small acreage and bringing the bees to the plot is not efficient.

Following the application of the above-mentioned methods, intensity of bee flights in the respective crop will considerably increase in step with the efficiency of pollination. Nevertheless bees' training has an essential disadvantage — it entails large labour expenditure for preparing scented syrup, bees' daily feeding, transportation of feeders and screens, etc. Although some apiarists successfully use bees' training for the pollination of red clover seed plots and green-house cucumbers, the large amount of work entailed is the main obstacle for generalizing this method in current conditions.

Ș. M. Soloviov and E. G. Ponomariov of the Bee Research Institute worked out a simpler method which asks for less amount of work in order to attract bees to a certain plot by means of the so-called "bait crops". A scarcely visited crop (red clover for instance) requires other honey plants to be sown at the same time, mixed up or separated (100—150 m distance) — for instance crimson clover. Red clover secretes much nectar accessible to bees and therefore it is more intensely visited by them. As a rule it starts to blossom 1—2 weeks before the crimson clover. At the beginning bees visit the red clover which leads to the development of a conditioned reflex for the given place; the reflex is then strengthened by supplying supplementary food. When crimson clover starts to blossom bees accustomed with the respective plot start visiting red clover.

One can intensify the visits of pollen foragers on red clover bringing to the target crop strong colonies with a large amount of unsealed brood. If bee-bread combs are taken off, the lack of protein rich food induces bees to collect red clover pollen in order to maintain brood rearing and pollination.

According to data supplied by the Experimental apicultural station in Bashkiria this method is apt to double the number of visits on red clover seed crops and has an ever greater effect when combined with scented syrup (V. N. Anferova).

An important part in a more efficient pollination by bees of the entomophilous crops is played by preparation of hives and of transport means. The annual plan of any kolkhose or sovkhose should also include the directed pollination of crops. Moving bees to the target crops requires also a strict timing.

Efficiency of bee pollination should be taken into account. In the target crop special plots are delimited, at various distances from the apiary (50 ; 250 ; 500 ; 1,000 and 2,000 m). These plots are 1 m wide and 50—100 m long. During the peak blossoming of the crop, an operator walking along the plots will count the bees on the flowers. After seed maturation the yield is calculated for each plot. Providing that external factors were identical on all plots (soil, agro-techniques, fertilizers, harvesting etc.) the data obtained will prove efficiency of bees' activity under the given conditions. They can also serve as a means of genuine promotion of pollination of crops by bees. Such data about efficiency of pollination by bees are more significant if the yields of large plots situated at various distances from the apiary are harvested separately by mechanical meas.

POLLINATION OF ORCHARDS AND BERRIES

Almost all fruit-tree and berry crops are typical entomophilous plants. Many fruit species are characterized by protandry, i.e. the stigma matures before the anthers, which excludes the possibility of flowers being pollinated with their own pollen. Most apple-, pear-, plum- and morello-trees cultivars as well as other plant species are self-sterile, i.e. they cannot set fruit either with the pollen of their own flowers or with pollen from other trees belonging to the same cultivar. Thus, with these species the possibility of self-pollination is excluded not only by isolation of the reproductive organs of the flower but also by their physiological incompatibility.

Some fruit-tree cultivars are self-fertile, i.e. they can set fruit or berries by pollination with pollen of the same cultivar. But self-fertile cultivars yield higher crops of high-quality fruits when cross-pollinated with pollen from other cultivars.

The self-fertile cultivars Calvil (apple) or Winter Bere Michurin (pear) can set fruit by pollination with the pollen from plants of the same sort. On the contrary, the famous Antonovka self-sterile apple sets fruit only by pollination with pollen of given cultivar.

The pollen of one cultivar reaching the stigma of a flower of another cultivar often does not fertilize it because it does not germinate or — in case of germination — the pollen tube is unable to reach the embryonary sac : a phenomenon due to complex biochemical peculiarities of the given cultivar, which are insufficiently studied so far.

There are *compatible* cultivars which set fruit with their own pollens and *incompatible* ones, the pollens of which do not induce fruit setting.

For instance, the Antonovka apple is best pollinated by Borovinka and Belyi naliv. Pomologists study such data on which sort is best pollinated by pollen of other (compatible) cultivars ; compatibility between various cultivars of fruit-trees and berries are supplied by the literature of speciality.

The plan of a new orchard requires thorough knowledge about the compatibility, besides the trees of the basic cultivar, trees belonging to the pollinating sort. For a better cross-pollination the pollinizer must blossom yearly and simultaneously with the main cultivar. The pollinizer should be adapted to the local conditions and apt to yield rich crops.

As a rule, every 4—5 rows of the main cultivar trees are alternated with a row of the pollinizer. The number of rows of the main cultivar must not be higher because the longer the distance between pollinized and pollinizer trees the lower the yield. Practice has demonstrated that the best fruit sets are scored in the rows neighbouring the pollinizer trees. In older orchards where are trees of only one cultivar, it is recommended to graft cuttings of a pollinizer cultivar in the crown of some trees, to facilitate cross pollinations.

When pollinating fruit-trees and berries one must take into account that most of them blossom early in spring when temperature is generally low and it rains often, which makes the bees' pollinating activity difficult. Early in spring the colonies are weaker than in summer and bees' flight range is shorter.

As a rule, at the beginning of spring there are few natural pollinators. Thus, they practically play no part in the pollination of large orchards. Therefore, about 2—3 bee colonies must be settled for each hectare of orchard. Bees must be prepared early in autumn, to stimulate the rearing of young bees for winter and to secure them a good overwintering. Local conditions permitting, it is better to use Caucasian mountain grey or Carpathian bees for orchards pollination. They come out to forage at lower temperatures even on covered days and are less aggressive. In a large orchard bee colonies must be set in groups of 40—50 lest the distance separating them should surpass 400—500 m. Below are given some biological peculiarities and the efficiency of pollination by bees of the main fruit trees and bushes.

The apple-tree (*Pirus malus* L.) is a basic fruit-bearing crop in the USSR. It is widely distributed from the sub-tropics up to the forest areas. It holds hundreds upon thousands of hectares in many farms. Apple-tree flowers are hermaphrodite and the stigma matures 2—3 days earlier than the anthers. Blossoming lasts for 4—8 days, depending upon cultivar. The nectar flow and the degree of self-sterility varies to

Table 17

Nectar flow in various apple-tree cultivars (the orchard of the „Novoselski" sovkhose)

Cultivar	Sugar content per flower (mg)		
	Total amount	out of which	
		monosaccharides	disaccharides
Corichnoe polosatoe	2.533	1.530	1.003
Streipling	1.987	1.210	0.777
Slavianca	1.179	0.982	0.197
Antonovka	1.087	0.949	0.128
Grushovka Moskovskaia	0.937	0.661	0.276
Kitaia zolotaia ranniaia	0.723	0 494	0.229
Papirovka	0.432	0.228	0.204

a large extent according to the cultivar (see Table 16) and to the external conditions, which is greatly important for the cross pollination by bees.

Over 80% of the apple cultivars cultivated in the USSR are fully or partly self-sterile and the remainder of 20% are self-fertile. Even the self-fertile cultivars yield a higher best quality fruit crop in case of cross pollination by bees.

The researchers of the Apiculture Department under the "K. A. Timiriazev" Academy for Agricultural Sciences have estimated the productivity of various apple-tree cultivars depending upon the distance between trees and apiary, in a great specialized sovkhoze — Mikhailovski pereval", Krasnodar. The data are given in Table 17.

Table 18

Effect of the distance between trees and apiary on apple-tree yield

Cultivar	Fruit yield on plots placed at					
	300 m		1,000 m		1,500 m	
	q/ha	%	q/ha	%	q/ha	%
Reinette Simirenco	62	100	37	60.0	16	25.8
Reinette Shampanski	75	100	34	45.4	17	22.6
Parmen zimnii zolotoi (Winter golden parmen)	18	100	18	100.0	17	99.4

NOTE : During the blossoming of Winter golden parmen cultivar it rained, the sky was cloudy and the bees could not fly. As a consequence, all plots yielded very low amounts of fruit. Blossoming of Reinette Simirenko and Reinette Shampanski sorts occured under propitious weather conditions and bees intensely foraged nectar and pollen. Nevertheless, the number of bees decreased in step with greater distances from the apiary. On the farther lots, where bees did not pollinate the apple-trees, only one quarter of the presumable yield was scored.

The chemical analysis of the fruits demonstrated that by cross pollination by bees the yield not only grew in quantity but also in quality (Table 18).

Table 19

Effect of pollination by bees on the quality of apples

Cultivar	Self-pollination		Cross-pollination	
	sugar content (%)	acidity (%)	sugar content (%)	acidity (%)
Reinette Simirenco	9.44	0.63	10.00	0.55
Reinette Shampanski	10.74	0.75	11.65	0.66
Parmen zimnii zolotoi	17.50	0.32	18.00	0.30

The pear-tree *(Pirus communis* L.) holds the second place among seed crops. Very much like the apple-tree the female reproductive organs grow mature faster than the anthers, thus excluding self-pollination. Most cultivars are self-sterile. There is a small number of self-fertile cultivars but they too yield a larger quantity of high-quality fruits by cross-pollination with pollen from other cultivars. Therefore, cultivation of special pollinizer cultivars and planning cross-pollination of the pear-tree play the same part as with the apple-tree.

The plum-tree (*Prunus domestica* L.) is one of the most widely spread stone-bearing cultivars. Most of the plum-tree cultivars are self-sterile but all are intercompatible. Large yields can be obtained by cross-pollination of common Venguerka with green Reine-Claude pollen ; the reciprocal cross scores weaker results.

When pollination is adequate plum-tree crops increase 2—3 times.

The apricot and the **peach-tree** are prone to cross-pollination. Some apricot-tree cultivars are self-sterile and require interplanting of adequate pollinizer cultivars.

The morello-cherry-tree *(Prunus cerasus* L.) is represented by numerous self-sterile cultivars. A series of cultivars cannot be pollinated by their own pollen since the stigma emerges out of the bud before the anthers get mature. The flowers of some cultivars (such as Duchesse, Prevoskhodnaia) do not produce pollen at all. Many cultivars are incompatible and therefore a minute selection of pollinizers is needed.

Cross-pollination contributes to a considerable increase in yield and to a higher quality. This is obvious in Table 19 presenting the results obtained by the "Novoselski" sovkhoze, Moscow region.

Table 20

Effect of pollination by bees on fruit set in different cultivars of morello-cherry-tree

Cultivar	Isolated from insects			Free access of insects		
	Number of flowers	Fruit setting	Fruit setting (%)	Number of flowers	Fruit setting	Fruit setting (%)
Liubskaia	88	32	36.4	80	48	60.0
Plodorodnaia Michurina	105	36	34.0	90	67	74.4
Krasa Severa	89	4	4.5	89	50	56.1
Griotte (Ostheim)	93	3	3.2	90	59	65.5
Shirpotreb, black	241	7	2.9	240	195	81.2
Shubinca	87	0	—	85	40	49.1

Blossoming and pollination of **cherry-tree** are biologically similar to morello-cherry-tree. The former's productivity also depends on the pollination of its flowers by means of bees.

The **common red raspberry** *(Rubus ideaeus* L.) — one of the most wide spread fruit bearing bushes in the USSR. The spontaneous forms cover huge areas in the forest zone of Siberia and in the northern area of the RSFSR. The raspberry flower with numerous pistils and stamens can be self-pollinated, but best by insects since the heavy and sticky pollen is not carried by wind and the styles of flowers are much longer than the stamens.

The raspberry is a complex berry in which every carpel can develop only after the respective ovary is fertilized. If the number of pollinating insects is insufficient, only some of the ovaries are fertilized. As a consequence, small, undersized, with irregular forms, low quality fruits develop.

In the conditions of Moscow region raspberry cross-pollination induced an increasing of three times in fruit set and twice the yielded crop, in three successive years.

The **black currant** *(Ribes nigrum* L.) and **red currant** *(Ribes rubum* L.) can be self-polinated. This process takes usually place by means of insects, among which the main place is held by honey bees. When isolated from insects, only an extremely small number of flowers set fruit.

According to data supplied by I. V. Sazykin of the Bee Research Institute, the Laxton cultivar set fruit at 1.01% when flowers were isolated from insects; when plants were freely visited by bees and other insects the fruit set was 48.7%; a bush isolated from insects yielded 0.12 kg; when pollinated only by honey bees — 2.40 kg; when freely pollinated by bees and other insects — 2.70 kg.

The **goosberry** *(Ribes grossularia* L.) flowers are adapted **to cross-**pollination since the anthers get mature before the stigma. Its sticky and

On the ordinate : nectar yield (mg)

——— self-fertility
– – – nectar yield

A = Belyi triumph
B = Pastorskyi
C = Triumphalnyi
D = Hauton
E = Avenarius
F = Chornyi negus
G = Brasilski
H = Bochonochnyi
I = Industria
J = Finnik

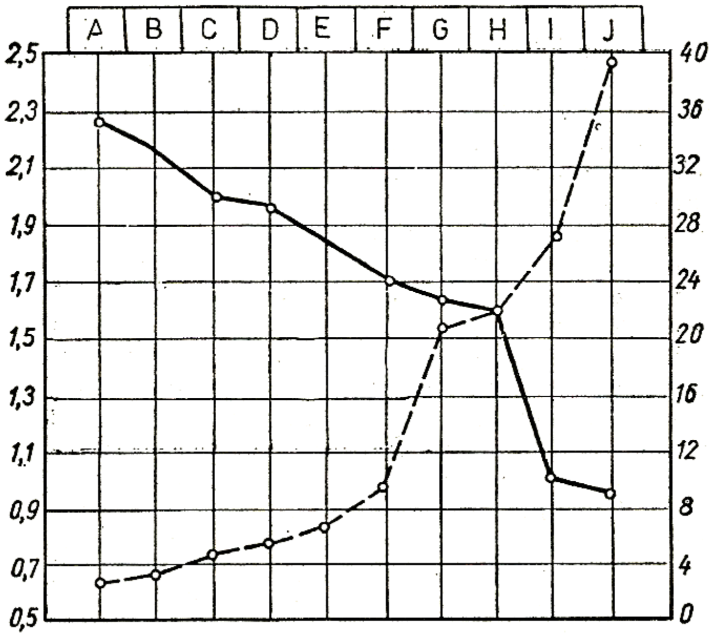


Fig. 83 — Nectar secretion and self-sterility in different gooseberry varieties

relatively heavy pollen is not carried by wind so that the only reliable pollinating agents are the insects, first and foremost the honey bees. The degree of self-fertility greatly varies from one cultivar to another. In this case a close relation can be noticed between the degree of self-fertility and nectar secretion. The better marked the self-sterility — and therefore the greater need for cross-pollination — the larger the amount of nectar secreted by flowers, attracting the insects.

Within the experiences undertaken at the Apiculture Department of "K. A. Timiriazev" Academy for Agricultural Sciences fruit set in isolated trees varied from 9% (Finnik) to 35.6% (Belyi triumph).

The **strawberry** (*Fragaria vesca* L.). Most cultivars have hermaphrodite flowers which self-pollinate. Nonetheless, there are also cultivars, Komsomolka for instance, in which the stamens are underdeveloped and pollination is possible only with pollen from another one. Therefore in fields with such cultivars one must interplant a pollinizer cultivar with well-developed male reproduction organs. Roschinskaia and Misovka are two good pollinizers for Komsomolka strawberry.

According to data supplied by the Bee Research Institute, cross-pollination in strawberries lead to an average crop of up to 57 quintals/ha in the kolkhozes in Lenin district (Moscow region). The same kolkhozes — not using modern techniques, pollination by bees included — obtained yields under 13 quintals/ha. According to data provided by N. D. Screbtsova, full fruit setting in strawberries requires fullest development of the reproduction organs. The average weight of the fruits increases about 30 times (and even more) when the visits made by bees grow in number. No more than 1.0—1.5 bee colonies are adequate for pollinating 1 ha under strawberries.

The **Citrus** crops : in spite of holding relatively small areas in the sub-tropical regions of the USSR, they are highly important for the nutritive qualities and pleasant taste of their fruits.

The tangerine-tree (*Citrus nobilis* An.), the lemon-tree (*Citrus sinensis* L.) supply bees an abundant nectar flow and pollen and they are frequently visited by insects. In California, Florida, Texas and other states in the Southern US, bee colonies collect a high-quality nectar from the orange-tree and other citrus trees. During the blossoming periods, many large bee keeping farms from northern areas move their bee colonies to take best advantage of the main nectar flow ; the cross-pollination by bees in the USSR considerably increases the citrus fruit productions and their quality. The few cultivars of stoneless tangerins are an exception : pollination does not result in higher productions since it leads to stone formation and to delay in fruit ripening. About 2—3 bee colonies are necessary to pollinate 1 ha of citrus orchard.

The **vine** (*Vitus vinifera* L.) has small flowers adapted to wind pollination. In cultivated varieties the flowers are either hermaphrodite (with stamen and pistil) or unisexual (with female reproduction organs). Many cultivars of table grapes with functional female flowers need supplementary pollination which leads to a higher production and higher quality fruits.

The experiments carried out by N. A. Popova at the "Dirunitsa" kolkhose, Novoanensk district, Moldavian SSR, proved that this measure ensured a higher productivity of Madeleine Angevine, Ceauş, Bikan and Coarnă neagră. Supplementary pollination favours an increase in the weight of the clusters (by 17.5—56%), fewer underdeveloped grapes and a better shape. The surveys carried out at the Experimental agricultural station in Khazakh SSR (F. N. Steshenko) proved that honey bees could play an important part in supplementary pollination of vine. Experiments undertaken by this team (in the conditions of Alma-Ata and Chimkentsk regions) proved that cross-pollination of vine (Saperavi and Nimrang cultivars) resulted in a 10—40% increase of production. With Muscat and Culdzinska bee pollination has induced no production growth.

The experiments of some authors confirm the positive effect of training bees for the pollination of certain vine cultivars. Some supplementary pollination of vine is now accomplished by mechanical means. Air crafts are used also for pollination in large farms. The frequent use of honey bees for pollinating vine calls for further experiments, with different cultivars, under various environments.

POLLINATION OF PUMPKIN AND LEGUMINOUS CROPS

Pumpkins are typical entomophilous crops, with large lively-coloured flowers (unisexual plants). In water melon (*Citrulus vulgaris* Shard.), melon (*Cucumis melon* L.) and common pumpkin (*Cucurbita pepo* L.) as well as in other pumpkin plants some flowers bear only female reproduction organs while others only male. Fruit set follows the transfer of pollen from the flowers of plant to the stigma of another plant. In order to ensure selectivity in fertilization every female flower requires more than 30 insect visits.

Honey bees play the most important part in pollinating pumpkin crops.

According to data supplied by the Experimental beekeeping station in the Ukrainean SSR (A. N. Nevkryta), out of the total number of pollinating insects the bees represented 91.7% in water melon, 93.1% in melon and 94.7% in common pumpkin.

By training the bees the visits to the pumpkin flowers became more frequent by several times and the number of fruit sets increased accordingly.

