BIOLOGIC EVOLUTION AND ADAPTING OF THE TUNISIAN BEE, *APIS MELLIFICA INTERMISSA*, TO THE LOCAL ENVIRONMENT

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Abstract

The development of a bee colony is influenced by two groups of factors: the first of them comprises the environment, that is the flora, and the climate; the second one includes the beekeeping techniques, especially those that make possible influencing the colony's development in such a way, that its production becomes optimized. The yearly biologic cycle of the Tunisian honey bee is characterized by the existance of a winter phase (November - January), during which the bees' activity is very restricted. Notwithstanding, the queen only diminishes its egg-laying, without ceasing it completely, what is translated, in Apis mellifica intermissa, *into the absence of a winter rest period, from the brood rearing rhythm point of view. During the spring phase (February - May), an intensification of the brood rearing is to be recorded, as well as an increase in the colonies stock, and the first signs of the spring flow appear. The summer phase (June - August) begins with the summer flow, but after it, colonies enter a regression phase, and the queen shows the tendency of ceasing egg-laying, because of the adverse climatic conditions (temperatures can reach up to 45° - 48 °C, in the shade), as well as of the scarcity of the honey flora. The fall phase (September - October) coincides with the first fall rains, that determine a new blossoming in certain honey species, the resuming of the egg-laying with the queen, and the important increase of the pollen and nectar supplies that are stored in the hive, expecting winter. As concerns the swarming techniques: during the spring season, the swarming period has a strong effect on the bee foraging: 22.2% of the early swarms (obtained in February), compared to 12.2% of the late swarms, take part in the spring foraging; 66.6% of the early swarms, as compared to 53.6% of the late ones, take part in the summer foraging; 11.2% of the early swarms, as compared to 34.2% of the late ones keep staying at the stage of only five or six combs occupied by bees, and don't take part in the foraging activity during the first year. The average yearly rate of swarming is 29.4%, and the average rate of succeding swarms reaches 79.3% per annum. Three types of swarming are practiced, that show similar success rates, that is: for the artificial swarming, the succeeding rate is 82%, for the fan swarming, the average rate is 81.4%, and for the multiple swarming, this rate is about 74.5%. In the case of the colonies with laying workers, the succeeding rate reaches a 75%, that is, out of ten colonies with laying workers, an average of seven or eight will become back to the normal, and have fecundated queens.*

Introduction

The bee biology is the fundament of beekeeping. The development of a bee colony is influenced by two groups of factors: the first of them is grouping all that is related to the environment, that is, the flora and the climate; the second one refers to the beekeeping techniques, especially those that make possible influencing the colony, in such a way, that its production becomes optimized (LOUVEAUX, 1966). The beekeeping technique means the wholeness of the operations that are associated to the apiary as environment, given the colony closely depends on its evolution mechanism. The biologic yearly cycle of the bee, whose adapting at the local conditions have been done during thousands of years, can be very precisely described by means of a whole series of parameters, such as: the brood developing cycle, as well as that of the worker population, or the collecting cycles of nectar and pollen. That cycle varies from a bee race to another (RUTTNER, 1988). Checking-up of the natural swarming is also one of the important elements of the beekeeping technique, as this phenomenon leads to wasting a great number of bees. Among its consequences, there are the lowering of the output, and the coming back to normal of the swarming colony. Swarming is closely related to the bee reproduction. It has a seasonal rhythm, so as to ensure the survival of the species, in the best of conditions. The swarming frequency varies from a year to another. The Tunisian colonies are multiplying the most, and swarms prosper in the best conditions, during the period from March to April. *Apis mellifica intermissa* is the local bee race, that is known as a swarming race (RUTTNER, 1988). It is also a race of great vitality and having a great adapting capacity. During the spring season, frequently enough it occurs to have some strong colonies, that got orphans because of some accidents. In an orphan colony, that have lost its queen, - after a few days, or a few weeks, depending on the race - one assists at the laying workers appearance. According to RUTTNER (1988), *Apis mellifica* shows the shortest latent period in dequeening: approximately 5.6 days, in *Apis mellifica intermissa*, as compared to 30 days, in *Apis mellifica carnica*. So, when the population of a bee colony is strong, thus it being worth of being restablished, the only possibility of saving it lies in requeening it, although the new queen will be accepted with difficulty, if that colony already has laying workers.