Table 21

Effect of different pollinating methods on fruit set in pumpkins
(after A. N. Nevkryta's data)

Crop	Fruit Set (%)	
	Pollination with insects	Pollination without insects
Common pumpkin	70.8	19.3
Water melon	77.5	15.6
Melon	89.6	0

Vegetable crops need cross-pollination by insects for seed and fruit set. Most of them are typical entomophilous plants. As the experiments have proved, following cross-pollination by bees the yield of a crop grows and the quality of seeds improves — in cabbage, Jerusalem artichoke, winter radish, early radish, sugar-beet, onion, carrot etc. For instance, according to data supplied by the pilot station in Kostroma, the yield of seed cabbage cross-pollinated by bees increased 4—5 times and that of turnip more than twice.

Besides honey bees, an important part is played in carrot and onion pollination by flies. Nevertheless, the number of these insects greatly varies from year to year; it drops as a consequence of plant pests drug control. An important role in seed set of these crops is held by bees.

During experiments with seed onion, carried out on plots in the fields of the "K. A. Timiriazev" Academy of Agricultural Sciences, the seed yield grew 23—27 times as compared to self-pollination. The carrot umbels which were freely visited by bees and other insects set 15.3 more seeds that the caged ones.

The seeds obtained through cross-pollination of flowers by insects are bigger and their germinative power higher than those obtained through self-pollination.

The seed producing vegetables blossom earlier when there are few wild pollinators in nature. That is why 1—2 bee colonies must be located for 1 ha. Bees can be substantially helpful in obtaining hybrid seed for vegetable crops.

Among vegetable crops, cucumbers best represent the advantages of pollination by bees. The separation of different flowers of the female reproduction organs from the male ones, the heavy and sticky pollen, the lively-coloured corolla suggest the adaptation of this plant to cross-pollination by bees. Cucumbers are cultivated in all regions of the USSR, starting with the subtropical ones and the oases of the desert and semidesert areas up to the Far North, beyond the Polar Circle. Cucumbers are cultivated both in open fields and in hot-houses. Hydroponics develops nowadays. When cucumbers are cultivated in the open, pollination by bees is organized very much like that for pumpkin and leguminous entomophilous crops. The pollination of the cucumbers cultivated in hot-houses is characterized by certain peculiarities arising from the specific conditions in greenhouses and hotbeds.

Crops in hot-houses. The most important crop in hot-beds and greenhouses which needs pollination by bees is the cucumber.

In the greenhouses where wild insects have no access, controlled pollination is compulsory. Until not long ago the cucumber flowers under glass were pollinated manually, a time and labour consuming method. Estimations showed that 24 thousand work days were necessary for 1 ha. The operator had to shake the pollen from the anthers on the stigma. In spite of the operators' skillfulness this practice could not replace the multiple insect visits on flowers which bring to the stigma a wide spectrum of pollens. Fruit set and crops were low in case of manual pollination, because of the many "nubbins", "balls" and "crooks".

The experiments carried out for several years within the Department for Apiculture of the "K. A. Timiriazev" Academy for Agricultural Sciences in sovkhozes in the Far North have demonstrated the high efficiency of pollinating by bees of hot-house cucumbers. Thus, in the "Industria" sovkhoze (Murmansk region), the production of hot-bed cucumbers was 1.5 kg per hot-bed when manually pollinated (cost price — 2.73 roubles). Pollination by bees brought an increase of the harvest up to 7.1 kg (the cost price dropped down to 1.2 roubles). In the "Arctica" sovkhoze (Murmansk region) the greenhouse cucumbers crop was 7.5 kg/m^2 when manually pollinated and 22.1 kg/m^2 when pollinated by bees. Following pollination by bees not only the production was higher but the quality of the cucumbers too. The average wieght of the 'Klinisky' and 'Nerosimyi' cultivars rose by 20%, the quality improved as well as the seed shape and quality.

Pollination of hot-beds cucumbers requires strong bee colonies to be placed near the greenhouses (one colony for 500—600 hot-bed plots when blossoming starts. Bees work forcely on the hot-beds, flying through the window panes a little raised for ventilation. The frequency of bee visits may be considerably increased if the bees were trained with sugar syrup specifically scented with cucumber flowers.

Pollination of hot-house cucumbers requires the bee colonies within the greenhouse. Each greenhouse of 1,000 sq.m needs a strong colony. Such plantings are often started by the end of winter. Therefore pollinizer bees must be brought early in spring, before their cleansing flight. At the beginning, bees ought to be kept in an empty, warm hot-house for a couple of days, allowing them to undertake the cleansing flight; subsequently they are moved to the hot-houses with blossomed cucumbers. The bee hives are placed alongside the wall of

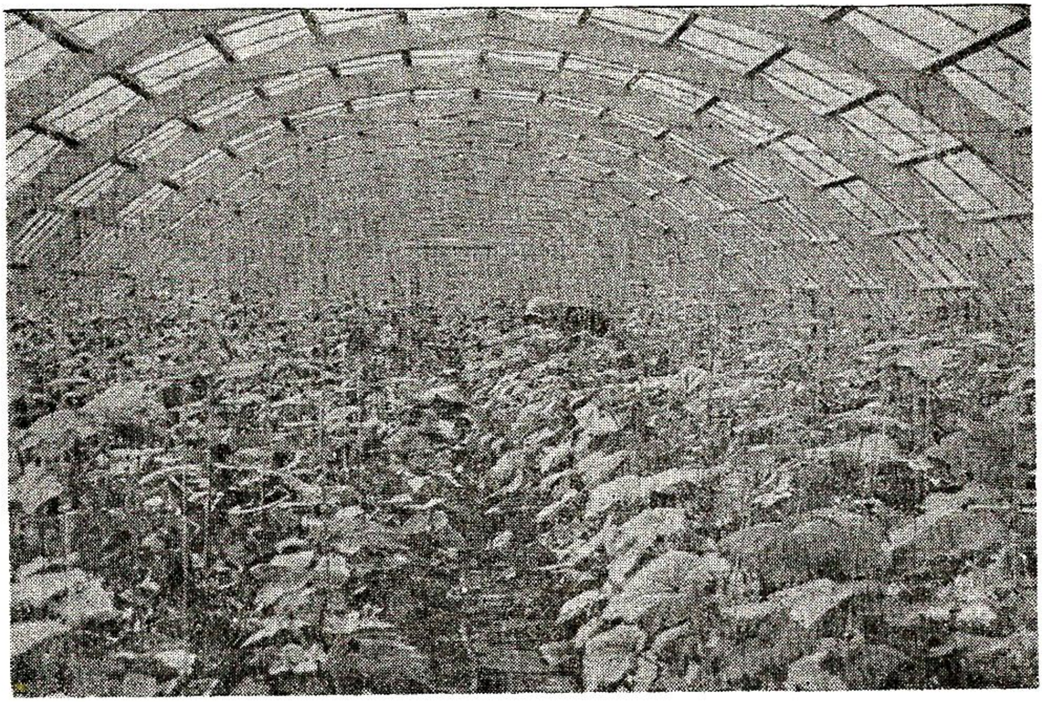


Fig. 84 — Hothouse for cucumbers in the "Zaitsev" sovkhoze, Karelian A.S.S.R.

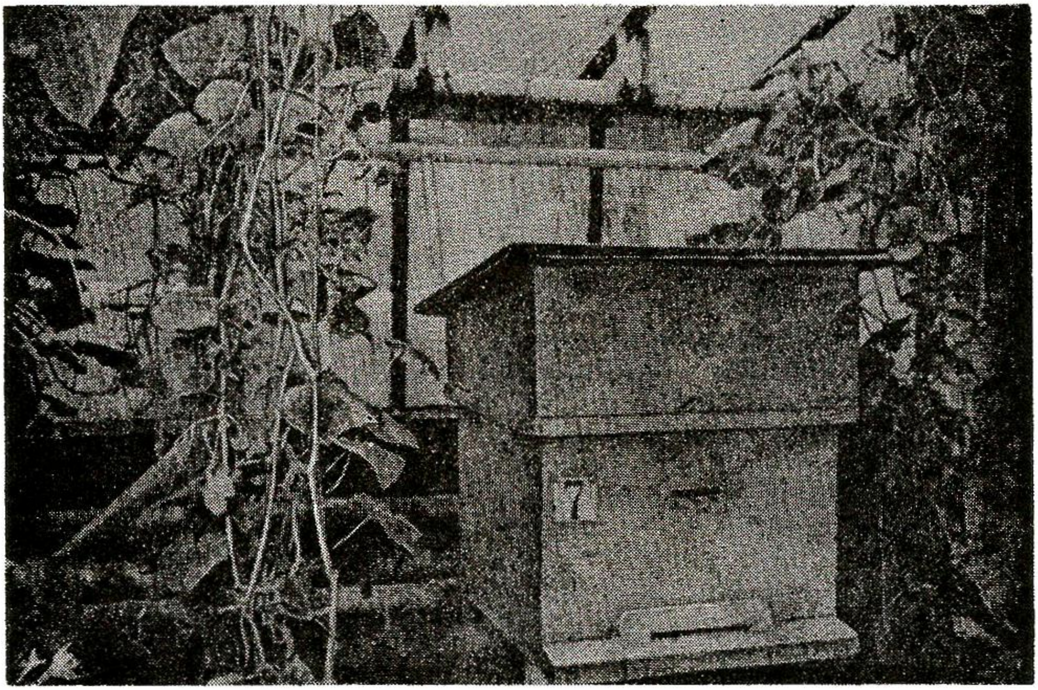


Fig. 85 — Bee hive for cross pollination of hothouse cucumbers

the greenhouse, on 40—50 cm high supports to facilitate their flight. The hot-house flowers are too few to supply the necessary amount of protein food, so the brood chambers must be periodically supplied with bee-bread combs. During the blossoming period of some major honey plants the hot-house bees can fly outside to collect nectar and pollen. If the bee-keeping farms have not bee-bread stores, the bees should be fed on a protein food consisting of 4 parts defatted soy flour, 1 part brewers' yeast and 1 part bee bread. All is mixed up with sugar syrup or honey and supplied to the colonies as small cakes of 0.4—0.4 kg every ten days. A better ventilation of the hive prevents the inhibitory effect of high temperatures and air humidity ; besides the main entrance a supplementary one is practised in the upper part of the front wall of the hive, as well as an opening to the outside. Bees' poisoning can be avoided with drug controls of the parts being applied only during the second half of the day when the bees' flight ceases in the greenhouse.

The general use of hydroponics in plant cultivation gives large possibilities to expanding and improving the hot-house cucumber yields. Hydroponics offers better conditions for plant growing and development, which influence nectar production — as illustrated by the data in the Table below.

An increase in nectar production results in a higher number of visits made by bees to the flowers and eventually in a higher cucumber yield. The Caucasian grey mountain and the Carpathian bees are

Table 22

The average nectar production per flower (mg)

	female flowers		*male flowers*	
Soil culture	2.42	100 %	1.62	100 %
Hydroponic culture	3.40	140.4%	2.04	125.6%

adequate for hot-house cucumber pollination thanks to their behaviour. Their extreme gentleness allows the operators in the hot-house to do their tasks without incurring the risk of being stung.

POLLINATION OF FODDER AND CEREAL CROPS

The flower of all leguminous fodder plants proves their adaptation to cross-pollination by insects. Moreover, in most of them self-pollination is absent because of physiological incompatibility. Thus, an increased seed yield in these species requires insects' participation.

The **red clover** *(Trifolium pratense* L.*)* is a fodder crop, cultivated in regions with sufficient humidity. Besides the high protein content it is also valuable because it improves soil fertility. Most spread are the cultivars accounting for only one cut (which ripe late) as well as those with early ripening supposing two cuts. The red clover seeds set only by insect pollination with pollen of another plant. The red clover flowers secrete much nectar.

The study of nectar production of over 20 cultivars of red clover in the collection of the All-Union Institute of Fodder Research (Moscow region), cultivated under similar conditions, proved that northern or alpine cultivars are characterized by a higher nectar secretion. In some exceptional cases 1 ha red clover can yield more than 250 kg nectar.

Nevertheless, bees can use only a very small amount of nectar because it is to be found at the bottom of a deep corolla tube. In two-cuts red clover the length of this tube is about 8.8 mm (variations ranging from 6 to 11 mm), and about 9.2 mm (variations ranging from 7 to 12 mm) in the one-cut red clovers.

The Central Russian bees can hardly collect the nectar in a 6 mm tube while the Caucasian ones in a 7 mm tube. Thus, honey bees can take nectar of only some species; Caucasian bees for instance, having a longer proboscis, take it from the flowers of more species while the Central Russian bees, with a shorter proboscis, from fewer. Bees visit the red clover flowers not only for nectar but also for pollen.

Bees with longer proboscis visit more intensely the flowers with a longer corolla (red clover, different fodder plants); it has been so demonstrated by numerous scientists (V. V. Alpatov, R. B. Kozin etc.) and on the fields of the didactic farm "Druzhba", Iaroslav region, of the "K. A. Timiriazev" Academy.

Of all insects, bumble bees, with a 10—12 mm proboscis, are the best red clover nectar collectors. Nevertheless their number decreases with every year due to the more and more frequent use of pesticides, their role as pollinizers of the crops being practically annulled.

As early as 1912, I. N. Klingen demonstrated on the Brasovsk estate (chief of the Orlov province) that seed yield increases by 80% thanks to the pollination of red clover seed plots by Caucasian bees. A broad network was organized in the 30's under the supervision of professor A. F. Gubin for stuying the problem of pollination and increasing the production of red clover seeds. The fact was demonstrated that the rise in red clover seed production was highly influenced not only by Caucasian bees but also by the local bees with a short proboscis. Later on A. F. Gubin suggested a method of considerably increasing the efficiency of pollination by bees by training them.

Proper agronomic care and the utilization of potassium — phosphatic fertilizers permit an increase in red clover nectar secretion as well as a greater frequency of bee visits ; all this results in a higher red clover seed yield.

An apiary of 100—120 bee colonies is required for pollinating an area of 50 ha seed red clover. The same field requires 5—6 times less bees when they are specially trained. In colonies with great brood nest activity, taking out of the bee-bread stores resulted in a higher pollinating efficiency.

Proper agronomic care and pollination with bees resulted in quite high crops of red clover seeds. Pollination with bees can play an important role in seed production and mass reproduction of red clover seeds.

Measures for protecting bumble bees on red clover seed areas are recomended because some species are efficient pollinizers of this valuable crop as they do trip the flowers.

The pink and white clover are important honey plants adapted to pollination by bees. The abundant nectar secretion and the short tubes of the corolla attract a great number of bees to these crops. Bees forage this nectar and perform an efficient pollination. In many North American states the pink white clovers as well as alfalfa hold wide areas representing the major honey sources. Clover and alfalfa honey are considered among the best. Because pink and white clovers are intensely visited by honey bees the pollination consists in moving bees to the seed plots.

The common **alfalfa** *(Medicago sativa* L.) is an entomophilous crop well-adapted to pollination by insects. The peculiarity of its

Fig. 86 — An apiary moved to a red clover seed field for pollination.

flower is the sexual column which is hidden in the keel of the closed flower; the stamens and stigma are released under certain conditions, the flower being tripped. The flower is tripped under the action of sunbeams (especially in the southern regions) but more often by insects. The stamens and the anthers strike the insect, powdering its body with pollen. As a rule, honey bees do not visit the alfalfa flowers with pleasure because sometimes their proboscis is caught between the sexual column and the standard petal: they prefer the open flowers. Solitary bees are more efficient in tripping the alfalfa flowers.

According to N. S. Davydova, the Caucasian and Italian bees trip twice more alfalfa flowers than the Central Russian bees. In Central Asia and the Transcaucasian republics, under a warm climate, in irrigated areas most flowers open by themselves, without insects: thus, bees collect the nectar and cross-pollinate the alfalfa seed plots easier.

A proper scheme for the pollination of alfalfa seed plots by bees results in an important increase of the seed crop.

According to N. S. Davydova, in the "Baiat" sovkhose (Uzbek SSR) 320 kg alfalfa seed were obtained per 1 ha on a plot located very close to an apiary whereas without honey bees only 150 kg.

The problems of pollinating alfalfa seed crops are much the same as for the red clover. Studies undertaken by the Institute of Zoology under the Academy of Sciences of the USSR (Blagoveshchenskaya, etc.) proved the important part played by solitary bees in alfalfa pollination. Therefore the areas with large colonies of wild solitary bees ought to be protected as indirect and supplementary source of alfalfa pollination.

Esparsette *(Onobrychis sativa)* as well as sweet clover are very important honey plants, intensely visited by bees; they practically do not self-pollinate. Among the cultivars used in the USSR the Transcaucasian (Sisianski in Armenia and Ahalkalakski in Georgia) are highly important; they flower in the very year of their sowing and secrete 2—3 times more nectar than the common cultivars. The saturated pollination by bees of esparsette results in yields of about 14—15 quintals of seed per hectare in Georgia and Armenia. Hives must be taken to the seed plots at the beginning of blossoming (3—4 colonies per ha).

Fodder **beans** *(Vicia faba* L.). Although most cultivars multiply by self-pollination, pollination by bumble bees and wasp increases yield and germination capacity of seeds (the yield is increased by 35—300% in the different cultivars). This crop is mainly pollinated by honey bees (90% of all insect visitors). The farther are the plots from the apiary the less are they visited by bees and the poorer the seed yields. The seeds set after cross-pollination by bees were heavier, had a higher germination capacity and vitality. Photosynthesis is more intense in plants grown from seeds resulted from cross-pollination by bees than from self-pollination. This favours the better growth and development of plants in the second generation, formation of more flowers, a greater amount of nectar and — most important — an increase in the seed yield and protein content.

Chemical analyses proved that the seeds resulted from cross-pollination have a 4—8% higher protein content than those resulted from self-pollination.

A bee colony is enough for the pollination of one hectare of seed fodder horse bean. One must take into account that Caucasian mountain bees visit the horse bean flowers better than the Central Russian bees.

The buckwheat (*Fagopyrum esculentum* L.) is a typical entomophilous crop plant the main for the honey and groat production. Cross-pollination is ensured by the flower dimorphism. Half of the buckwheat plants have flowers with long style and slender stamens whose anthers produce relatively small pollen grains (plants with long style). The other half have flowers with short style and long stamens (which produce relatively big pollen grains). This phenomenon known as heterostlyly allows three types of pollination : (a) cross-pollination between plants with different types of flowers ; (b) cross-pollination between plants with similar flowers and (c) self-pollination.

The type (a) pollination was found normal in buckwheat ; it is the origin of the largest amount of high-quality seed. With type (b) pollination, twice less seeds of lower quality, are set ; under certain conditions, self-pollination can result in a very small amount of seeds — of the poorest quality.

Buckwheat cross-pollination can be partially be due to mechanical agitation of the flowers by wind, but the main role in pollinating this crop is held by insects, in the first place honey bees. Sometimes buckwheat artificial pollination is practised by shaking plants with a rope or a long stripe of sack cloth.