The present work, fundamented on the data collected by us during five years on end, has as an object to define the intimate processes of the Tunisian bee's adapting to the local environment she has to face every day. We demonstrate that, by mastering the basic techniques, we succeed to control the marked swarming tendency of the local bee race, *Apis mellifica intermissa*. We can also establish which of the different techniques of artificial swarming are best suited to our local climatic conditions, and our local bee race. Besides, we are trying to establish the capacity of *Apis mellifica intermissa* of coming back to normal through introducing new queens into the strong colonies that got laying workers following some accidents.

Material and methods

The bee colonies used in this study belonged to the Italian bee race *Apis mellifica intermissa*, settled in Langstroth hives (the general model adopted in Tunisia). As an average, the apiary consists of 70 hives (depending on the year), and is of the sedentary type, installed on the INAT premises. All colonies were continuously overseen during five years on a row, from 1993 to 1997. Observations were made weekly, concerning the number of combs covered by bees, the number of brood combs, the presence and the state of the queen, swarming, the sanitary condition of colonies, etc.

A) The yearly biologic cycle of the Tunisian honeybee. The strongness of a colony is estimated according to the number of the worker population and the brood quantity. The method consists in determining the number of combs that are occupied by workers, and the number of brood combs for each colony taken separately. Totally, we effected 16,800 observations in the field. The sum of these observations allowed us to evince the critical periods, due to the environment influence on the yearly biologic cycle development of the Tunisian honeybee.

B) Swarming techniques. The object of having a stable stock doesn't hinder normalizing an apiary, by systematically supressing the weakest colonies. This policy is completed by that of multiplying colonies by artificial swarming, so as the stock be restored. Different swarming techniques were used, in different moments of the spring season.

B-1) Artificial swarming is realized, starting from colonies with strong population. Three brood frames are taken from each colony (at least one of them has to contain unoperculated brood, in the case there already is a queen), and a comb with supplies, from the end of the hive. As they are taken out of the hive, each brood comb is to be shaken, for driving bees away, and then placed in an empty eke, that, after that, must be placed over the hive body, after a queen excluder is previously placed between them. The next day, the four combs completely covered by bees, are to be taken out, one by one, and placed in the same order, in a Langstroth nucleus for five or six frames. The free space in the nucleus has to be completed with already built combs. For avoiding the foragers to go back to their hive of origin, the new colony has to be moved at least three kilometers away of the mother-hive.

B-2) Fan swarming: a strong, well-populated colony, is divided in two equal parts, concerning both the brood, and the supplies and the pollen, without taking into account the queen. All combs should be placed back in the initial order into other two hives, at the same time reconstructing the brood nest, surrounded by supplies. The two new hives should be placed on both sides of the old hive entrance. The mother-colony doesn't exist any more, but it is replaced by the two daughter-colonies, that are to be made stronger by workers of the mother-hive. The two new colonies have brood, but only one of them has a queen, the other having to rear a new one. The one that already has a queen, shall re-establish faster. Nevertheless, sometimes it happens both colonies to become queenless.

B-3) Multiple swarming is, in fact, a variant of the fan-swarming, mentioned above.It is practised on a double, very strong, colony, with a population large enough, that has become queenless following an accident, and where there could be queen-cells. This colony should be equally divided into five nuclei. These five nuclei are to contain four combs each, of them two of brood, and, possibly, a queen-cell. The five nuclei are to be disposed as a fan, round the place formerly occupied by the mother-hive, so as the foragers to be retrieved.

In all cases of swarming, a bee colony that completely fills the nucleus, and the free spaces between frames, is compulsorily being translocated into a ten-frames hive, for avoiding any possibility of natural swarming.

C) When there are laying workers. The laying workers most frequently lay several eggs in a worker cell. In the same comb area, their brood is scattered, and of very different ages. Besides, the brood that results from these unfecundated eggs is exclusively male. For bringing back to normal a colony with laying workers, an egg-laying queen, or a queen-cell should be introduced, and, for this, the colony must be disorganized. The laying-workers colony should be moved a few meters away of the old place, where an empty hive is to be placed. Into the empty hive, a young brood comb is placed, as well as an operculated brood comb, and a supplies comb. Then, the laying-worker colony is well shaken, and, in this manner, the shaken bees will returnto the hive on the old place, while the laying workers, whose abdomens are heavied by their ovules, could't fly, and thus not enter the new hive.

Results and discussion

A) The rhythm of the main honey plants blossoming

The Tunisian bee is well adapted to the climatic conditions, and the characteristics of the local vegetation. The mild climate, with average temperatures around 10 °C in winter, and 30 °C in summer, and with a rich enough honey flora, allow for bees to forage nearly all year long. Nature has the only really operational calendar for managing bee colonies. Beginning with the blossoming calendar of the main honey plants (see Table I), we can elaborate the calendar of the main nectar flows during a year in Tunisia, of course according to the area where the apiary is placed, and the nectar flow area. So, in Tunisia, the beekeeper benefits generally of two consistent nectar flows every year. The first nectar flow, known as the spring flow, is that from the orange blossoms, that is realized in the Citrus orchards at the Cape Bon. The second one, is the summer flow, mainly realized in the forest massifs in Tunisia, being thus a nectar flow from thyme, or from *Eucalyptus camaldeus*. Some beekeepers began orienting themselves towards the sunflower nectar flow, but so far this is not usual in the conditions of Tunisia, as in this country the cultivation of this crop on an industrial scale is only practised for a short time. Since the end of July, and practically during all the month of August, the bee activity is almost nil, this period being one of scarcity, because of the inexistance of any nectar flow following the adverse atmospheric conditions (there are days in a row when the simoon blows, and the outer temperatures ascend to over 45 °C. In September, the resuming of the bee activity is to be noticed, in the areas covered by forests of *Eucalyptus gonfocephala*, in October there starts the foraging on heather, and then, on rosemary, depending on the regions. Starting in January up to March, a large gamut of honey and pollen fruit trees begin blossoming: almond, apricot, peach, pear, apple trees, that would help the bee colonies gradually to get out of the winter drowsiness. Turning to account these new sources of honey and pollen, the brood will begin developing. All these resources are mainly used for developing the bee colony. This calendar is, certainly, far from being complete, but it nevertheless allows fore stablishing a correlation among the different stages of the yearly cycle of bees, the main tasks to be done in the apiary, and the mass blossoming of the different honey plants in the area.

Table I

Calendar of blossoming in the main honey species in Tunisia

August	September	October	November	December	January	February	March	April	May	June	July
	Eucalyptus gonfocephala										
						Peach tree					
							Pear-Apple				
				Heather							
					Rosemary						
						Lavender					
						Almond - Abricot					
								Citrus			
								Foeniculum spp			
								Cumin			
								Coriander			
										Sunflower	
									Opuntia		
										Thyme	
										Eucalyptus camaldeus	

B) The biologic yearly cycle of the Tunisian bee

The number of the bee population and the quantity of brood in a hive represent what we commonly call the colony strongness, that consequently is estimated by means of the number of combs covered by worker bees, and of that of brood combs. If we are graphically representing the monthly averages of the number of bee-covered combs for each month of the five years of the experiment, we'll obtain unimodal histograms, very close to each other, and consistent for the different years (Fig. 1). Superposing these results (Fig. 2) confirms the perfect concordance, in the five years, of the five developing curves of the bee colonies.

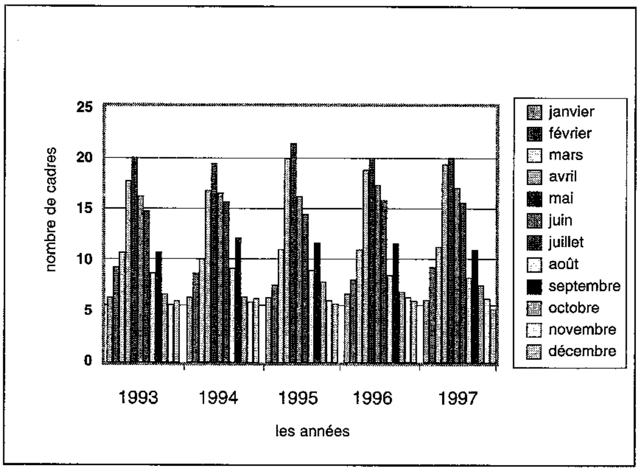

Fig. 1 - Diagram of the five yearly successive developing cycles in Apis mellifica intermissa
On the abscissa: years, months; on the ordinate: number of combs