This manual method however is time and labour consuming ; moreover, according to data supplied by the Institute of Apiculture Research it results in an only 10% increase of production. Nevertheless, buckwheat pollination by honey bees brings about an increase of over 60—70% in the seed crop.

According to data supplied by N. D. Skrebtsova, the seeds acquire higher qualities in step with increasing from 1 to 10 the number of bee visits on the buckwheat flowers.

Plants grown from the seeds resulted from repeated visits of bees to buckwheat flowers develop better in the first and second generations ; consequently, the absolute weight of seeds as well as the total production grow.

The most efficient pollination is registered with buckwheat under advanced agrotechnical conditions.

According to data supplied by the Institute of Bee Research (G. M. Soloviov, E. G. Ponomariova, G. V. Keplkievski), calcium, nitrogenous and potash fertilizers, as well as sowing in distant rows lead to an increased nectar secretion which in turn favours a better pollination by bees and finally higher buckwheat honey and seed crops.

For an optimum pollination, when buckwheat starts blossoming 2—3 bee colonies/ha must be located in the field. On larger areas, junction pollination is more advisable ; in this case the apiaries must be located so that the distance between them be under 1—1.5 km.

Sun-flower is the most important oilseed plant in the USSR and a valuable honey plant which provides a main nectar flow in the steppe and forest-steppe area. Although sun-flower has bi-sexuated flowers, self-pollination is hampered by the different stages of maturation of stamens and pistils (protandry).

The plant has large flowerheads called capitula, with a 15—25 cm in diametre. Each and every capitulum has, 1,000—2,000 individual florets whose great majority have generative functions. Few florets have only the function of attracting insects : the so-called beam-like florets are large, the petals are grown together and are bright yellow.

The tubular florets open gradually from the periphery to the centre of the head. Each floret lives for two days under normal pollination conditions : the anthers alone grow mature in the first day (the male stage of blossoming) ; the stigma matures and acquires the capacity of accepting pollen only the next day (the female stage of blossoming) — which practically eliminates the possibility of self-pollination. After a successful pollination and fecundation the flower withers. Otherwise it may live for two weeks at most as if "waiting" for pollination ; in these florets, even in case of cross-pollination, seed set is lower.

In case of self-pollination, the seed set is very poor and the seeds are empty, small, underdeveloped, with a low fat content.

The main pollinizer agent of sun-flower is the honey bee which holds 95—98% of the total pollination performed by insects. For pollinating sun-flower on 200 ha, 100—150 colonies are necessary.

In addition to a good pollination bees induce a higher fat content of seeds as well as an improvement of their germination capacity (Tables 21 and 22).

The seeds obtained by cross-pollination have germinated in proportion of 98.2—99.5% while those resulted from self-pollinated heads only in proportion of 90—94%. The seeds obtained from self-pollinated plants have sprouted more slowly and less energetically than seeds of the cross-pollinated ones.

Table 23

Effect of Various Kinds of Pollination on Seed Set and Quality in Sun-Flower (Zhdanov 8281 cultivar)

Pollination method	Seed weight/head (g)	Weight of 100 seeds (g)	Weight of kernels/100 seeds (g)	Seed set (%)
Free pollination, with bees	112.6	9.4±0.3	5.72±0.14	86.9±1.8
Manual pollination every four days	104.3	7.7±0.3	4.31±0.20	74.9±2.4
Manual pollination, once	67.8	4.9±0.3	2.24±0.23	40.2±5.1
Self-pollination	45.8	3.0±0.2	0.83±0.12	8.8±2.0

Improvement of sowing qualities of seeds influences their set, seed yield and the weight of the kernel in the second generation. Seed set, seed yield and kernel weight in self-pollinated plants are lower than those of the plants developed from cross-pollinated with bees.

Table 24

Effect of the Pollinating Method on Fat Content (%) in Sun-Flower Seeds (Dry and Decorticated)

Pollination method	8281 Zhdanov Sort	8883 Vnimik Sort
Free pollination, with bees	50.18	57.54
Manual pollination, every four days	49.42	56.55
Manual polination, once	46.69	51.67
Self-pollination	47.06	49.51

The plants grown from seeds resulted from manual pollination hold a medium position (Table 23). Thus manual pollination of sun-flower (as well as of other crops) is not advisable — not only because it is time consuming but because it cannot replace the long-standing interdependence insects — plants.

Table 25

Effects of Various Pollination Methods of Sun-Flower (Zhdanov 8281-cultivar)

Pollination method	Weight of seeds per head		Weight of kernel per 100 seeds		Seeds set (%)
	g	%	g	%	
Free pollination, by bees and other insects	79±2.9	100	4.56±0.09	100	85.8±1.2
Manual pollination, once	49±3.6	61.8	3.48±0.33	76.3	78.1±1.4
Self-pollination	55±4.5	69.6	3.53±0.55	78.8	76.9±2.1

The pollination by bees of sun-flower and other entomophilous crops is more efficient than manual pollination both biologically and economically.

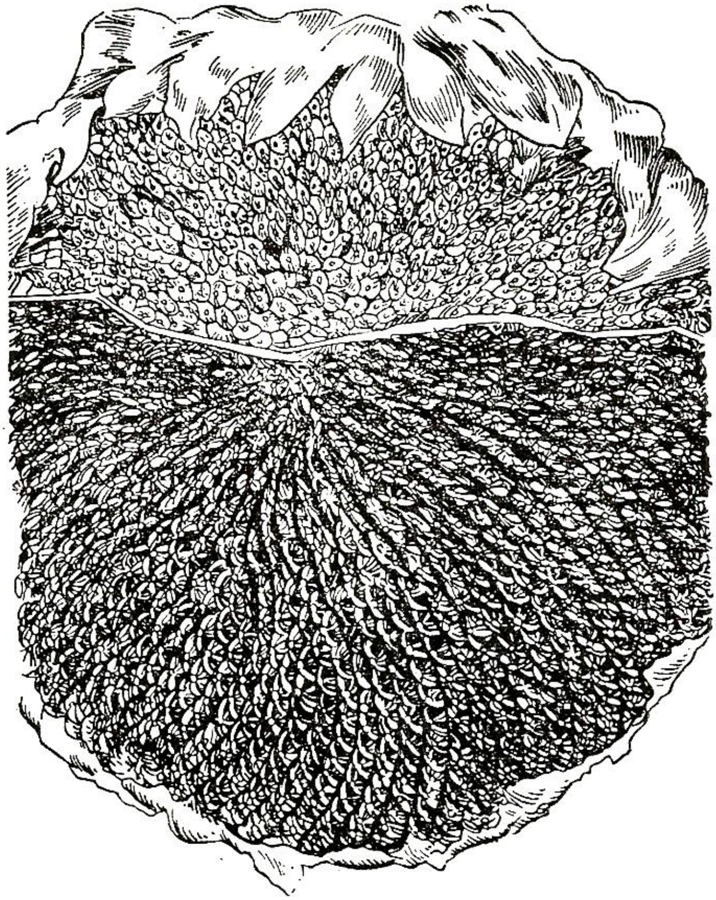
Oil seed crops in the USSR need cross-pollination by bees : **white, edible mustard** (*Sinapis juncea* L,) **rape** (*Brassica napus oleifera* Metz), **wild rape** (*Brassica rapa oleifera* Metz) and others. All the above-mentioned plants secrete a large amount of ready accessible nectar and are therefore intensely visited by bees.

Bee pollination is similar to that of sun-flower.

Cotton: the flower morphology reports this species to the group of cross-pollinated crops. The amplitude of self-pollination and cross-

Fig. 87 — Effect of insect insulation from the sun-flower heads on seed set

The higher part of the head was covered with gauze during the flowering period, while on the lower one honey bees and other insects had free access



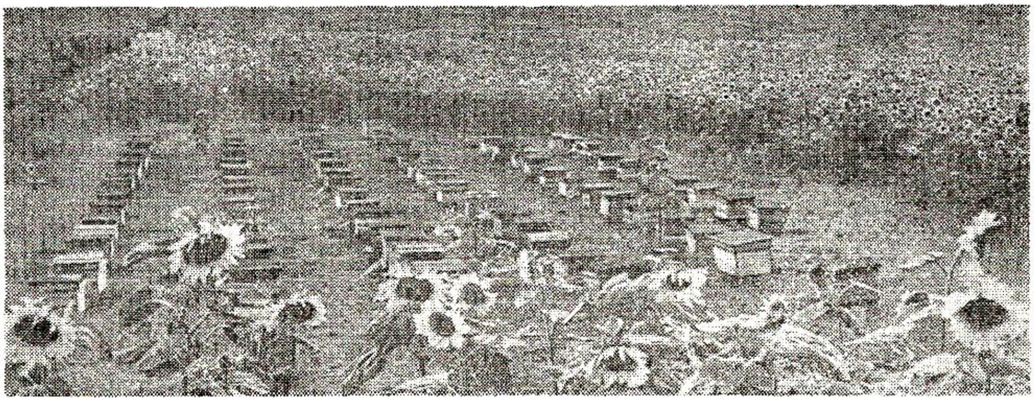


Fig. 88 — Pollinating apiary in a sun-flower field

pollination very much differs according to cultivar and conditions. A proof of adaptation of the cotton flowers to cross-pollination is the large and coloured corolla, the floral nectaries and the stigmas of different length even at the flowers of the same plant. In the most widely spread varieties *(Gossipium hirsutum, G. barbadense)*, a partial self-pollination takes place when the flower opens. Nevertheless, only part of the pollen reaches the stigma of the same plant and as a consequence the ovules are not all fertilized. Full pollination of flowers is performed by a mixture of pollens, carried by insects : in this case the remaining ovules are fertilized. Therefore, in most of the partly self-fertile cotton cultivars pollination is completed by insects.

The surveys undertaken by Soviet and oversea researchers prove the important part played by bees in increasing the seed fibre yield in cotton. Thus, according to professor A. M. Kuliev, the cross-pollination with bees resulted in a higher production of cotton fibre — by 29.4% in cultivar 2421, in cultivar 2018 by 25.9%, by 23.2% in cultivar 1472, and by 19.4% in cultivar 2018/2. According to data supplied by the Institute of Apiculture Research, in the Uzbek SSR saturated pollination leads to an increase of production of 5 quintals/ha, i.e. by 15—20%.

Due to pollination by bees the technical characteristic features of lint — such as resistance and length — improved. Concurrently the germinative qualities of the seeds are also higher and finally, production and technological qualities of the fibre improve in the second and subsequent generations.

Thus, in T. I. Kaziev's experiments, in case of triple cross-pollination with bees, within the same cultivar, the fibres yield from a G_3 cotton plant grew as compared to that of the plants in the same generation but pollinated without bees (Table 25).

Table 25

Effects of Pollination by Bees on the Productivity of Cotton at the Third Generation

Cultivar	Amount of fibre (g) obtained from a plant when		The extra % in the first case as compared to the second
	pollinated with bees	natural pollinated (without bees)	
1298	79.0	57.7	37.3
2018/2	89.0	65.0	52.3
2421	116.0	74.0	56.7
2018	112.0	81.2	26.1
S-1472	124.0	76.0	63.1

Cross-pollination of cotton by bees can play an important part in obtaining hybrid seeds.

The researchers of the California University (Frank M. Eaton *et. al.*) have discovered a "gametocide" which destroys the male sexual cells of cotton. Plants treated with this chemical substance completely lose their capacity to self-pollinate and can be cross-pollinated with the pollen of the sort indicated for the required hybrids. Dr. Eaton considers that by obtaining large amounts of hybrid seed one could create for the cotton industry the same opportunity as it was for maize years ago.

With proper agronomic care, the effect of cross-pollination of entomophilous crops by bees is higher.

In terms of cotton production, the USSR holds the first place in the world. Expansion of this crop on large areas, irrigation and chemical treatments, are congenial prerequisites for cross-pollination with bees as a source of further higher yields.

Unfortunately the present state of bee keeping in the areas under cotton (especially Central Asian republics) can provide less than 10% of the bees necessary for the pollination of cotton fields.

Therefore urgent steps must be taken for developing bee keeping in the areas under cotton, to meet the pollination demands in cotton and alfalfa fields, in orchards etc.

In the meantime, the existing bee colonies could be moved more frequently to pollinate the crops.

BEE DISEASES AND PESTS

Honey bees are affected by various diseases which can be infectious or non-infectious. Non-infectious diseases occur especially owing to inadequate management and nutrition of the honey bee colonies. These diseases have no specific pathogen agent and are not transmissible from sick to healthy colonies. Contagious diseases are caused by pathogenic microorganisms of vegetal origin (bacteria, viruses, moulds) or animal origin (amoebas, *Nosema* spores, acarine mites). Diseases caused by pathogenic agents of the vegetal kingdom are called infectious ; they include American and European foul brood, sac brood, chalk brood and stone brood. When the causing organisms are of animal origin the diseases may be parasitary (amoeba disease, Nosema disease,acarine — *Acarapis* and *Varroa* — disease). Contagious diseases are transmitted from the diseased to the healthy colonies and from infected to free apiaries.

Diseases cause great damage to the industry. The honey yield of foul brood diseased colonies drops by 20—80% and of the Nosema diseased — by 50—65%. If adequate care is not offered in due time, the ill colonies weaken and die. Great bee damages are registered following to poisoning with pesticides, honeydew honey poisonings, and other non-infectious diseases.

An important part in disease control is played by the preventive measures meant to increase honey bee resistance to a disease or another. It is therefore important to keep only strong colonies, with adequate food. It is also important to practice a permanent selection, keeping the only strong colonies which resist diseases. Disease prevention requires renewing nests, annual requeening, disinfection of hives and of equipment, and strict observance of hygiene in the apiary.

NON-INFECTIOUS DISEASES

Chilled brood is an abnormal condition caused by the strong chilling of the brood nest, which causes death of larvae and pupae. This "disease" occurs mostly in spring when sudden frosts are still possible in autumn — because of the low temperatures bees cluster and leave the brood on the marginal combs. Chilling is frequent in weak colonies. The main symptom is the compact comb brood area on the marginal frames or in the lower part of the nest. The condition cannot be spotted before bee start gnawing the caps and cleaning the cells. The dead larvae are first grey, then they darken. Prevention of this disease requires a thorough thermic insulation and restriction of the nest in due time, to enable the bees to keep constant temperature.

Honeydew poisoning is caused by honeydew honey — bees collect it in summertime. This disease is found both in winter and summer. In summer, field bees are poisoned first, then the larvae. In winter, the symptoms of the disease are diarrhoea and massive death of bees. The diagnosis is based on pathologic changes in the gut and honeydew elements in the honey stores. The midgut becomes limp, friable and gets a violet-blue almost black or brown colour (see colour table VIII, B-4).

Before restricting the nests for wintering one must check the honey stores for the presence of honeydew. Honeydew honey must be taken out and the colonies should be fed pure flower honey or 8—10 kg of sugar syrup (2 parts sugar and 1 part water). It is recommended as a preventing measure.

The diseased colonies are given flower honey or dry sugar soaked with water. The bees are encouraged to perform an earlier cleansing flight. The colonies are moved into clean, restrained and thermically insulated hives.

Poisoning with nectar occurs with field bees, when they collect nectar of poisonous plants (for instance — *Veratrum* L., *Ledum palustre*, *Aconitum*, *Rhododendron* etc.). Sometimes this disease is unnoticed because bees die outside the hive. The sick bees lie on the bottom of the hive or crawl. The colony weakens considerably. The disease coincides with the blossoming of poisoning plants. There are no other means to check this poisoning but taking the combs with fresh nectar out the hive and replacing them with frames with sugar syrup.

Poisoning with pollen occurs with nurse bees when they are intoxicated with pollen from poisonous plants (*Ledum palustre, Delphinium, Aconitum, Veratrum* etc.).

The incidence of this disease is higher in May (it appears more frequently in June and July) and it causes a high death-rate in bees. Sick bees have swollen abdomens and their gut is filled with a dense, yellowish matter (colour plate VIII, B-3). The disease does not last for a long time.

Chemical poisoning is caused by noxious chemical substances used in agriculture and forestry. One may distinguish anorganic pesticides (arsenic, fluorine and barium salts), organic and synthetic (chlororganic and phosphorganic) and vegetal (anabasine-sulphate, nicotine-sulfur, pyrethrum) pesticides.

According to their aim, pesticides are divided into several groups, but most frequent are the insecticides, herbicides and fungicides. The first ones are used against insects ; herbicides — against weeds, and fungicides against the fungi causing damages to plants.

The most dangerous for bees are the insecticides: they contain arsenic (calcium arsenate and arsenite), fluorine (sodium fluoride, natrium silicium fluoride), barium (barium chloride) and chlororganic preparations (hexachloran, heptachloran, toxaphen, chlordan and many others).

According to the mode of their action one can distinguish ingestion, topic and fumigant insecticides. From among the insecticides used at present the most noxious for bees are the ingestion and the topic preparations. They affect not only the field bees but also the younger ones — which cannot fly — and the brood, because they poison the pollen and nectar. The group of ingestion poisons includes preparations such as arsenic, fluorine and barium, which are very noxious to bees. Contact poisons affect the nervous system of the bee. Hexachlorane is one of them. Less dangerous for bees are mineral oils and soap solutions.

The fumigation insecticides penetrate into the bees' bodies being absorbed through the tracheal system. This category of toxic substances does not represent a great danger for bees because the poison evaporates soon.

One must take into account that some toxic substances exert a simultaneous ingestion, contact and fumigation effect (for instance hexachlorane). Toxic effect upon bees depend on external temperature and humidity and wind speed. With high temperature, strong winds or rains, toxicity decreases.

Herbicides and pesticides are dangerous to bees only in the first 5 hours following the treatment, because they disintegrate fastest. The poisoning effect of insecticides is longer. So, arsenic and fluorine preparations are toxic for bees for four days while hexachlorane — for 2—3 days.

The poisoning effect on bees depends on the concentration of the preparation, the duration of the contact as well as on the time elapsed from the treatment.

Disintegration also depends on the way of treatment. The less dangerous is the aerosol spraying; the pesticides are sprayed as fogs consisting of fine liquid drops. The plants sprayed with hexachlorane fog are harmless to bees the first 6—7 hours after the treatment.

Poisoning symptoms. Poisoning with pesticides result in different symptoms. When nectar, honeydew or water poisoned with highly-concentrated preparations are collected, it is difficult to find the causes of population decrease, because foragers die in the field. When plants are treated with harmful substances with a slow effect, the symptoms are manifest on the second and the third days only. In case of chemical poisoning one can notice the massive death of bees. Dead bees are found near the hive entrance, round the hive and all over in the apiary. Numerous bees are crawling on the walls of the hives and fall down on the bottom. As a rule the digestive tract of these bees is full of necroses (colour plate VIII, B-2) and sometimes diarrhoea can be noticed. If bees bring contaminated pollen into the hive, this situation lasts for a longer period. The nurse bees and the brood are affected. Rainy and cold weather have a negative effect : bees are obliged to feed for a long time on contaminated pollen. The diseased midguts are shorter and have a vitreous appearance. A preliminary diagnosis of pesticide injury is based on high death rate of bees in most colonies of an apiary ; final diagnosis is based on the chemical analysis of the dead bees and of the bee bread.