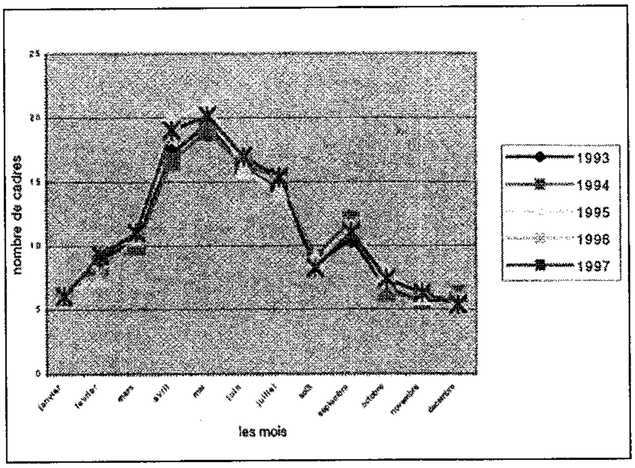

Fig. 2 - Comparative evolution of the developing cycle in Apis mellifica intermissa, *in the five years of the experiment*
On the abscissa: months; on the ordinate: number of combs

We performed a variance analysis with two factors, for rendering obvious the effect of months and years on the developing cycle of the local bee. The variance analysis confirmed the homogeneity of the variance among years (F_{obs} = 1.85 < F4; 44; 0.01 = 2.58). There were recorded no significant differences among years as concerns the developing cycle of the bee colonies. On the contrary, the difference is very significant among the various months of the same year. After verifying the variance homogeneity among the years, we could establish a monthly average of the number of combs covered by bees, and of the brood combs (Table II). The graphic representation of the monthly averages of the bee-covered combs, and of the brood combs, consists in two nearly parallel curves (Fig. 3), that show clearly the development of the worker population, as well as the developing cycle of the brood, in the *Apis mellifica intermissa* bees, that are in a equilibrium balance with their environment, during all year.

Table II

Average monthly number of bee-covered combs, and of brood combs per hive, during a whole year

Month	Ja.	Fe.	Ma.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Bee covered combs	6.2	8.4	10.6	18.2	19.9	16.4	15.0	8.6	11.3	7.0	6.0	5.7
Brood combs	4.0	6.0	9.0	16.0	14.0	10.0	8.2	4.4	7.0	3.6	3.5	3.3

As concerns the developing rhythm of the brood, the Tunisian honeybee is characterized by the absence of a winter rest period, as the queen does not cease definitely its egglaying, although it is notably slowed down during winter. The average number of the brood combs, in the Tunisian honeybee, is of 3.5 combs in November, 3.3, in December, and 4, in January. At the beginning of the spring, and at the same time the first flowers are appearing, the queen resumes its normal egglaying activity, what determines a rapid growing of the brood covered area, as an average six brood combs per hive in February, nine, in March, 16 combs, in April,

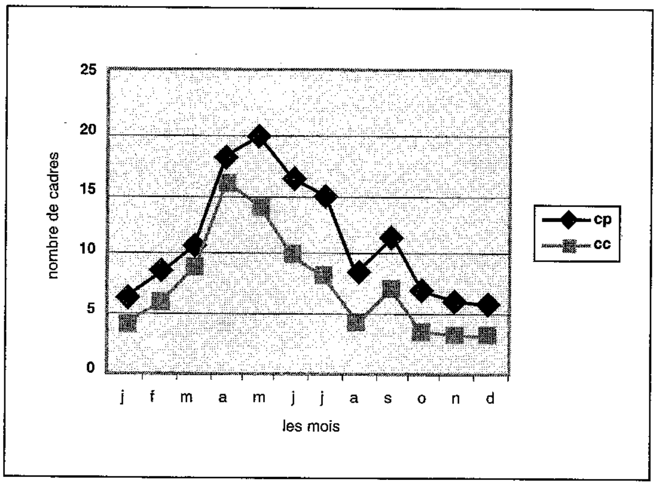

Fig. 3 - Evolution of the bee population, and of the brood, during a year (averages for the five years)
On the abscissa: months of the year; on the ordinate: number of combs (cp - black line with rhombs = bee-covered combs; cc - grey line with squares = brood combs)

and 14, in May. In summer, at the end of July and beginning of August, frequently a summer rest is recorded, owing to the high temperatures. First of all, the queen is constrained to restrict for some time its egglaying, and the brood area diminishes, getting again restricted in size, with a hive average of ten brood combs, in June, 8.2 combs, in July, and 4.4 combs, in August. The egglaying, and the brood rearing activity are resumed in September, and go on through mid-October, the average being of seven brood combs per hive in September, and 3.6 combs in October. This resuming of the activity coincides with the first autumn rains, the getting back to normal of the temperatures, and the reappearance of flowers.

The comparative representation of the monthly averages of the number of bees covered combs, and brood combs (Fig. 4) shows a regular evolution of the worker and brood population. Nevertheless, it can be noticed the distance between the two curves is practically negligible at the beginning of the beekeeping season, that is between January and April, a period during which the queen's egglaying ensures maintaining, and then increasing the population, whose acme is reached

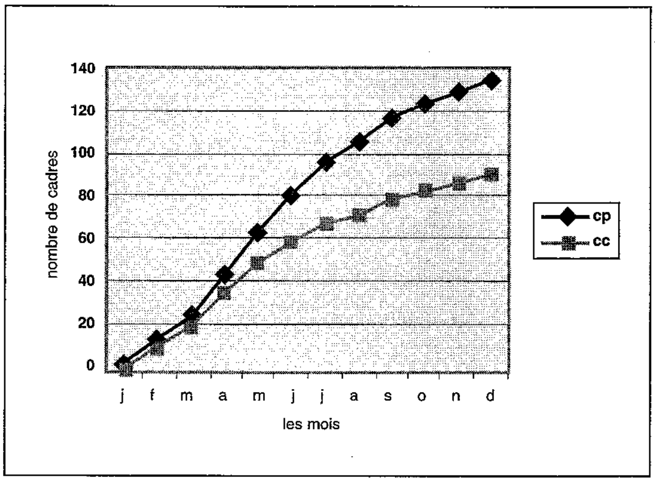

Fig. 4 – Evolution of the total number of bee covered combs and brood combs, during a year
On the abscissa – months of year, on the ordinate – number of combs.

in April. Beginning with the month of May, the distance between the curves becomes more and more marked, as this period corresponds to the spring nectar flow, followed then by the summer flow. In the same period, a blocking of the queen egglaying is also recorded in summer, when the climatic conditions become more difficult, and a scarcity of the honey sources becomes manifest. The whole of these data allow identifying four typical, neatly defined phases in the yearly biologic cycle of the *Apis mellifica intermissa* bee race in Tunisia, namely:

- the winter phase, which approximately extends from November to January. The bee activity is very scarce, and they only rarely get out of the hive. The colony lives on the reserves accumulated during the fine weather season, or that are supplied by the beekeeper, through the emergency feeding. Starting from January, especially during mild winters, the queen resumes its egglaying;
- the spring phase, that starts in February. The vegetable species, that are blossoming in spring, are represented mainly by the fruit trees, that offer to bees both nectar and pollen. Brood rearing intensifies itself, the colony enter the expansion phase, and the total stock tends to increase in numbers. Nevertheless, the bee activity is still restricted, because of the meteorologic conditions, sometimes adverse (abundant precipitations, and temperatures below 10 °C). The months of April and May correspond to the spring nectar flow, as it is the period of maximum blossoming of the Citric species. The weight increase of the hives can be noticeable. The brood quantity reaches its maximum level. Starting with the end of May, that is, after the spring flow, and before the summer one, a period of relative scarcity is recorded, that bees go beyond by going and visiting the *Opuntia* flowers, that are well spread in Tunisia;
- the summer phase starts in June, and lasts until the end of August. In June, there begins the summer flow, together with the blossoming of *Eucalyptus camaldeus* forests, and the bulky one of thyme, as well. The weight of the hives increases considerably, and the activity of the colony is maintained at the maximum level, up to harvesting the summer output, at the end of July. At the beginning of August, the colony enters a regression phase, and the queen shows a tendency of blocking its egglaying because of the adverse climatic conditions, as the outer temperatures can reach 45° to 48 °C in the shade. Besides, the honey flora is practically missing during all that period;
- the fall phase extends along the months of September and October. During that period, in certain areas the resuming of the nectar and pollen forage can be noticed, thanks to the blossoming of *Eucalyptus gonfocephala* forests, of heather, and, later on, of the rosemary. Generally, the weight of hives increases considerably, as well as the brood quantity. In the good years, an autumn harvest of honey of *Eucalyptus gonfocephala*, heather, or rosemary can be obtained, but, as a rule, the most of the foraging would be stored in the combs, to be used during winter.