P r e v e n t i o n. All enterprises which apply chemical control measures are obliged to warn the beekeepers. The treatments ought to be applied before or after the flowering period. The beekeepers move their bees 5—7 km away from the treated area ; if not possible, hives are left on place, entrance closed. Water is supplied in empty combs in the hives ; the volume of the hive is enlarged, with empty supers placed upon. Entrances may be opened by night. In case of arsen or fluorine treatments, hives are closed for 4 days at least ; after tiophos hexafluorine or metaphos treatments — for 2—3 days and after nicotine or pyrethrum — for 5 hours.

C o n t r o l. As soon as poisoning occurs, the combs containing bee bread (supposed to be poisoned) and fresh nectar are taken out the nest. For three days, bees are fed on sugar syrup.

INFECTIOUS DISEASES

European foulbrood is an infectious disease affecting the young larvae — worker, drone and queen. Causative agents are *Streptococcus pluton*, *Bacillus alvei* and *Streptococcus apis*. (Colour plate VIII, b.). As a rule the disease occurs in May — June. The appearance and development of the disease are favoured by scarce nectar flows, cold weather and poor feeding and management conditions. The pathogenic agents of the European foul brood can survive for one year in bee bread, in old contaminated combs and honey. *Streptococcus pluton* and *Streptococcus apis* are resistant to boiling water for 15—20 minutes ; a 2% solution of "kynosole" kills them in 10 minutes. The solution penetrates into the organism together with the food.

S y m p t o m s. The diseased larvae have an altered position in the cell, they are no longer bright ivory, they become opaque and slightly cream ; the trachaea can be seen through their thin epidermis.

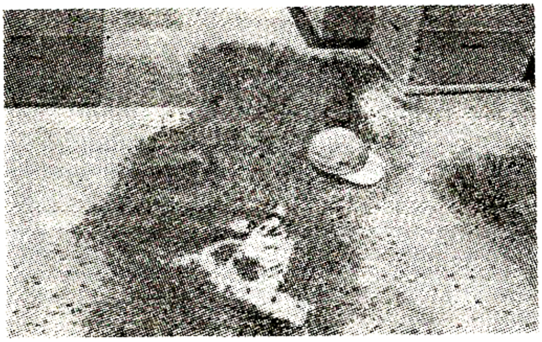


Fig. 89 — Dead bees after a pesticide treatment

Next they darken and dry getting little scales which can be easily removed.

When capped larvae are affected caps are darker and punctured. The decomposed mass is drawn out like thick threads with a specifical sour smell. The characteristic sign of this disease is the scattered brood

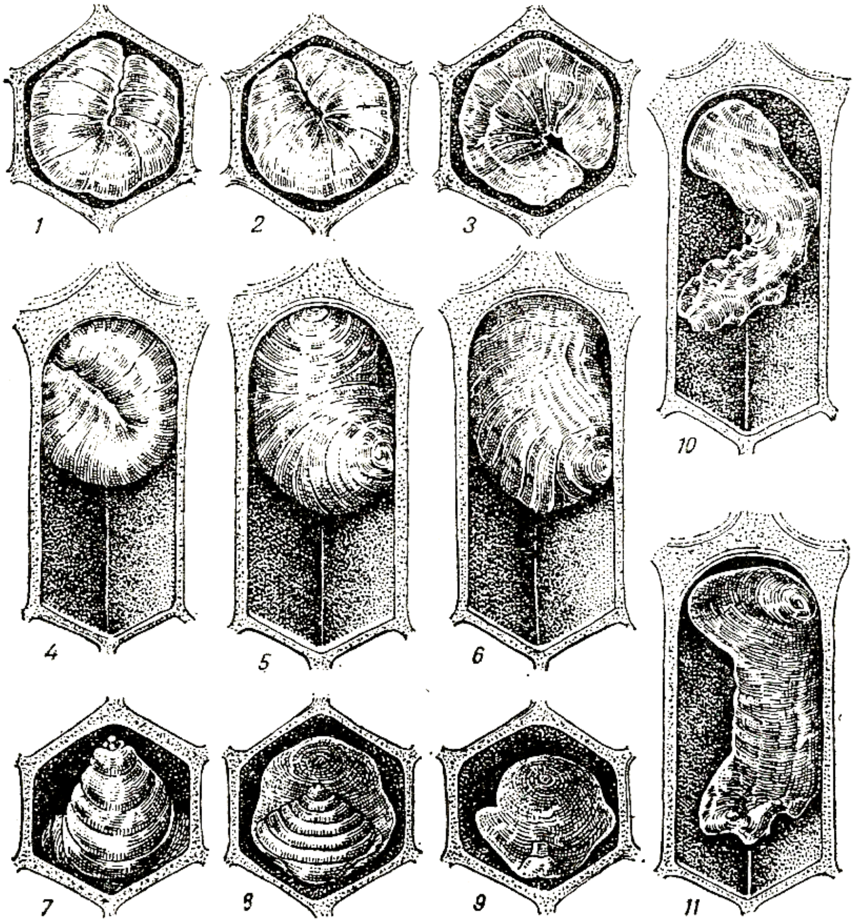


Fig. 90 — Larvae dead of European foulbrood

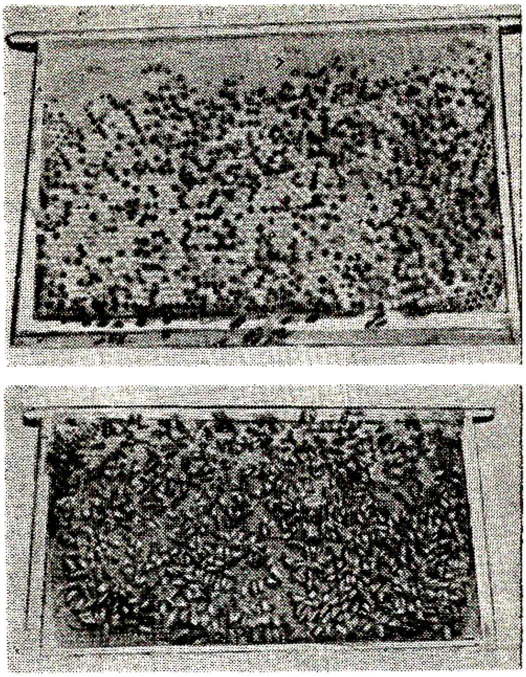
1 — normal larva ; 2, 3 — changes in the appearance of E.F.B. diseased larvae ; 4, 5, 6 — position of the larvae in open cell ; 7, 8, 9 — changes in the appearance of old larvae ; 10, 11 — mumnified dead larvae

pattern — many empty cells in combs with capped brood. Final diagnosis is established only by laboratory test.

S p r e a d i n g. The causative organism reaches the healthy colonies by drifted bees, by drones and by bee-keepers.

P r e v e n t i o n. Only strong resistant colonies must be kept. Anyway plenty of food as well as good feeding conditions must be ensured. Prevention is ensured by feeding the colonies sugar syrup with antibiotica in spring and autumn, and discarding the old brown combs in the nests.

Fig. 91 — Above — Scattered brood pattern (suspect of foulbrood); below — normal brood pattern



C o n t r o l m e t h o d s. When disease occurs, the whole apiary must be submitted to a thorough inspection to find all sick colonies. The nests of these colonies should be restrained and thermoinsulated. The bees are treated with sulpha drugs (natrium salt or norsulphazol, sulphantrol) or with antibiotica (biomycin, streptomycin, tetracyclin, eritromycin, monomycin).

The sodium norsulphazol is given in doses of 1 g, sulphantrol — 2 g, antibiotica — 500 units per liter of sugar syrup. The syrup is poured into the feeder or directly into the combs which are introduced within colonies in the evening. Food containing drugs is administered every 5—7 days until the colonies are cured. In case of severe disease the colonies are transferred in other hives, on clean combs.

American foulbrood is an infectious disease of old larvae, caused by *Bacillus larvae* (see colour plate VIII, A). Under unfavourable conditions the agent gives spores, very resistant to physical and chemical agents : they survive for several decades under natural conditions. In hot water the agent dies after 13 minutes. Solutions of formalin and carbolic acid have a slight effect against these spores. The agent can live for a long time within the bee colony (in the bee bread or in the honey combs). It penetrates into the bee organism with food. The disease symptoms are obvious immediately after the cell capping. The American foul brood especially affects the old larvae, in capped cells. However, sometimes young pupae may fall ill. The development of the disease is favoured by high temperatures, lack or scarce nectar flow and unsatisfactory bee management conditions.

The main source of infection are sick and dead larvae as well as infected food. The disease is transmitted from sick to healthy colonies by robber and stray bees as well as by drones. The disease may be also transmitted by the bee-keeper when transferring the frames from a hive to another. Transmission of infection to other apiaries in other areas is favoured by selling and moving sick colonies.

Symptoms. One of the symptoms is the scattered brood. The cappings of the cells containing diseased larvae become flat and punctured. The sick larvae lose their normal glistening and the segmentation disappears. The dead larvae decompose and turn into a rotten and viscous

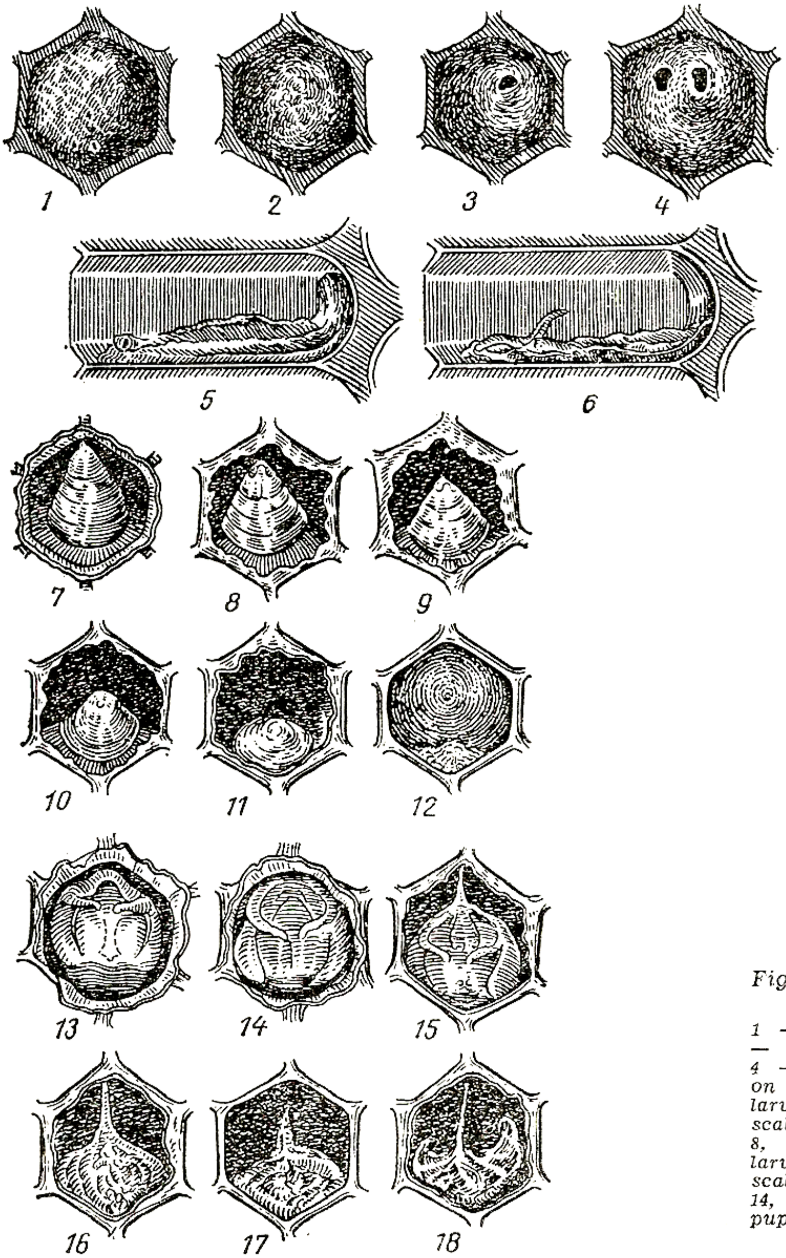


Fig. 92 — AFB dead larvae and pupae

1 — normal cell cap ; 2 — sick larva cell cap; 3, 4 — punctured cell caps on the sick larvae ; 5 — larval scale ; 6 — pupal scale ; 7 — healthy larva ; 8, 9, 10, 11 — diseased larvae ; 12 — dead larva scale; 13 — healthy pupa ; 14, 15, 16, 17 — diseased pupae ; 18 — dead larva scale mass, which looks like long and thin threads. This mass smells like decomposed carpentry glue.The dry larvae become dark and stick against the lower part of the cell.

The diagnosis is established on the basis of the laboratory bacteriological test.

P r e v e n t i o n. Adequate management conditions are very important. The ventilation must be intensified during too hot periods and the hives must be located in the shade. The old brood combs must be replaced by new ones every year. Bee colonies and queens must be brought only from disease free apiaries.

C o n t r o l m e a s u r e s. After confirmation of the diagnosis the apiary is placed under quarantine. All the colonies are controlled and the diseased ones must ne isolated. If they are only a few it is better to destroy them ; the hives should be disinfected. If the number of diseased colonies is wide, they shall be separated from the healthy ones and located at minimum 5—7 km away from the closest apiary. The adult bees in these colonies must be transferred into disinfected hives on foundations. They are fed on sodic norsulphazol (1 g for 1 l 50% sugar syrup) or sulphantrol (2 g for 1 l syrup). The drug is previously dissolved in 10—20 ml water, then warm sugar syrup is added.

American foul brood may be controlled with streptomycin, biomycin, tetracyclin, eritromycin, monomycin (500 thousand units per litre of syrup). The medicated syrup is fed in doses of 100—150 ml per bee way, every 5—7 days, until the colonies recover. The combs and the bees can be directly sprayed with water solutions or powdered. The brood of the transferred colonies is reared separately in special colonies ; after they emerge, the bees are shaken in the hive they belonged. Concomittantly all hives should be disinfected and also the other tools and equipment which came into direct contact with the ill colonies. The hives must be thoroughly cleaned, sterilized by burning with a blowlamp until they get light brown ; then they ought to be washed with hot alkaline solution and dried in the sun. Metal objects are disinfeced by boiling for an hour in 1% lye wash. The insulaing material must be boiled too, for 30 minutes and dried in the sun. The crumbs of wax and other residues in the hive and the dead bees must be burnt.

Sac brood is an infectious disease of the brood caused by a virus *(Morator virus aetatulae)*. Old larvae are affected before the capping of the cells. The tegument of dead larvae is hardened while their organs and tissues turn into a liquid suspended with grains. Such a larva recalls a sac full of liquid which can be easily taken out of the cell. The dried larva becomes C-shaped and it darkens.

Spreading of disease and prevention measures are the same as with European foul brood. Sometimes both diseases occur concomitantly.

The drug control of this disease has not been elaborated yet. Restriction of nests and their thermic insulation is recommendable ; the queens in the diseased colonies are caged for 5—7 days, then liberated. It is better to replace them. In case of a strong infection the diseased colonies must be transferred.

Nosema disease affects the adult bees ; the agent is a unicellular parasite called *Nosema apis* Z. The Nosema spores survive for several years. The spore reaches the bee organism with the food. Their embryos hatch in the bee's midgut and locate in the epithelial cells of the midgut wall, where the multiplication occurs : in a short time lots of spores result, which are eliminated with the excrements.

Nosema spores multiply through direct division, rapidly filling and destroying the host epithelial cells, resulting in digestive troubles and finally the bees' death.

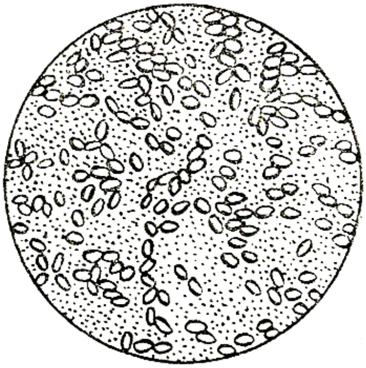


Fig. 93 — Nosema disease agent — spores of Nosema apis

Nosema disease affects the worker bees, queens and drones. It occurs by the end of winter and reaches a peak in April and May. The development of the disease is favoured by honeydew honey stores and by prolonged wintering under unfavourable conditions.

The symptoms are diarrhoea and the higher death rate of bees by the end of wintering. Late in winter the colonies are weak and sometimes the queens are lost. The midgut of the bees is whitish (plate VIII, B-5). The final diagnosis is necessarily based upon a microscopic examination.

Spreading of disease. The causative organism is carried by diseased bees by leaving excrements on frames, combs and honey and by frames moved from diseased colonies to healthy ones. In the apiary the disease is spread by the robber bees.

Prevention. Before preparing the bees for wintering the honeydew honey stores are replaced with flower honey or with concentrated sugar syrup. The latter must be fed after the end of the main nectar flow in order to have it processed by the same bees. Strong colonies with a great number of young bees must be prepared for wintering.

Control Methods. A first measure after diseased colonies were found is to induce an early cleansing flight ; the suitable food stores are taken out of the nest combs and replaced with flower honey or sugar syrup. In spring bees are transferred in disinfected hives. The dirty combs (broodless) are replaced with clean combs. Measures to increase the number of young bees must be taken.

The diseased bees must be treated with Fumagillin DCH — a yellowish crystallized powder. About 50 mg — 100 mg Fumagillin must be mixed up with 1 l sugar syrup (cooled down to 30°C). The colonies are treated in spring, with 200 g, 3—4 times at one-week interval. In other countries "Fumidil B" is used.

Concomitantly, a disinfection is necessary. The wooden objects are disinfected with hot 2% lye wash. The hive walls are thoroughly cleaned and sterilized with a blowlamp until they become brownish. The combs are disinfected with acetic acid (80%) : they are put in a hive body ; above their top bars cotton wool imbibed with acetic acid (200 ml for a 12 frames hive) is placed.

The hive is subsequently closed and left as such for three days at 16—18°C ; then combs are held in the open. Combs may also be disinfected by spraying them with a 4% formaline solution after which they are kept in special boxes for at least four hours. Then the combs are sprinkled with 1% ammonia solution and left to dry in a shaded place.

Acarine disease affecting the breathing system of the adult honey bee is provoked by the microscopic acarine mite *Acarapis Woodi*. The mite is oval, has four pairs of legs and its mouth parts are adapted to piercing and sucking. It lives as a parasite in the tracheae, at the base of the wings of the adult bees. The mites feed on bee's haemolymph. In honey bees invaded by *Acarapis* the haemolimph circulation is troubled and necrosis spots occur on the tracheae. The diseased bee can no longer fly ; it weakens and dies. This acarine mite lives only on the honey bee ; alone, it dies rapidly ; in mumies it resists no longer than five days. The disease appears especially in winter, seldom in summer, after rainy weather, when bees gather in clusters. During this period the acarine mites can easily pass from a bee to another.