C) Spring manipulations

C-1) Introducing building frames with comb foundations, and drawn-out combs

All beekeepers know that, for obtaining in a short time strong populations of bees, it is recommendable to help the queen to extend its egglaying by widening the brood nest. Introducing the comb foundations, to be further built, beginning with the end of winter, allows the building colonies to develop better than the others, and be more dynamic. At the beginning of spring, bees start building beautiful and very regular combs, provided they have good conditions for it. Once the first comb is built, a second one can be added, then a third, and so on. Nevertheless, as the spring development of the colony is not optimal, extending the nest can be achieved by introducing built combs.

In the mild winters, the comb foundations can be introduced as early as January (Fig. 5).

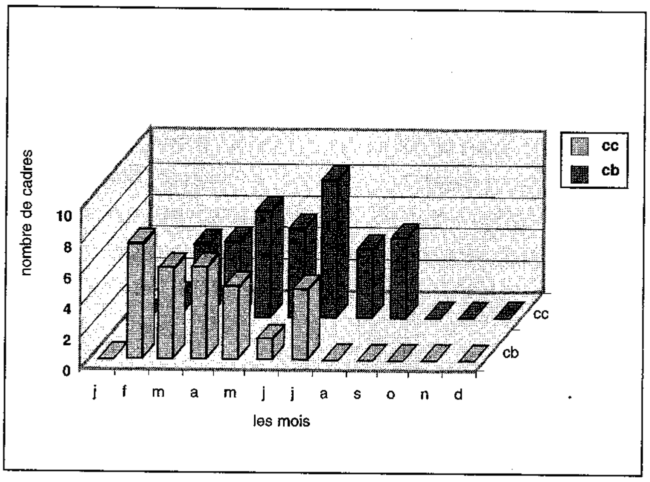

Fig. 5 - Introducing comb foundations (light colour columns), and drawn-out combs (dark colour columns)
On the abscissa: months of the year; on the ordinate - number of combs

Nevertheless, the colony development starts effectively in February, gradually, according to the needs of the colony. This development phase (both bees and brood) is the logical consequence of the nest extension. Starting with March, in the case of the strong colonies, and when the climatic conditions and the blossoming stage are propitious, the beekeeper has to place the honey supers for honey, all combs being provided with foundations. By building the combs - placing these supers extends the space that later shall be used for storing the honey yield. In the conditions of Tunisia, from January till July, there are many chances the local bee to build correctly combs, that it fills later on either with brood or with honey. Notwithstanding, beginning with the end of July (immediately after extracting the summer yield), the colony enters a stagnation phase, the queen egglaying is diminished, the nectar sources are scarcer, and less are the chances of the bees building on the introduced foundations. On the other hand, introducing drawn-out combs is made mainly during the main flows, or when the colony development is optimal. In these situations, for increasing the nest, drawn-out combs are to be introduced. The graphic representation of the drawn-out combs introduction process, as well as of those built during a year (Fig. 6) points to the fact that more artificial combs are used during the period from January to June (which corresponds to the start of the colony developing, and the spring flow appearing). Starting from July (summer flow), the number of the drawn-out combs used is larger, and this increase of their number (as compared to that of the artificial ones) is more marked in September, when the first autumn rains appear, when the queen's egglaying is resumed, and in nature many honey species start blossoming.