S y m p t o m s. The disease is regularly discovered in spring, when bees are taken out of the shelter. Bees try to fly but they fall down and crawl in the apiary. The position of the wings is altered — they look as twisted to various directions. For a final diagnosis samples of

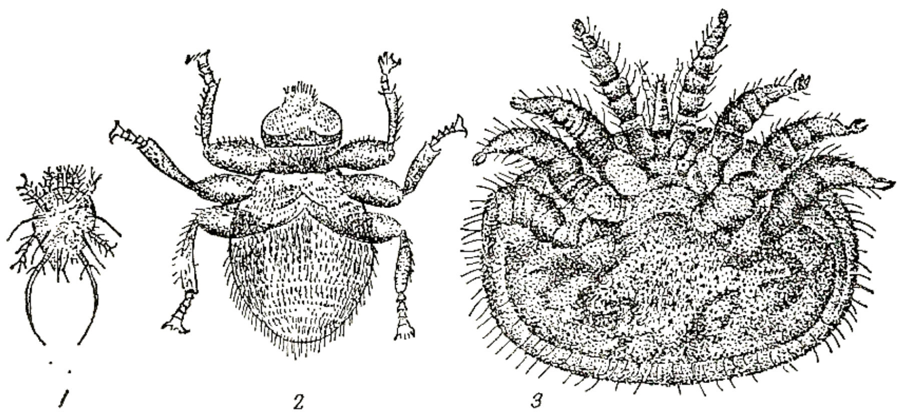


Fig. 94. — Parasites of the honeybee

1 — *Acarapis* (a mite) ; 2 — *Braula* (a fly) ; 3 — *Varroa* (a mite)

bees (50 of each colony) are sent to the veterinary laboratory. In case of disease the apiaries on a radius of 5 km are placed under quarantine.

The dead bees are a permanent source of infection. The acarine mites reach the healthy organism only through direct contact with the sick bees. Robbery and swarming favours the dissemination of the disease.

Prevention. Only strong colonies must be kept in the apiary. Wintering shelters should be dry. The location of the apiary must be a little higher than the surrounding places. New colonies must be taken only from healthy apiaries.

Control methods. If several diseased colonies are discovered in an apiary it is better to destroy them in order to hamper the dissemination of the disease. All the colonies in an affected apiary are sprayed with acaricides such as tedion, ethyl dichlorbenzilate or sulphonated ether. Before treatment the marginal honey frames should be taken out; sheets of paper must be placed on the bottom. All the fissures in the walls of the hive bodies and supers ought to be tightened with clay and paper. Treatments are done in the evening, when all the bees are in the hives. For ten days one must introduce through the main entrance special smouldering tendon cartridges — 1 g for each colony with 5 hours exposure. Ethyl dichlorbenzilate (0.5 g) or ether sulphonate (0.3 g) are applied eight times.

Varroa disease is an invasive disease, dangerous for bees, caused by an acarine mite, *Varroa Jacobsoni*. It is widely spread in South-East Asia (China, Japan) where the native bee is the Indian bee; in the USSR it is spread in the Far East areas. It was found for the first time in the Indian bee from which it was transmitted to the "European" honey bee. Varroa disease was discovered lately in some European regions of the USSR and Eastern Siberia, fact accounted for by the many transports of bees to the Far East. The acarine mite is parasite on adult bees, larvae and pupae, feeding on their haemolymph.

Symptoms. The diseased colonies become weak and die. The parasites can be seen on the diseased bees with the naked eye (the females are 1.1 mm long and 1.6 mm wide).

Dissemination of the disease. The disease is disseminated within the apiary by drifted diseased bees, by frames containing brood and bees transferred from the diseased to the healthy colonies. The disease is disseminated at wide distances by selling diseased colonies and queens, by swarms and by migratory bee-keeping. The female mite lays 12—20 eggs on the cell walls containing drone and worker larvae. After two days, when the cell capping begins the mite larvae hatch; then they develop into varroa females and males at the same time with the emergence of bees and drones. Mated females are parasitizing the worker bees.

Control methods. When the first cases of varroa disease are obvious, the infested colonies must be killed, the combs melted and the hives and frames disinfected. Measures to limit the dissemination of the disease and to heal the colonies are taken in all the apiaries in the affected area. All colonies in the apiary are treated with phenothiazine

Fig. 95 — Braulosis : a bee louse on the honey bee thorax

aerosols. During the whole season drone brood must be regularly uncapped and discarded. One must can clean empty combs ; in step with the development of the drone brood on these frames this is cut down and the combs melted.

The treatment must be applied in autumn, when the outer temperature is still favourable and the bees still active ; when the colony has no more brood to rear the treatment has to be finished. Colonies are smoked three times at 7—10 days intervals (1.5 phenothiazine, i.e. a total amount of 5.6 g), early in the morning or late in the evening, when all the bees are inside.

The brood nest is restricted before the treatment ; 3 g of phenothiazine are introduced into a smoker with a prolonged cone of 20—24 cm : with the white-greyish smoke which emerges, four colonies are treated — 30—40 puffs. Then the smoker must be fed again and the same colonies are smoked a second time.

As soon as varroa disease is detected the apiary is placed under quarantine and all the control measures recommended by the instructions in force must be taken.

B r a u l o s i s. The causative agent is the bee louse *(Braula coeca* Nitzch) — a parasite on the body of queens and worker bees. The adults are small, apterous insects of brown colour, as large as millet grain. They are more often met on the queen and more seldom on worker bees.

The female lays eggs under the capping of the honey combs. The larva feeds on bee bread and honey ; it digs tunnels under the wax cappings of the honey combs.

A good control measure consists in systematic uncappings of the brood combs : the cappings must be melted.

Adults are killed with naphtalene or phenothiazine. In the evening sheets of paper are put on the floor boards, with 10—20 g naphthalene on them, according to the size of the colony. The sheet of paper is taken off in the morning and the parasites are killed.

Phenothiazine treatment requires 3 g for every two colonies ; the crystals are wrapped in paper and introduced in the smoker on ambers. When the whitish-silvery smoke appears, 30—40 puffs are sent in one hive and then to the other one ; and again, other 20 puffs are sent in each hive. The treatment is applied for three days and again resumed after 10-day intervals until the complete healing.

The apiary can be subjected to some infectious diseases such as virotic paralysis, or invasive diseases (amoeba disease, septicaemia). Nevertheless, these diseases are less spread as compared to those described above. Data about the causative organisms, about prevention and control measures can be found in the literature on bee pathology.

PARASITES AND PESTS

Wax moth is a parasite of the bee colony. Two species are known : the bigger wax moth *(Galleria mellonella* L.) and the lesser wax moth *(Achroea grisella* Fabr.), both nocturnal moths. The females can live up to 26 days. During this interval they lay eggs (2,000—3,000 the bigger species and 300—400 the smaller ones) in the hive, in fissures and combs. The larvae, feeding with wax, dig a net of tunnels, surrounded by a web very much like cobsweb. They pupate in the hollows they chew by themselves in the wood of the hive or frame or under the web : they spin cigarette-shaped cocoons. Usually the bee brood in the affected combs is ruined. The wax moth very often attacks weak colonies, on old combs, as well as empty combs or wax residues stored under unsatisfactory conditions.

In case of a massive invasion all combs can be covered by this web, refusals and residues. As a consequence, the combs turn into a mass of waste.

P r e v e n t i o n. Only strong colonies must be kept in the apiary; the old combs should be replaced by new ones.

Spare combs must be kept in special store rooms or boxes, laid on supports. The distance between combs must be at least 15 mm. They must be treated with sulphur dioxide : 50 g for 1 cu.m. The boxes or the special rooms must be smoked three times at 10—20 day-intervals. Before introducing them in the colonies frames must be exposed to air. Combs can also be treated in stacked hive bodies. The lower body must be emptied to allow the location of sulphur on the bottom board. The upper body must be tightly covered and all fissures of the walls or between the bodies should be plastered with clay.

C o n t r o l m e t h o d s. In case of strong invasions the colony is shaken on new combs ; slight invasions are cured with mechanical means.

Mice penetrate into the hive in autumn and winter. They build their nest in the insulating material and they eat dead bees and honey ; they also destroy the combs. The presence of mice in the hive can be noticed after the remnants of bees fallen on the bottom board as well as the mice excrements. Mice cause great damages to the bee colonies : bees do not bear the mouse smell and they avoid the combs attacked by mice.

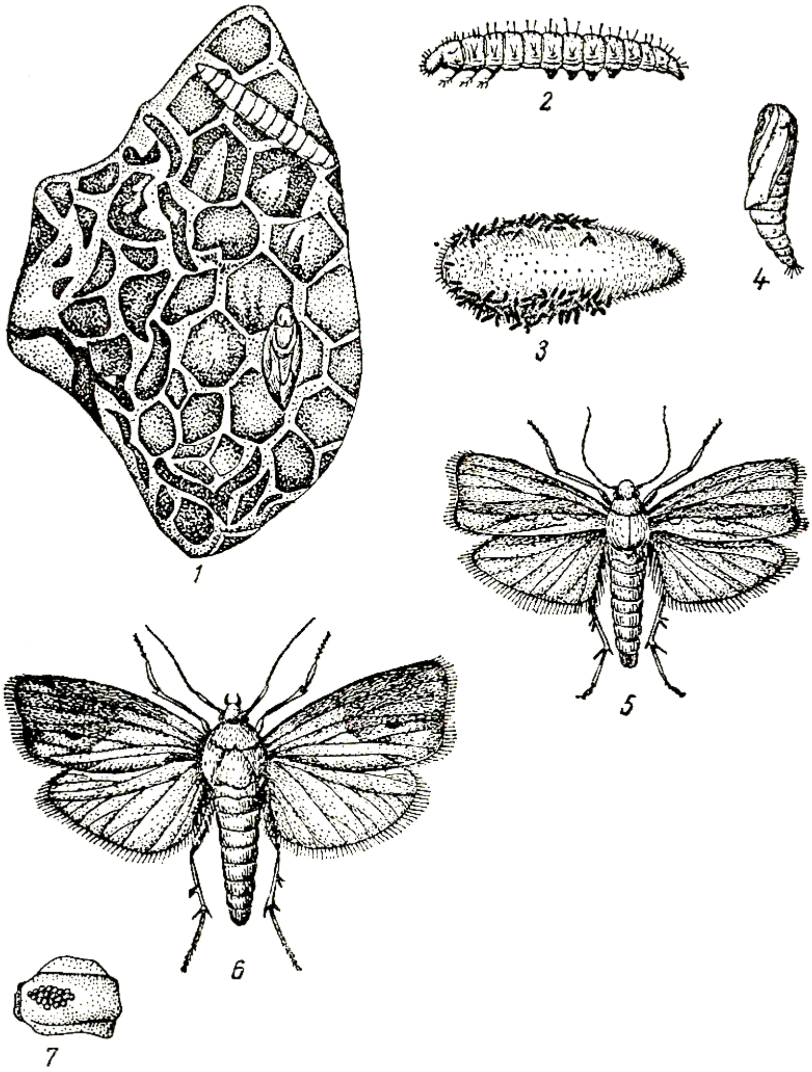


Fig. 96 — Large wax moth

1 — part of a comb affected by the wax moth larva ; 2 — caterpillar ; 3 — cocoon ; 4 — pupa ; 5 — male adult ; — 6 female adult ; 7 — eggs, on the cell wall

Control methods. All openings of the hive walls must be well filled in and in autumn the main entrance must be blocked with special closing devices. The wintering shelter must be cleared from rats.

Pests of the bee colonies. They are usually classified in honey and bees' pests. The first category includes wasps, hawk moth and ants, while the latter one — hornets, bee-killer wasps and bee-eaters.

Wasps *(Vespa germanica* F., *Vespa silvestris* Scop.) attack the colonies especially in autumn and rob their honey.

Control methods mainly consist in using various devices of closing the main entrance.

The ants penetrate often into the hive to rob honey. Sometimes they hive themselves in the insulating material. Some species also destroy bees.

Control methods. The hive supports and stakes must be oiled with mineral oil.

The hornet (*Vespa crabro* L.) is a big wasp, 26—27 mm long. It catches bees in the field, in the apiary or near the hive entrance. It perforates the honey sac of the bee to suck the nectar it contains. It feeds its larvae on chewed bees. The hornets appear in the apiary in autumn. They nest in hollow trees, sometimes under the hive roof.

The bee-killer wasp (*Philantus triangulum* F.) is 12—15 mm long. It looks like a wasp, but with a bigger head and a more yellow abdomen. It attacks flying bees. It feeds its larvae on bees: rearing of one such larva requires almost six honey bees. The bee-killer wasp is frequent in Uzbekistan and Turkmenia, where it causes great damages to apiaries. It lives on dry sandy soils.

Control methods — their nests must be dusted with hexachloran. To catch the adults, bottle-traps are kept in the apiary.

The bee-eater (*Merops apiaster* L.) is a small bright-coloured bird, with a long and curved beak. It feeds on insects. It is more frequent in Southern areas. They fall down in bevies on apiaries and eat flying bees. They build their nests on the tall river banks and cliffs.

Control methods. They must be destroyed either by shooting them or by destroying their nests.

GENERAL MEASURES TO PREVENT BEE DISEASES

Protecting the honey bee against diseases is highly important for maintaining strong colonies in the apiary. A dry location ,protected from winds, with rich honey flows, is a sound prevention measure. The colonies must be provided with rich honey and pollen stores and an adequate management. In the forest areas part of the food stores can be replaced by sugar syrup. One of the main prophylactic measures is breeding productive colonies, winter and disease resistant. In this case inbreeding is not recommendable.

Hives and tools are disinfected to prevent the spreading of diseases. Cleanliness must be maintained all the time in the apiary and dead bees must be either burnt or burried. The bee-keeper must observe the rules of personal hygiene. The drinking place must permanently supply clean water. It is very important to prevent drifting and robbery too.

In addition to the prophylactic measures indicated above special medicines are used to prevent infectious bee diseases. They include antibiotica (tatracyclin, monomycine, biomycine, fumagillin) as well as chemical preparations (natrium norsulphazol, sulphantrol). They are given the bees with sugar syrup in spring and autumn.

Prophylactic, current and final disinfection. Prophylactic disinfection is undertaken when no diseased colonies are in the apiary ; its aim is to prevent the diseases. Current disinfection is applied when an in-

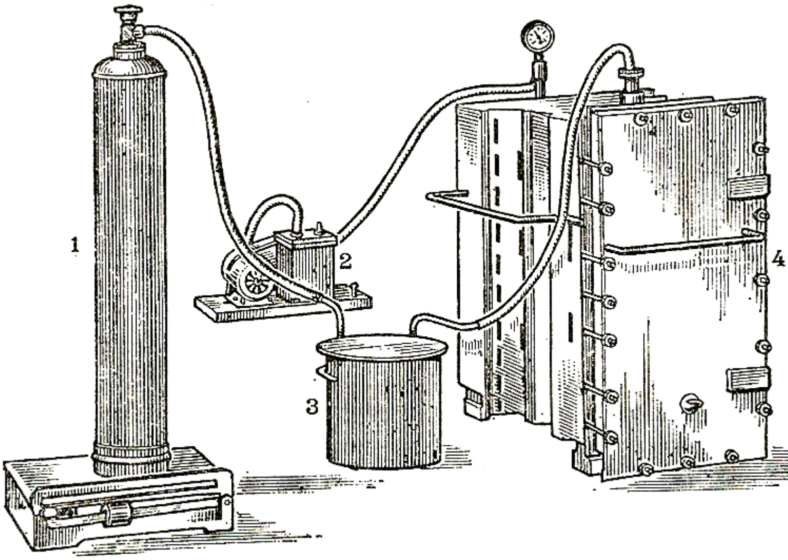


Fig. 97. Comb disinfection device
1 — reservoir ; 2 — vacuum pump ; 3 — water-bath ; 4 — disinfection room

fectious disease is registered — as a rule concurrently with curative measures and improvement of the management conditions. Final disinfection rounds off the measures of healing after the center of contagion was destroyed.

There are physical and chemical disinfection means. The physical ones are boiling, sterilizing in live flame and dry heat. The most frequent is boiling in water. Overall, towels, metal tools and wood objects (frames, queen excluders, queen cages) must be usually boiled. Disinfection of hives, feeders, frames and other wood objects is made by flame sterilization. They must be previously cleaned from wax, propolis and diarrhoea spots. Then they are sterilized in the flame of a blow until they get a brown colour. Dry heat disinfects overalls, quilts and sack cloth. To this effect a hot iron ("linen") is used.

Chemical disinfection is very extensively practiced in beekeeping. They include slaked lime, lye wash, formalin, hydrogen peroxide, vinegar, ethylene-oxide, methyl bromide. Freshly slaked lime, prepared out of quick lime, is used for white washing the wintering shelters and the store rooms. Lime solutions are used for disinfecting the areas affected by foul brood.

Formalin is used for comb disinfection. A water solution (4%) must be prepared (one part commercial formalin 40% concentration and 9 parts water). The combs must be sprayed or sunk in this solution for four hours; the solution is then centrifugated and the combs must be well aired.

Lye-wash is prepared out of ashes resulted from burning wood. For one kg of ashes 5 litres of water are necessary ; they are boiled together for two hours while being continuously mixed up; finally the solution is filtered through a sieve. The primary lye-wash solution contains 6—7% basic substance. In order to obtain a lye-wash solution (1%) one must add 3—4 parts hot water.

Chloramine (4%) is used for disinfecting combs and hives.

Kinosol is a yellow, water soluble powder; it is used in 2% solutions for disinfecting combs when European foul brood occurs.

Sulphur dioxide is obtained by burning sulphur; it is used for destroying the wax moth.

Diagnosing of a disease. The success of a treatment depends first and foremost on a correct diagnosis. The preliminary diagnosis is carried out taking into account the chemical symptoms of the disease even in the apiary. When tracking down a catching disease or even when only the suspicion exists, the material for analysis is sent to the closest veterinary laboratory.

Dispatching samples for analysis. In cases of brood diseases, samples of combs (10×15 cm) are sent, which contain dead and/or diseased larvae or pupae. The samples are placed in a wood box. In case of adult bee diseases, 50 bees are taken from 5 colonies presenting the characteristic symptoms of the disease (dead or live bees). Every such sample should be introduced in a box (a match box, e.g.) which bears the very number of the colony. In case of complete destruction of the colony, bees from the upper seam must be taken.

Supplementary samples of honey and bee-bread are also necessary. The documents accompanying the sample should mention the location of the apiary, the beginning of the disease or the day of the death and the data resulting from the control of the apiary. For tracking down the chemical intoxication, about 400—600 bees must be sent in glass recipients. Samples of honey (50—100 g) for determining the content for honeydew are sent in tight glass recipients. Samples of pests and parasites with chitinuous tegument are sent also in boxes, but protected by cotton wool; the insects with a soft tegument are sent preserved in formaline solutions (7% concentration). Such samples are sent by mail or by a courier.

Quarantine. According to the instruction of controlling bee diseases, the apiaries affected by American and/or European foul brood, sac brood, varroa disease etc. are placed under quarantine. In case one of the above-mentioned diseases has been tracked down in an apiary, the beekeeper must warn the neighbouring apiaries as well as the veterinary man of his own kolkhoze or sovkhoze.

The quarantine is declared by the responsible bodies in keeping with the description made by the veterinary expert. In this case the sale of bee colonies and queens as well as swarms is forbidden. The state of quarantine ceases a year after the last incidence of the disease.

BEEKEEPING ORGANIZATION AND ECONOMY

Planning, organization and rational remuneration of work play a very important part in intensifying beekeeping production processes, increasing the colonies' productivity and the efficiency of honey flows, at the same time decreasing the cost price of apicultural production.

BEEKEEPING SPECIALIZATION AND CONCENTRATION

Specialization of beekeeping farms as well as of kolkhoze and sovkhoze apiaries according to the climate conditions, the character of the honey flows and the demands of the main branches of agriculture bears the mark of peculiarities specific to this branch. Among them, worthy of mention is the very close relation between the growth, development and productivity of bee colonies and the environment conditions as well as the honey sources. Bees gather, process and make food stores. Compared to other branches of farming, there are fewer possibilities in beekeeping to keep under control the above-mentioned processes. Not considering the climatic factors, the farms have reduced or no possibilities to change and efficiently adapt the crops (even fewer possibilities in case of the spontaneous ones, which are the main honey sources) to the needs of the apiary. It is much better to specialize the beekeeping farms setting out from the local natural and economic conditions.

Thanks to the huge variety of natural conditions existing on this country's territory — tundra, tundra forest and dry and humid subtropical areas — there are large but still too little used possibilities of specializing beekeeping farms. First and foremost are the honey flows — the so-called supply of raw material for beekeeping — as well as the date and scope of the nectar flow in various regions of the country.

Intense massifs of wild honey plants (willow, raspberry, gooseberry, lime-tree, fireweed, etc.) lie in the mountain forests and taiga. The felled and burnt forests alone with a rich honey plant vegetation, stretch today over more than 50 million hectares while the lime tree forests hold almost 2 million hectares.

The northern and mountain districts have an outstanding abundance of honey plants; moreover, the nectar flow of the same honey plants in these districts are 2—3 times more abundant than in the southern and flat areas. In the northern and mountain regions there is a relatively late but abundant nectar flow on lime tree, fireweed and angelica; during this period the increase in weight of the control hive must reach even 10—15 kg/day. In these districts only a small part of the natural resources are used for honey production and even the apiaries which do not avail adequate equipment can obtain bumper honey productions (i.e. one quintal per colony and even more).

The bee forage in southern areas as well as that in the steppe, humid and dry sub-tropical areas is entirely different. In the depressions and sub-mountain districts of Central Asia and Transcaucasia there are considerable massifs of spontaneous honey producing trees, bushes and herbaceous crops. They offer an early nectar flow not too rich but quite long. The massive forrests (cornel-tree, hawthorn, maple tree, almond tree, sloe tree, wild apple- and pear-tree, etc.) as well as the vegetation of the subalpine areas of the crests of the Capathians and in Central Asia very much like the huge plantations of fruit-trees cannot be sources of large amounts of honey, but they offer a good build-up opportunity in spring (in April-May). It is favoured by early spring, warm and sunny days.

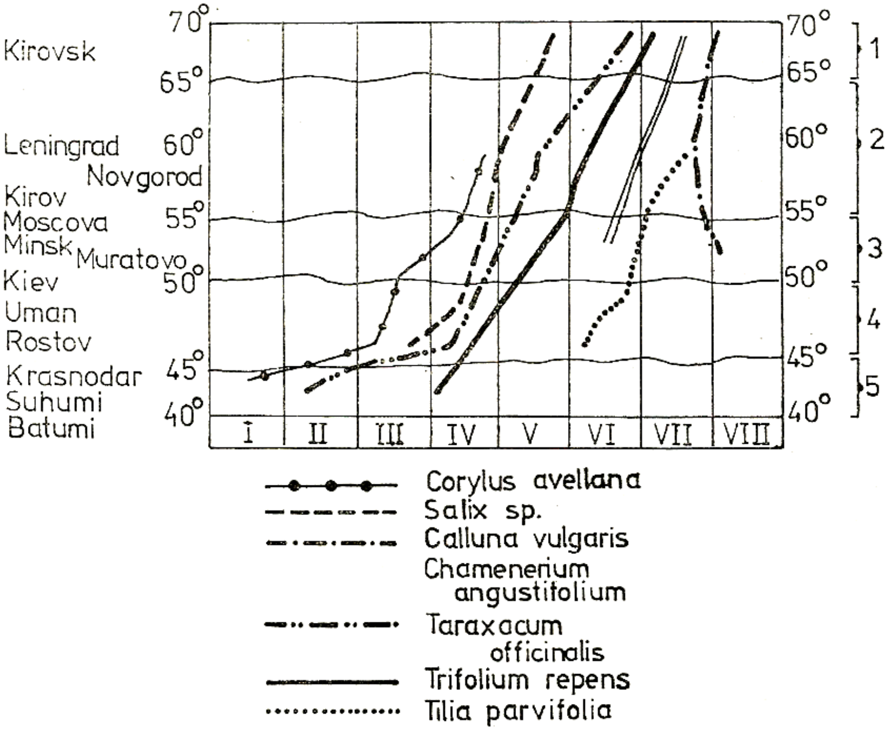


Fig. 98 — Flowering periods for some honey plants in different areas of the European USSR

On the abscisse: I—VIII, months from January to August;
On the ordinate: 1 — tundra; 2 — forest; 3 — forest-steppe; 4 — steppe; 5 — subtropics

The blossoming of honey plants and the build-up period start one month and a half — two months earlier than in the northern forest areas ; the average marketable honey output does not surpass 5—6 kg per colony.

The beekeeping farms in the steppe and the dry and humid subtropical areas can be better specialized in the production of queens and package bees as well as in pollination of the orchards.

The natural and economic conditions of the forest area favour to a greater extent the marketable honey production at a lower cost and lower labour expenditure than in southern districts (Table 26).

Table 26

Efficiency of Honey Production in the Sovkhozes in Several Economic Areas of the RSFSR

Economic districts	Cost price for 1 kg honey/roubles	Work expenditures for producing 1 kg honey (man/day)
North Caucasus	2.57	0.67
Western Siberia	1.23	0.27
Eastern Siberia	1.34	0.35
Far East	1.13	0.19

The specialized sovkhozes and the beekeeping farms in the forest area obtain 3—4 times more marketable honey per colony, with considerably lower labour and money expenditure than the farms in the southern districts.

Efficiency of bee-keeping farms in the southern areas can be increased by their specialization in rearing colonies and queens.

The Krasnopoliansk beekeeping farm of the Institute in Rybnoe may serve as an example of high efficiency ; yearly it supplies over 120—130 thousand Caucasian queens obtaining an income of 200—300 roubles. Another example is the sovkhoze at Bekansk (North Osetia ASR) specialized in rearing Carpathian queens and package bees.

Beekeeping can be specialized as follows :

1) Zonal specialization in the Far Eastern, Eastern and Western Siberia, Bashkir ASSR, Eastern Khazakhstan and in a number of mountain districts as well as in other regions with rich nectar producing flora ; beekeeping must mainly aim at higher marketable honey productions. In numerous districts (except Far East and Bashkiria) more honey is obtained when using package bees reared in the Southern districts of the country.

In the depression and subalpine districts, in the republics of Central Asia, on the Black Sea coast of the Caucasus the south of the RSFSR and the Ukrainean SSR (Daghestan SSR, Krasnodar and Stavropol region, Crimea) the beekeeping farms and the big farms in sovkhozes and kol-

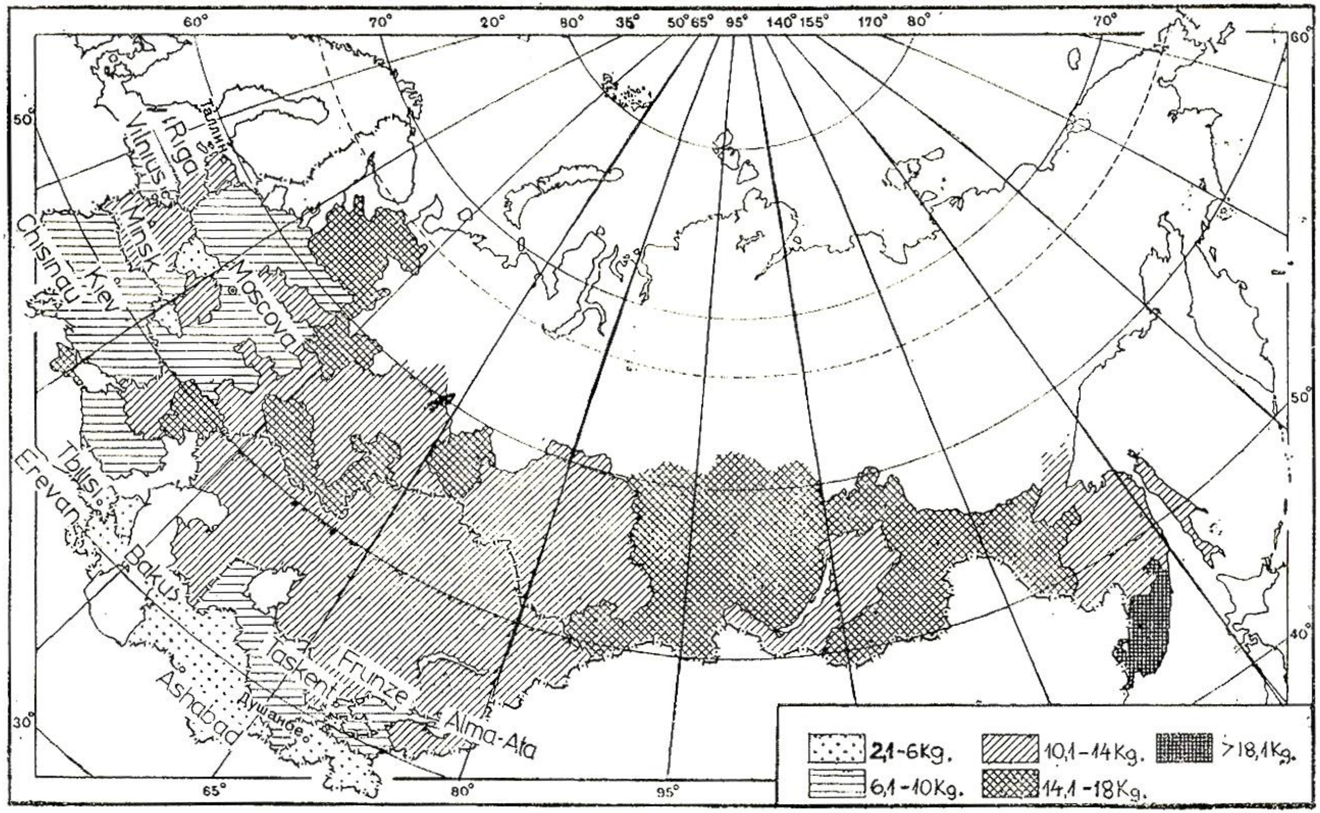


Fig. 99 — Mean honey crop per colony in the USSR

khozes should specialize in massively producing package bees and queens early in spring for their utilization in other regions of the country. It is also recommended to associate the production of bee queens with using bees for pollinating fruit trees and other honey-producing crops.

2. Specialization of separate farms. Large farms with bee-keeping as their main branch will be established where favourable conditions exist. Illustrative for this specialization are the beekeeping sovkhozes in Primorie and Habarovsk regions, in the Eastern region of Khazakhstan (Yakovlosk, Spasski, Putinţev). For a rational and wellbalanced distribution of labour all over the year it is better to organize supplementary activities linked to beekeeping such as building hives, packing bees, making agricultural tools, etc.

3. Specialization within the farm. The apiaries of various sovkhozes and kolkhozes can be put together in one beekeeping farm alone. In case of such a specialization one can more rationally use the colonies for honey production and for pollinating the honey-plants. The specialization of this type accounts in some instances for streamlining certain apiaries for rearing queens and bee colonies, for producing package bees, and royal jelly as well as for pollinating special cultures (for instance crops on covered areas). It is very important to set up specialized sections or apiaries when undertaking the selection work with checking up queens after their descendence, meant to ensure the respective material for the other apiaries.

The specialization of agriculture is closely linked to the concentration of production. The experiments show that in the farms located in favourable areas it is better to abandon the small and unefficient apiaries of the neighbouring kolkhozes and sovkhozes which do not allow for

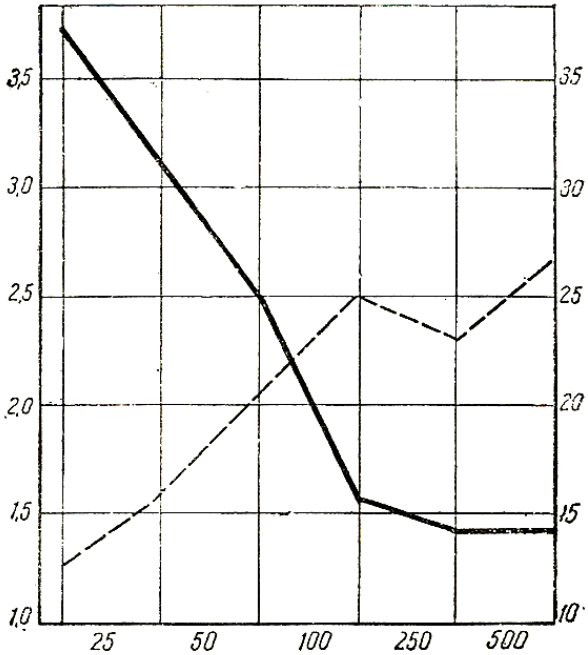


Fig. 100 — Marketable honey yield per colony and honey cost price as compared to number of colonies per farm in the state farms of the USSR
———— *honey cost price per kg*
- - - - - *marketable honey per colony*
On the abscisse: number of colonies per farm; on the ordinate: cost price per kg (roubles) — left; marketable honey per colony (kg) — right.

conditions necessary for highly productive beekeeping farms. As a rule within small farms the productivity of bee colonies is very low and the cost of production is high, often surpassing the purchasing price. Such apiaries are unprofitable and they constitute a supplementary concern for farmers.

Concentration of beekeeping is a very important source of increasing productivity of apiaries and of beekeepers, of profitableness of farms, lowering the cost price and improving production. The efficient production of honey and of other apicultural products is possible only by concentrating these branches. To support this assertion one can recall the experience of some large beekeeping sovkhozes and farms in our country as well as the practice of foreign countries with an advanced beekeeping.

Table 27

Size of Bee-keeping Farms and the Productivity of Bee Colonies in Sovkhozes in Far East (on the Average for the 1966—1970 Period) after Data Provided by L. V. Prokofieva

Groups of sovkhozes per size of beekeeping farms (bee colonies)	Number of sovkhozes	Conventional honey obtained on the average per colony (Kg)		Cost price for 1 q conventional honey (roubles)	Gross production day/man (roubles)
		Gross production	Commodity production		
Up to 100	7	31.6	14.2	388	15.4
101—250	18	32.5	14.8	210.7	16.1
251—500	25	36.0	19.8	185.1	17.9
501—1000	19	40.3	21.1	164.2	19.1
1001—2000	21	41.6	22.5	163.6	19.6
over 2000	7	45.1	23.6	160.9	21.8

According to the data presented in table no. 26 the greater the beekeeping farm, the higher the productivity of the bee colonies and especially the more marketable honey ; at the same time the cost price of honey decreases while the beekeepers' labour productivity increases. Thus, within large beekeeping farms the gross output is by 42.7% while the honey commodity by 62% higher than in the apiaries with less than 100 colonies. For every day/man in small apiaries the production obtained was tantamount to 15.4 roubles while in large apiaries it stood at 20 roubles.

The advantages of the large specialized beekeeping farms are advocated by the experience of the sovkhozes in Stavropol region. Between 1970 and 1973 the five sovkhozes in this area, having 10,000 bee colonies, produced marketable honey to the value of 810,000 roubles (81 roubles on the average per each colony) ; 225 kolkhozes and sovkhozes which were not specialized in beekeeping, had 60,000 colonies whose production stood at a value of 96,000 roubles (i.e. 16 roubles on the average per colony).

Economic efficiency of beekeeping production increases very much by the mechanization of the complex processes, perfection of the technology and the industrialization of beekeeping. Highly interesting in this respect are the beekeeping complexes, especially those in the Lipetsk region. The small apiaries in kolkhozes and sovkhozes merged there into two large farms ; a modern material base and good living condi-

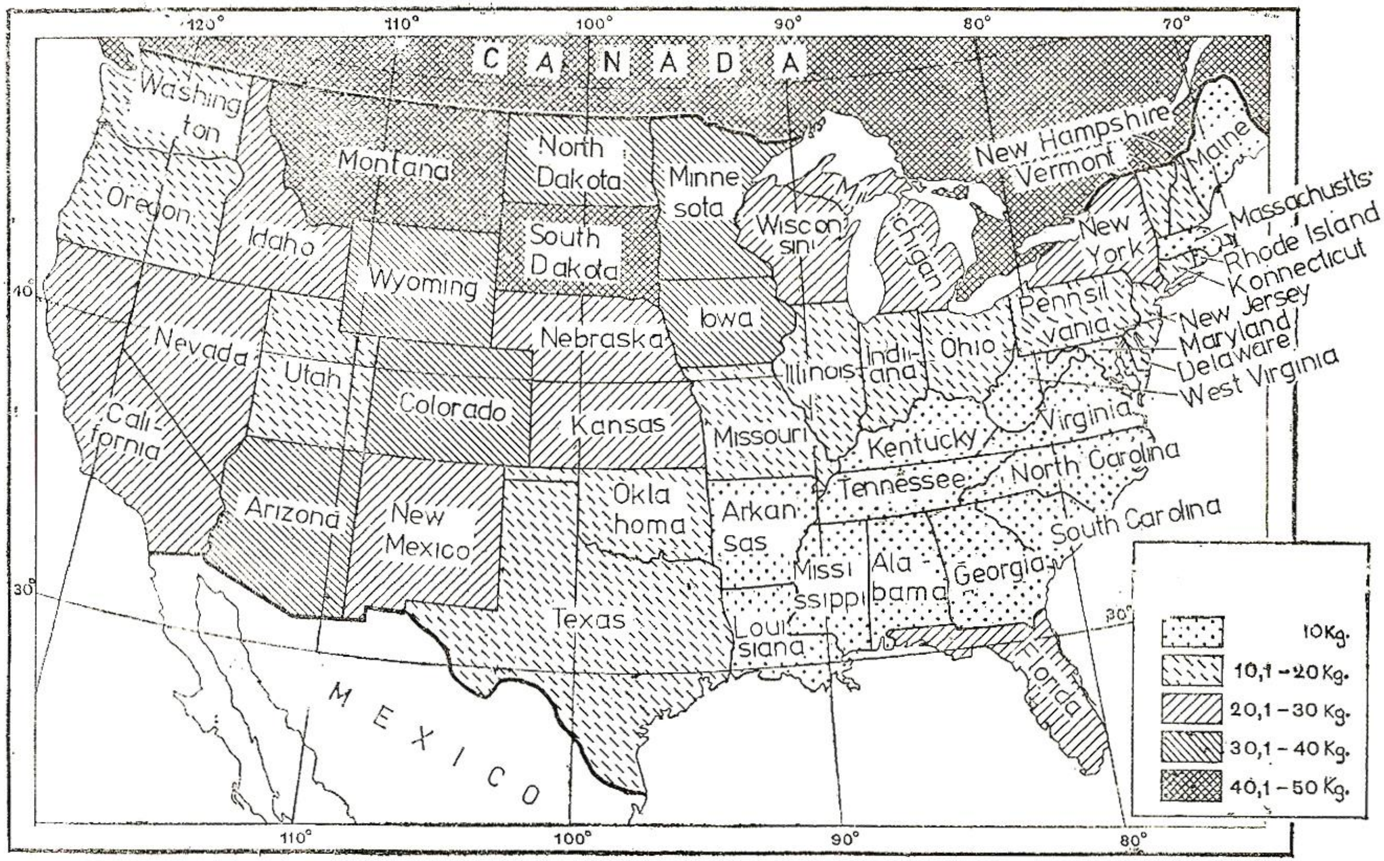


Fig. 101 — Mean honey crops per colony in the US and Canada

tions for beekeepers and experts have been created. In Stavropol region the specialization and concentration of beekeeping is made by organizing 20 inter-kolkhoze and intersovkhoze unions which turn out apicultural products, seeds of fodder plants and make the pollination of honey producing crops. This ensures a profitable beekeeping and the efficient pollination of crops by the help of bees.