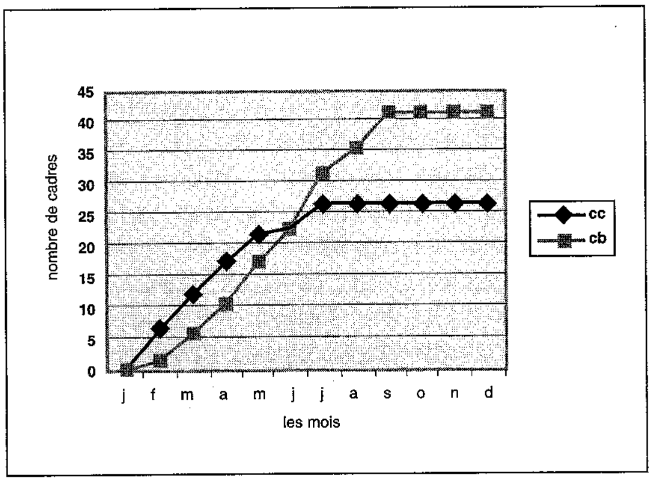

Fig. 6 - Evolution of the total to the date number of artificial combs (black line, with rhombs), and the number of drawn-out combs (grey line, with squares), during a year.

C-2) Swarming techniques

Swarming is often related to the bee colony reproduction. The process has a seasonal rhythm, meant to ensure in optimal conditions the survival of the species. In Tunisia, bee colonies multiplication in natural conditions, reaches its highest level in March - April. Nevertheless, in the mild winter years, good results can be obtained, by practising swarming as early as February. In both cases, swarms are developing well. These results are mirrored in the average percentage of succesfull swarms, that are to develop normally, obtained, on one hand, by the early swarming, made as early as February, and, on the other hand, by the late swarming, made during March and April. The successful swarms rate was 78.4%, and 80%, respectively, the general average being 79.2% of successful swarms. From the Fig. 7, it results 22.2% of the early swarms took part in the spring flow bee for

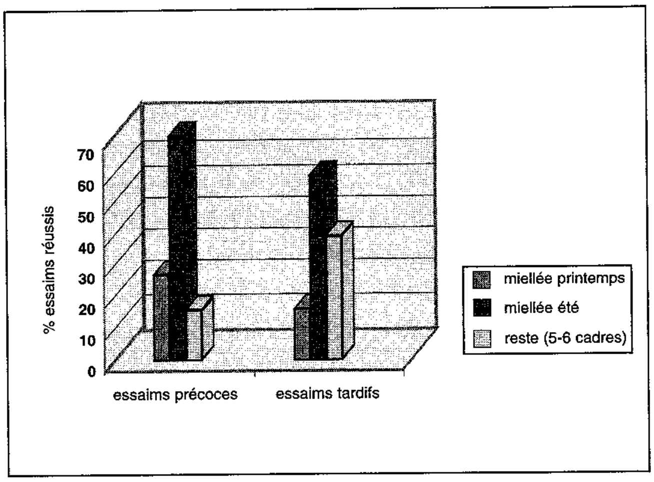

Fig 7- Rate of early and late swarms taking part in the honey flows during one year.
On the abscissa: left – early swarms; right – late swarms; on the ordinate: proportion of successful swarms;
☐ spring foraging; ■ summer foraging; ☐ remainder (5-6 frames)

age, as compared to only 12.2% of the late ones; 66.6% of the early swarms took part in the summer flow bee forage, as compared to 53.6% of the late ones; and only 11.2% of the early swarms, as compared to 34.2% of the late ones, will remain in the developing stage of five or six bee covered combs, these colonies wintering without having taken part in achieving some production that year. The value of squared χ excludes the nil hypothesis, and demonstrates the dependence between the nectar flow and the swarming period, which is fully confirming the opinion that the swarming period exerts an influence upon the bee forage.

During the successive five years of bee colonies supervising, and of artificial swarming practising in *Apis mellifica intermissa*, we achieved an yearly swarming rate of 29.4%, and a rate of successful swarms of 79.3% (Fig. 8).