ORGANIZATION OF THE BEEKEEPING PRODUCTION ON A COMMERCIAL BASIS

Concentration and specialization of beekeeping creates strong premises for introducing commercial management technologies in apicultural production and for increasing beekeepers' labour productivity.

According to this technology, a commercial apiary of 500—600 colonies is looked after by a team including a beekeeper and two seasonal workers. The best place as headquarters for such an apiary is that offering the most profitable conditions for nectar flow, wherefrom an efficient migratory beekeeping can be organized all through the season. All the 500—600 colonies are gathered there in autumn by the end of the nectar flow. There bees can overwinter and in spring — after the cleansing flights — about 70—120 colonies can be placed in areas with early nectar flow.

All activities which are not closely related to management of the colony are performed at the headquarters where there are the necessary rooms, apicultural equipment and tools. In case the colonies are kept on the very location the brigade will bring there all the necessary materials and beekeeping inventory.

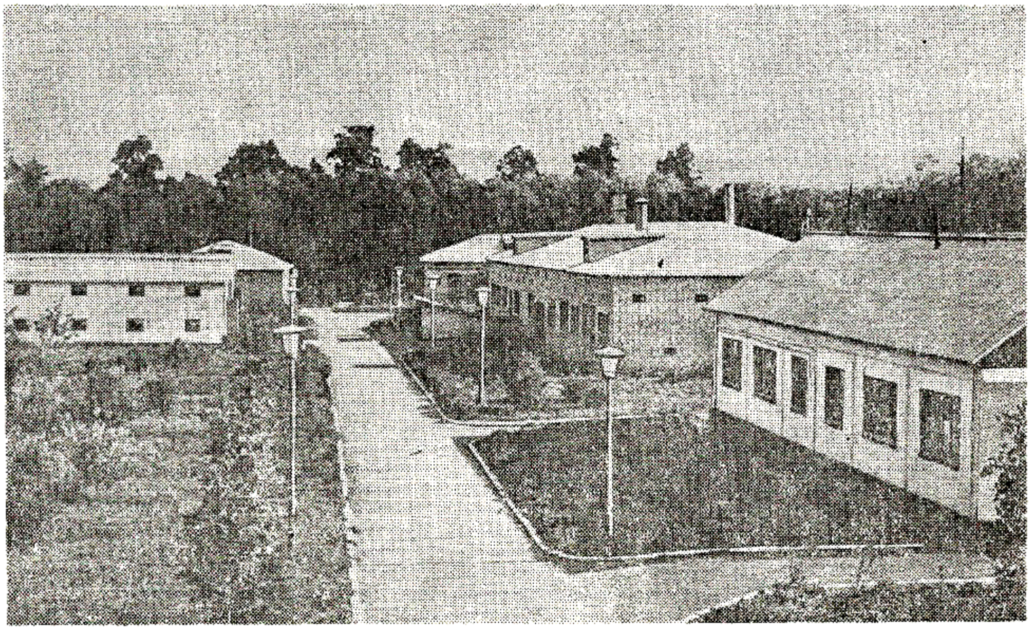


Fig. 102 — The central buildings of the beekeeping complex

Large scale beekeeping requires special management methods. In this case, on the basis of the preliminary control of 10—15 colonies and taking into account the data of the control hive, weather forecast and the experience of past years, the period necessary for carrying out operations with all colonies is established in advance (expanding the brood nests, making up new colonies, hives' supering, honey harvest, etc.).

This order of the various operations within the apiary allows for a 2—3 times reduction of labour expenditure in beekeeping.

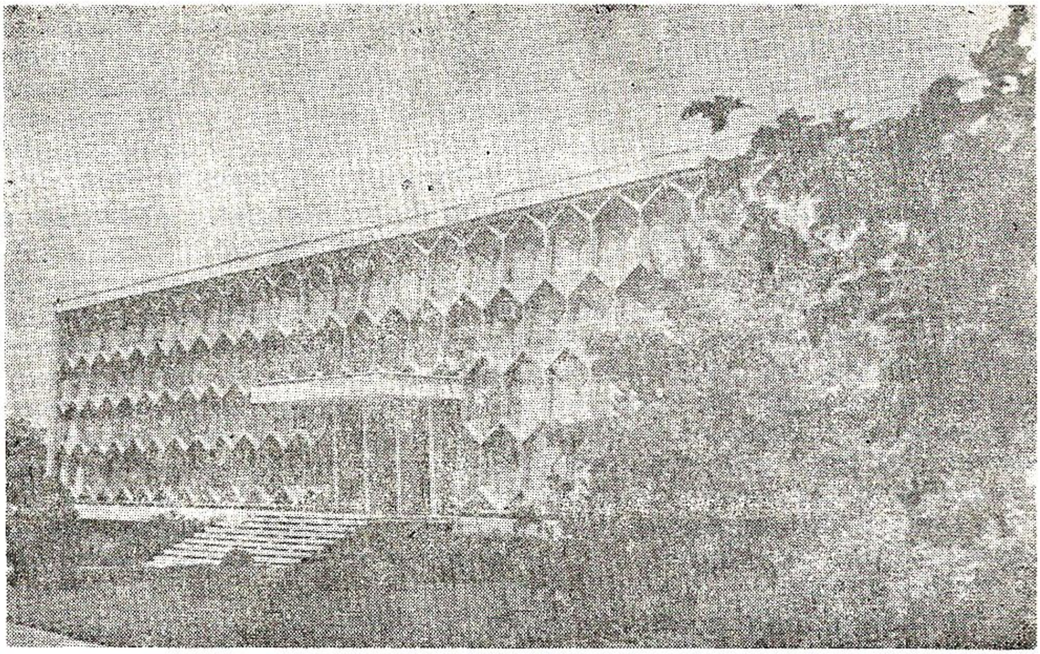
A very important activity within a commercial apiary is that of forming nuclei; as many as 200—300 nuclei are formed in a group of colonies looked after by a team. Their timely apperance prevents colonies from swarming and gives the oportunity of evolving a supplementary number of bees for the main flow. Moreover, when nuclei are formed the force of the colonies can be levelled up — a very important element for large scale management techniques. In this case a thorough discarding of the colonies must be undertaken in autumn, selecting the best colonies for wintering. For nuclei one must use mated queens obtained from the nurseries in the south or from apiaries specialized in rearing queens.

Although the formation of nuclei is a difficult work — entailing time for preparing the hives, their supplying with frames, food, empty combs, their thermic insulation and utilization of transport means — a brigade of beekeepers form about 50—75 nuclei in only one working day.

One can obtain a considerable saving of labour when feeding bees by passing from sugar syrup to a candy made up of sugar and honey (1 kg honey and 4 kg powder sugar) which is prepared at the headquarters using mechanical grinding mills for sugar and mixers for the paste.

If necessary — antibiotics are added to this paste with prophylactic purposes. The honey and sugar paste is placed on frames under the form of small cakes.

The total volume of the hive can be enlarged by supering it with empty combs alternating with foundations. Such supers are prepared at the headquarters. Five wired foundations alternating with five empty combs are put in each super of the Langstroth hive. The supers prepared as such are transported by car or coach up to the apiary. One of the seasonal workers unloads the hives and the beekeeper together with the other seasonal worker stacks them over the second body (for Central Russian bees). For mountain grey Caucasian bees or their hybrids, the supplementary body is introduced between the two bodies, after they had been previously interchanged. To this effect 5 frames with capped brood from the upper body are introduced; the latter are replaced by 5 wired foundations alternated with the remaining frames. In case of maintaining bees in two-storey hives, the second storey will be added only when the hive has almost 8 frames with brood and 10—11 bee intervals. Two combs with food, two wired foundations and two empty combs are introduced into the second body. Before adding the second body one must introduce 3 frames with capped brood and



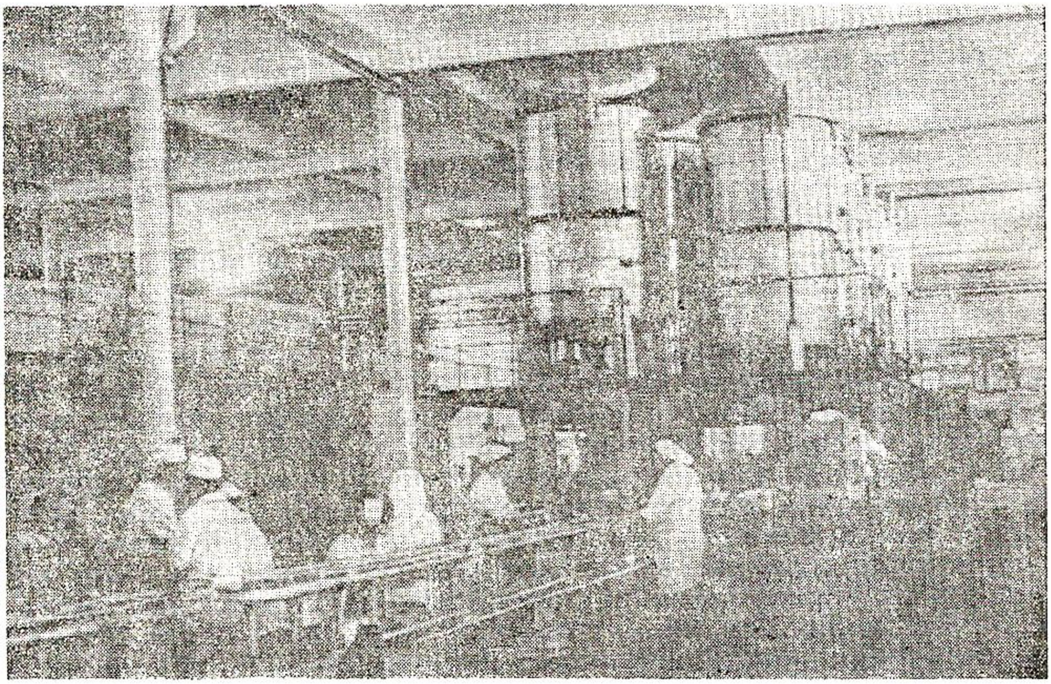


Fig. 103. Above — one of the modern building of the Beekeeping complex in Bucharest
Below — honey conditioning and bottling in the same complex

bees from the nest in it; the latter are replaced by five frames with empty combs.

The most important element of commercial beekeeping is probably the repeated and timely movement of bees to nectar flow and to massive honey flowers in bloom as well as pollination by bees of these flowers. They are moved 3—4 times depending upon the local conditions.

In commercial beekeeping, loading of hive bodies or of supers and honey extraction are performed separately. During the nectar flow the brigade takes the bodies and honey supers (or frames) receiving in their place empty honey supers or combs. The honey bodies, the honey supers and the frames are stored at the central headquarters and by the end of the nectar flow — in the off-season — one must undertake auxiliary operations such as warming up and uncapping combs as well as extracting, conditioning and packing honey.

The method of group management of the bees can be successfully applied when keeping in the apiary equal colonies, characterized by a low coefficient of variability of living, of queen prolificness, etc. One must employ queens with a high egg-laying, preferably belonging to the best strains, selected by systematical discarding underdeveloped colonies in autumn and when forming the nuclei. After making up 200—300 nuclei the operators can discard all weak and queenless colonies in autumn. Utilizing nuclei one can re-establish the initial number of colonies in the apiary. When the weather gets cold hives must be moved to the central apiary and introduced into wintering places (if not wintering in the open).

The practice of the top-ranking apiaries in this country and abroad shows that the type of hives has no essential influence upon the productivity of colonies and on the possibility of applying technological means in commercial beekeeping. It is possible to adopt technical procedures even when keeping bees in 12-frame standard hives; in 2-body hives, in multiple storey and in long hives. One must utilize even honey chambers when applying industrial methods. They are practical because the combs can be used years on end, the extraction of honey frames and supers is simpler by means of efficient electric devices; finally the honey in the supers is of better quality than that in the combs of the hive.

It must be emphasized that chemical preparations and antibiotics used prophylactically in the bees' food may accumulate on the frames of the hive. They are little likely to reach the honey in supers, since the honey chambers are filled with honey during the main flow, when food with an extra-amount of medicines is used.

LABOUR PLANNING AND ACCOUNTANCE IN BEE-KEEPING

Planning of farm production, especially of bee-keeping is starting at the very level of kolkhozes, sovkhozes, brigades, sections and farms.

Planning within the farm unit. The kolkhozes and sovkhozes draw up perspective plans of bee-keeping development (for 5—7 years and even more) and current plans (for one year).

In drawing up the perspective plan one must set out from the pecularities of the forage base, the possibilities of its improvement and its rational utilization, from the requirements of pollinating honey-producing crops. Function of these problems the targets for a few years are established taking into consideration the basic indices, i.e. increase of the number of bee colonies, honey and wax production, pollination of farm crops etc. After establishinig the tasks for the development of apiculture measures for their fulfilment are wroked out : the plan will indicate the sources for increasing the number of colonies, the expenditures allocated for the acquisition of hives, bee-keeping tools, and of materials required for honey-house building, for training. When elaborating the perspective and current plans much attention has to be paid to the measures aimed at increasing labour productivity and reducing costs, at moving bees to honey flows and crops requiring pollination, mechanization of more complex processess, passing from natural to artificial swarming of colonies, organizing queen rearing and getting strong colonies supplied with adequate stocks of food and cmbs.

The perspective plans drawn up in the farm units are sent to the next competent production division.

On the basis of the perspective plan approved, the kolkhozes and sovkhozes are drawing up one-year production and financial plans including also the indicators for the bee-keeping :

1. Increase of strength and number of bee colonies for the beginning of the next year ; 2. honey and wax production ; 3. marketing of beekeeping production ; 4. labour expenses ; 5. material expenses ; 6. calculation of production costs ; 7. building and capital repairs ; 8. training of personnel.

In addition to the annual production and financial plan, *annual production targets* are also drawn up for bee-keeping farms and apiaries. At the beginning, based on the peculiarities of the forage base, the state of colonies, endowment with equipment and outfit and to a number of other factors, production targets are established separately, for each apiary. Then, on these actual materials, the production target for the entire bee-keeping farm is drawn up. The production targets must aim at increasing the number of bee colonies and rearing queens, building new combs, honey and wax production, moving bees to the honey flow and to farm crops pollination. Concurrently, money outlay and material expenses required, and the value of gross output are established.

Targets for honey and wax production are established according to the number of bee colonies at the beginning of the year. In this case one must see to fully meeting the food requirements of the basic colonies, of the newly-born ones and of nuclei as well as obtaining maximum marketable honey (the gross production of an apiary is the amount of marketable honey and of honey used as food). The average honey production of a colony is established by dividing the gross honey production to the number of bee colonies at the beginning of the year. The production of marketable wax is calculated starting from the amount of combs which are discarded (by melting each comb one can obtain 120 g wax) and from the wax obtained from uncapping honey frames as well as from other wax sources (almost 200—300 g per colony).

The outlays of a bee-keeping farm are calculated by summing up the expenses directly entailed by bee rearing (the work done by bee-keepers, their assistants and watchmen) and the indirect, general ones, of the farm (remuneration of the chief of the farm and of the technician ; administrative expenses etc.) as well as other costs not directly connected with rearing colonies (manufacture of hives and packing, planting trees, building fences etc.). After having determined the total volume of the operations which are necessary for obtaining apicultural production and for rearing colonies as well as the price per work unit, the money expenses are established. In kolkhozes which have not passed yet to money remuneration, beekeepers and operators are paid according to the number of working days.

Bee-keepers participate directly in fulfilling the annual production targets. The latter must be discussed during the working meetings of the bee-keepers and their assistants and approved by the general meeting of the kolkhoze members or by the managerial board of the sovkhoze. Fulfilment of targets is controlled by the veterinary surgeon or the agronomist of the kolkhoze or sovkhoze and by the chief of the farm who directly controls the bee-keepers' work.

An important role in increasing productivity and reducing costs is played by the transition of bee-keeping farms and apiaries to *economic self-management*. To this effect production targets are established in natural and money units, and the limit man power expenditure as well as the material and financial means and total income per apiary are determined. A certain system of remuneration of labour is provided for the bee-keepers' work, according to the income obtained as a material incentive. Turning bee-keeping farms to economic self-management calls for a careful evidence of outlays and real production returns.

One of the most important conditions of making economic self-management operational and efficient are the material incentives granted to bee-keepers. There are various forms of material incentives, all of them relying on one and the same principle : the larger the amount and the better the quality of honey production, the higher the bee-keepers' remuneration.

The All-union Institute of Research for Agricultural Economy recommends the following system of work for beekeepers within farms and brigades with economic self-management. During the year the laborers on the farms are receiving 70% of the basic funds. By the end of the year the final calculations are made if the plan was fulfilled in proportion of 100%. The kolkhoze members receive the whole sum allocated for the remuneration fund (the 70% gauranteed remuneration is rounded off by the remainder of 30%) ; if the planned indicators have not been attained the supplementary payment is reduced accordingly. If for instance the plan has been fulfilled in proportion of 90% the warran ed sum will be rounded off by another 20% instead of 30%. For the extra-plan production the kolkhoze members receive a supplementary remuneration : as much as 10—15% of the value of the extra-plan production calculated in accordance with the state acquisition prices. If the farm made savings at the expenditures provided for in the plan, the kolkhoze members are given bonuses on the value of up to 50% of the means saved. In case of exceeding the given expenses, the respective sum is deduced from the supplementary remuneration.

In order to surpass the tasks provided for in the plan and reduce production costs the leaders grant the workers in beekeeping sovkhozes bonuses from a special fund.

The main index of the economic activity in the beekeeping farms is the production cost or the summing up of expenses made for the production unit. Following must be established for the calculation of the production cost :

1) Direct expenses, including remuneration of beekeepers' and their assistants, food price, foundation, common appliances and other materials, expenses made for repairs and amortization quotas for beekeeping buildings and equipment, transport charges and expenses made for heating and lighting of bee houses in the apiary.

2) Indirect expenses, that is general production and administration costs.

General production expenses include remuneration of the veterinary surgeon, the bee-keeping technician and the chief of the farm as well as expenses for repair, cleaning, heating and electricity and for maintaining the vehicles required by the experts of the bee-keeping farm.

General operations expenses include the remuneration of administrative personnel, amortization, current repair and maintenance of rooms, transportation expenses etc. They are divided by sections of the farm in relation with the wages funds.

As a rule, at the apicultural farms the main share of expenses is held by food representing 55—60%, labour remuneration is holding about 25%, and 20—25% for the rest.

For calculating the cost per unit of agricultural production it is necessary for each and every category to be previously converted into conventional units. Such a unit may be considered one kg of honey. When converting other elements of production into conventional units one must use corresponding coefficients.

The state plan of the USSR, the Ministry of Agriculture of the USSR, the Ministry of Finance of the USSR and the Central Statistical Board of the USSR approved the following conversion coefficients, on June 11, 1970 :

Category of products	Conventional honey units (kg)
1 kg honey	1.0
1 kg wax	2.5
1 colony (swarm)	5.0
1 mated queen for sale	2.0
1 queen of pure breed for sale	2.5
1 unmated queen for sale	0.5
1 kg bees for sale	5.0
1 frame with comb	0.5
1 kg royal jelly	440.0

Dividing total expenses by the entire production (converted into conventional units) one can determine the cost of a conventional unit, i.e. of one kg honey. For determining the unit cost with other product categories one must multiply the unit cost of honey with the corresponding coefficient.

Thus, if the cost (price) of one conventional unit — therefore of one kg honey — is 1 rouble and 20 kopeiks, the cost of one kg wax will be 3 roubles (1.20×2.5), of a colony — 6 roubles (1.20×5), of a queen — 2 roubles and 40 kopecks (1.20×2).

Efficiency of production is one of the economic coefficients of the farm activity. For determining the economic efficiency of a bee-keeping farm, the entire bee-keeping production must be estimated in conformity with the acquisition prices ; from the total amount obtained one must deduce all the expenditures of the farm entailed by the achievement of this production. The difference represents the profit. The profit rate for one or for another product is determined by the coefficient (norm) of profitableness. The latter is obtained in keeping with the formula :

$$CP = \frac{Sp}{Cp} \times 100$$

in which CP is the coefficient of profitableness, Sp — the selling price of production, and Cp — the unit cost (price). The coefficient of profitableness is expressed in percentage.

The farms which used bees for pollinating honey-producing crops, part of the expenditure are reimbursed from the supplementary harvest. To this effect the value of apicultural production is rounded off by the value of the supplementary production obtained by pollinating crops by bees. This total amount must be compared with the expenses of the farm. Taking into account that part of these expenses are entailed by plant cultivation, the unit cost of the basic production will be lower while the coefficient of profitableness will be higher.

The determination of the supplementary production obtained by pollination of plants by means of bees is implying some difficulties.

In some fields (for instance — fruit-tree growing) the production of honey producing crops is granted a well-determined quota of expenditures. In the fruit-producing sovkhozes in the Riazan region 20 per cent of pollination expenses of the apiaries are due to pomiculture. The same does the "Mikhailovski pereval" sovkhoze in Krasnodar region.

Production Records in the Bee-keeping farms (Apiaries). On the basis of such records the farm has the possibility to assess correctly the bee-keeping production and the expenditures incurred, to check the fulfilment of production targets, and the integrity of all goods.

The productivity data referring to bee colonies are necessary for the selection work as well as for studying and estimating the conditions of the honey flow.

The apiaries of kolkhozes and sovkhozes take into account the number and the state of colonies in spring (at the beginning of the season) for assessing the results of wintering, and in autumn (by the end of the season) when the nests are restrained for wintering. Such checks are made by a commission made up of the chief of the farm, the representative of the administration of the sovkhoze or the managerial board of the kolkhoze and the bee-keeper of the respective apiary.

Each apiary must draw up a report on the control of colonies mentioning their number and strength, the total number of frames, the number of brood frames the amount of food stock, the age of the queens. On the basis of the data obtained the forms of spring and autumn checks are drawn up.

An apiary is recommended to have : a) a diary of the indicators of the control hive and phenological observations (it is preferable to record observations from the day when bees are taken out from the wintering shelter until they are placed again into the shelter) ; b) records for bee colonies (with the mention of the queen's age and origin, development of colonies during the season and their productivity). In queen rearing apiaries where queens are checked after descendence, all colonies will have such a record ; in the other apiaries such records will be drawn up only for stronger and more efficient colonies (as a rule 10—15%).

Every apiary must keep a record of the production delivered to the farm, of the equipment received or discarded as well as of the other necessary materials.

The chief of the farm follows up the correct recording of the data referring to the production of the apiary.

A situation of production must be also drawn up referring to the whole apiary.

The gross honey crop includes the food stocks left to the colonies and nuclei for winter and the marketable honey delivered to the store of the farm. The amount of honey in the combs for wintering is roughly estimated when nests are restrained. A nest frame full of capped honey contains — depending on the strength of the comb — about 3.5—4 kg of honey ; shallow frame — about 2 kg, and a Langstroth hive frame — 3 kg. For a more exact estimation weighing of a few frames is recommended.

The gross wax production of a colony is determined according to I. A. Titov's formula :

$$GW = \frac{(C\text{-}c) \times 0.140 + W - WF}{n}$$

in which :

GW — the average gross wax production per colony ;
C — the total number of combs (calculated in nest combs by the end of the season, after autumn discardings ;

c — the total number of combs (calculated in nest combs) at the beginning of the season before spring discarding;

0.140 — the amount of wax in a comb (kg);

W — the amount of wax and slumgum (calculated in pure wax) obtained in the season (kg);

WF — weight of wire foundation used during the season for building up combs (kg);

n — the number of bee colonies existing at the beginning of the year.

LABOUR ORGANIZATION AND REMUNERATION

A good labour organization and its fair remuneration depend to a great extent on the results of the activity of bee-keeping farms and apiaries, the productivity of colonies, the cost of production and bee-keepers' labour productivity. The problems of labour organization and remuneration are dealt with by the farm itself, taking into account the actual conditions. It is important for all forms of labour organization and remuneration to favour the increase of the apiaries' productivity, decreasing cost and raising bee-keepers' labour productivity. All measures taken by bee-keeping farms in kolkhozes and sovkhozes must be subordinated to increasing labour productivity and reducing costs. Until not long ago the bee-keepers' work has been appreciated only by the average amount of honey obtained from a colony, without considering the total honey production, its cost and labour productivity.

Labour productivity in bee-keeping is expressed in money and products and it represents the volume of production obtained by a worker per time unit (man/day or 1 worker on the average per year). Because various products are obtained from bees (honey, wax, new colonies, queens etc.) it is necessary for determining labour productivity to establish a conventional unit for all products and to estimate them in acquisition prices. Dividing the sum obtained by the number of man/days or by the number of workers during a year, one can determine the index of labour productivity in money. If we divide the entire volume of production (for converting the value of by-products into honey units one can use the above-mentioned coefficients) by the number of workers during a year or by the number of man/days, the index of labour productivity will be expressed in natural units.

Unfortunately, the bee-keepers' labour productivity is very low in many small apriaries. The average annual quantity is merely 1—1.5 t gross honey production (out of which 0.5 t marketable honey). Nevertheless, in large and specialized bee-keeping farms the average annual quantity per worker is 7—8 tons and at the John Hafely's firm "Monte Vista" of the USA the record of 20 tons of honey was attained.

In bee-keeping labour productivity can be increased by applying the experience of front-ranking farm and of modern technology (i.e. raising the number of colonies reared by one bee-keeper, mechanizing difficult operations etc.). The experience of front-ranking bee-keepers shows that moving bees to the nectar flow and pollination of massive-honey producing crops plays a very important role in increasing productivity of bee colonies without too much supplementary expenses. The efficient utilization of honey sources is possible only by maintaining strong colonies, supplied with abundant food and a sufficient number of combs (wire foundation). Passing from natural swarming to artificial multiplication, rearing queens and selection work are highly important for increasing labour productivity.

In order to increase the number of colonies looked after by a bee-keeper first and foremost one must renounce inefficient amateur methods entailing many non-productive expenses : frequent checks up, employment of building frames and frame spacers, narrowing the intervals in spring and restraining nests, stimulating feeding with small portions of syrup, removing drone brood etc.

One of the modern means of increasing labour productivity is the system of team work within a brigade. A group of 3—4 bee-keepers fulfil all operations required by the apiary. In case of an adequate endowment with transportation means and equipment, the bee-keepers' labour productivity rise by 40—50% and the cost of production drops considerably.

The mechanization and utilization of electricity in some difficult operations such as in uncapping combs, honey extraction and loading of hives for migratory bee-keeping also pay a considerable role in raising labour productivity. Without our waiting for serial production of highly-productive machines which automatically uncap 5000 frames a day or the powerful electrically-driven radial centrifugal extractors, small mechanization can be applied : double centrifugal extractors with electric engine, electric wiring of combs, electric and steam knives for uncapping combs, hive loaders, mechanical methods (bee blowers) and chemical means (carbolic acid) of liberating frames of bees etc.

Organization of labour. In bee-keeping the greatest labour rquirements is felt in the period of intense activity of the colonies, starting with their taking out from the hives, in spring, until the end of the nectar flow. In winter when bees need almost no care bee-keepers have more spare time at their disposal which they must use for preparatory operations for the next season.

Experience has demonstrated that the best form of organizing labour in large apicultural farms is the permanent specialized brigade. Several such brigades may exist in the large bee-keeping farms. The team is generally made up of bee-keepers. Within small farms the brigade is replaced by a team of specialized bee-keepers who, very much like the brigade, is an independent productive unit.

When organizing labour in apiculture it is important to assess exactly the amount of work per bee-keeper. The norms existing at present in most apiaries (viz. taking care of 70—100 colonies) does not favour the increase of labour productivity. In fact, a number of front-ranking apiarists at the same level of technical endowment take care of 2—3 times more colonies and they score higher productions of honey.

Thus, in 1971, in each of the two apiaries of the Bee Research Institute — one in Scekinsk district, Tula region, and the other in Rybnoe district, Riazan region — the 500 colonies are looked after by one beekeeper and two seasonal workers (employed for only six months). About 250 colonies were looked after by a worker for one year. The average amount of commercial honey corresponding to a worker is up to 50 quintals whereas in the other apiaries in the above-mentioned districts stood at only 11.5 quintals. The bee colonies in the apiaries of the Institute divided into several groups are looked after by bee-keepers organized in brigades.

At the central headquarters of each and every apiary there is the wintering shelter, a workshop, a room for mechanical honey extraction as well as a garage for the cars and vehicles serving the apiary. The car is better to be driven by one of the bee-keeper's assistants. All basic operations (uncapping combs and honey extraction, frame wiring, transportation of hives etc.) are mechanized.

Apiarist V. I. Maronok of the "Novaia Zhizni" (New Life) kolkhose, Pravdinsk district, Kaliningrad region, who together with his assistant reared 320 bee colonies, reached a higher labour productivity. He obtained 40—50 kg honey on the average per hive, each quintal of honey calling for 4.3—5 man/day. Apiarists E. T. Gorbunov (the "Lenin" kolkhose, Axubaevsk district, Tartar ASSR) and V. S. Chernyshev (the "Kalinin" honey-producing sovkhoze, Novoderevensk district, Riazan district) look after 190—200 bee colonies.

Setting out from the experience of front-ranking bee-keepers we can recommend for the bee-keepers in the forest area to take care of 120—130 colonies of Central Russian bees, while in the southern ones — where the vegetation periods are longer and the Caucasian bees are less aggressive and swarming — 140—150 colonies. If the bee-keeper is helped by a seasonal worker this norm can be 30—35% higher.

The bee-keepers' work in large bee-keeping farms of the kolkhozes is run by a chief or a team leader who no longer deals with rearing bees. In sovkhozes the management is entrusted to a veterinary surgeon or an apicultural technician.

In the RSSFR sovkhozes owning over 5000 colonies may have one chief zootechnician — beekeeper, those owning 2—5000 colonies — a beekeeper-zootechnician and those owning 1—2000 colonies — a chief technician and from 500—1000 colonies a beekeeper technician.

Here are some of the duties of the veterinary apicultural surgeons and technicians who are chiefs or team leaders : managing bee-keepers' work ; drawing up production targets and controlling their implementation ; applying the advanced experience and the latest gains of science in production ; organizing measures of rational utilization of foraging base and of pollinating honey producing crops ; keeping the production records in the apiaries and other measures supporting the increase of honey production and reduce costs.

Bee-keepers are obliged to perform during the whole year all operations implied by bee-keeping, to take steps for the first processing of honey and wax, to ensure pollination of honey producing crops, prevention and control of diseases, preparation of thermo-insulating materials, wiring of frames and repairing of hives and bee-keeping tools.

Labour remuneration. When working out the system of bee-keepers' labour remuneration it is necessary to start from material cointerestedness of beekeepers in increasing productivity of apiaries and of labour and in reducing costs. It is necessary strictly to observe the basic principle : a higher-quality and production as well as a better quality will be better rewarded.

In order to increase material cointerestedness of beekeepers they are paid in accordance with the production obtained ; in addition to the warranted basic wages they will receive extra-sums (bonuses) for over-fulfilment of the plan.

In the kolkhozes the piece-work tariff ought to be elaborated in conformity with the local conditions. The same tariffs are not valid for all farms. Therefore standard tariffs are not recommended. In order to grasp a picture of the tariffs existing at the apicultural farms, we will further supply a few examples.

Following tariffs have been established for the management of each colony : in winter — 30 kopecks ; in summer — 12.5 kopecks monthly ; for a new colony : in winter — 2 roubles ; for 1 quintal of food honey — 10 roubles ; marketable honey — 15 roubles ; for each comb built — 7.5 kopecks ; for one kilogramme wax — 2 roubles ; for moving bee colonies to pollinate honey-producing crops — 10 kopecks.

At the beekeeping farm of Bagac kolkhoze (Bashkir ASSR) owning 2700 colonies the following tariffs are in force: for the management of a bee colony : in winter — 80 kopecks and in summer — 1.80 roubles ; for 1 quintal of honey — 13 roubles; for one kilogramme melted wax — 1.60 roubles ; for a built comb — 10 kopecks ; for a new colony — 3.20 roubles and for moving a colony for pollination — 50 kopecks.

In the kolkhozes belonging to the Eisk Production Board, Krasnodar region, the beekeepers' work is paid only in accordance with production yields ; for 1 kg marketable honey (when providing 25 kg honey per colony) — 80 kopecks ; for 1 kg gross wax output — 3.50 roubles and for a new colony — 6 roubles.

In the kolkhoze applying the system of money remuneration, the piece-work tariff is determined starting from the tariff wage of 60—70 roubles. The bee-keepers receive 70—75% of the tariff wage a month and the final calculation is made by the end of the season when the production is gathered in. As a rule the chief of the farm receives 20—25% more than the bee-keepers. For extraplan amounts the kolkhoze farmers receive supplementary amount (10—15 per cent of the acquisition value of extra-plan honey) and the members of the brigade 20% more.

In sovkhozes and other state agricultural enterprises the piece-work tariffs are elaborated in accordance with the production and financing plan.

As a rule bee-keepers' work is integrated into the fourth category of tariff norms, the assistants' one into the third category while that of queen-rearers into the fifth category. In the 1974—1975 period greater daily quotas have been adopted : for researchers (fifth category) — 4.06 roubles, for bee-keepers (fourth category) — 3.67 roubles, for bee-keeping assistants (third category) — 3.37 roubles.

For determining the piece-work tariffs one must establish the number of working days during which the bee-keeper is busy in the apiary. Practice has demonstrated that if a bee-keeper is taking care of 120—150 colonies he is busy almost all-the-year-round. The total number of paid days is 290. Bee-keepers who take care of a smaller number of colonies have more spare time which they can devote to other operations ; therefore their working days will be fewer in number. After determining the number of working days, one must calculate the annual tariff funds of the wages dividing the number of working days to the piece-work tariff.

In case of the apiarist with 290 working days the annual wages fund is 1.064.30 roubles. For bee-keepers' material stimulation this fund has been increased by 25% and therefore a fund of 125% (1330.37 roubles) was employed for calculations. Then the entire planned production of the apiary is calculated again in conventional units using corresponding coefficients. Dividing the annual fund of wages by the total volume of production (in conventional units) one obtains the value of the piece-work tariff per unit of production.

Suppose that the production of an apiary converted into honey is of 4840 units (or 4840 kg honey). Dividing the annual wages fund (1330.37 roubles) by 4840 we get the piece-work tariff per unit of production (12.5 kopeiks). Therefore for 1 kg honey the beekeeper will receive 27.5 kopeiks, for 1 kg wax — 68.7 kopeiks (2.5 times more), for a new colony — 1.37. Out of 365 days of the calender one must deduce 52 Sundays, 8 holidays and 15-day rest-leave roubles (5 times more), etc. The beekeeper's wage is calculated setting out from this tariff.

Before the entire production of the apiary becomes profitable the bee-keeper receives a monthly wage calculated on the basis of the number of days worked every month (at the full day tariff quota). Final calculations are made by the end of the year when the actual volume of production is determined. For surpassing the gross production plan the bee-keeper can receive a bonus which can stand up to 20% of the prices) or — with the consent of the executive bodies — a percentage payment in conformity with the topped planned figures. For reducing the direct expenses per unit of production and of cost people working in bee-keeping are granted 40% of the sum representing the saving obtained. The general quantum of bonuses scored yearly by a bee-keeper must not exceed five monthly wages (six wages respectively in the sovkhozes in the fallow-land regions).

Bee-keepers who move hives for migratory bee-keeping are stimulated being paid by 40% higher tariffs.

Highly-skilled bee-keeping in sovkhozes and other state farms obtaining 2—3 years consecutively high results are awarded the title of master in zootechny (the first and the second classes), and, consequently, a corresponding wage increase.

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This book has been edited under the supervision of Prof. Dr. Eng. V. Harnaj

English translation by the APIMONDIA Publishing House

Edited and printed by the International Beekeeping Technology and Economy Institute of APIMONDIA

București I, Str. Pitar Moș 20, ROMANIA