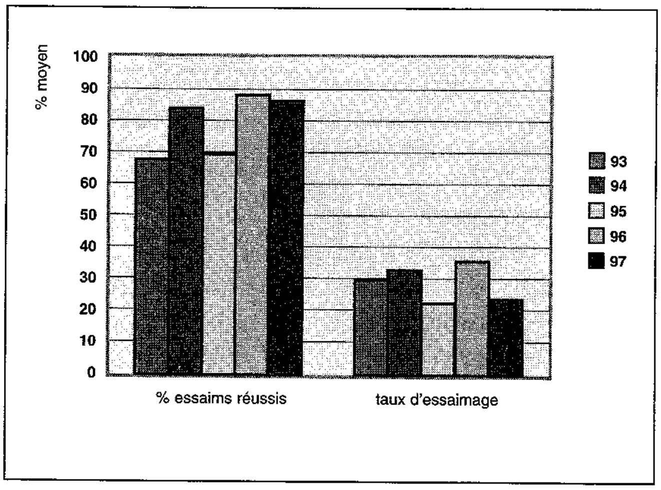

Fig. 8 - Swarming rate, and the successful swarms percentage (averages for the five years).
On the abscissa: left - % of successful swarms; right - swarming rate; on the ordinate - average %.
The five columns correspond to the five years of the experiment.

The swarming tendency has an hereditary character. According to RUTTNER (1988), the swarming rate in the black bee, *Apis mellifica mellifica*, is below 20%. In *Apis mellifica intermissa*, known as a swarming race, for the five years of observations there was found an average swarming rate of 29.4%. That rate is acceptable, and varies from an year to another, being possible to lower it through a whole series of co-ordinated activities, that are applied during the spring season.

If we are to refer ourselves to the three swarming types practised in the apiary, we verify that, during the five years of the experiment, the fan swarming (and the multiple one, inclusively) has gradually acquired an increasing share, as compared to the artificial swarming (see Table III).

Table III

Evolution of the artificial and fan swarming, during the five years of the experiment

Year	Artificial swarming (%)	Fan swarming (%)
1993	89.1	10.9
1994	75	25
1995	69.1	30.9
1996	59.3	40.7
1997	50	50
Average	68.5	31.5

We achieved a two factor variance analysis, for better emphasising a possible difference between years, as well as within the same year, among the different types of swarming practised (artificial swarming, fan swarming, and multiple swarming). The variance analysis confirmed the homogeneity of the variances among years (Fobs = 1.2 < F4; 4; 0.01 = 6.39); no significant difference was recorded among years, as concerned the different swarming types. The analysis also confirmed the homogeneity of variances within the same year (Fobs = 0.2 < F1; 4; 0.01 = 7.71); during the same year, there were recorded no significant differences as concerned the success percentage of the different swarming types. Owing to this fact, we could calculate an average for the five years: the average success percentages were 82%, for the artificial swarming, 81.4%, for the fan swarming, and 74.5%, for the multiple swarming.

Appearance of laying workers is an important phenomenon within the social organization of bees (NOETIMA, 1997). It is ascertained that, from this point of view, there are significant differences among the bee races. The phenomenon is measured by means of the interval lapsed between the moment the colony loses its queen, and the moment the workers begin laying eggs (i.e., the period of latence). This latence period varies: 5.6 days in *Apis mellifica intermissa*, 6.5 days in *Apis mellifica capensis*, 9.5 days in *Apis mellifica scutellata*, 16 days in *Apis mellifica adami*, 22.3 days in *Apis mellifica mellifica*, 27.3 days in *Apis mellifica ligustica*, and 30 days in *Apis mellifica carnica* (RUTTNER, 1988). There can be noticed the African bee races have a shorter latence period, as compared to the European races. As we came across this problem, of laying workers, during the five years of observation, we thought to try and retrieve those bee colonies, as they were commonly strong enough the moment the were dequeened. Actually, the phenomenon is often met during spring, and is due to several factors: the swarming character of the race, their relative aggresivity during interventions into the colony, etc., what determines the accidental loss of queens, and thus, transforms the orphan colony into a laying workers one. The average rate of success for the five years, was 75%, or, in other words, out of ten colonies, seven or eight are retrieved, and go back to normal, having fecundated queens. This result is very good, and it made us intervene, anytime is was possible, for saving the laying worker colonies.

Conclusions

Apis mellifica intermissa is a race endowed with a great capacity of adapting, and a great vitality, too, that allow the beekeeper, that possesses a good knowledge about the local bee, and masters the necessary techniques, to correctly manage its apiary, and avoid annoying surprises, thus succeeding in reaching the best results from bee colonies, that are well known as belonging to a swarming and aggressive race.

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