

## PERFORMANCE OF AFRICANIZED WORKERS BEES, *APIS MELLIFERA* HIVES AND PROPOLIS PRODUCTIVITY, TOTAL AND BY PARTS OF THE BOX, EVALUATED BY FOUR TECHNIQUES OF PRODUCTION IN THE FOUR SEASONS OF THE YEAR

Lucimar PERES DE MOURA PONTARA<sup>1</sup>, Regina Helena NOGUEIRA COUTO<sup>2</sup>, V. BETT<sup>1</sup>, M.R. NANNI<sup>1</sup>, Selma Lucy FRANCO<sup>1</sup>, F. DO LAGO RAMOS<sup>1</sup>, R. ALVAREZ<sup>1</sup>

<sup>1</sup>Universidade Estadual de Maringá, Av. Colombo, 5790, 87020-900, Maringá, BRAZIL, E-mail: pontara@wnet.com.br

<sup>2</sup>Universidade Estadual Paulista, Câmpus de Jaboticabal, Via de Acesso Prof. Paulo D. Castelane, s/n, 14884-90, Jaboticabal, BRAZIL

### Introduction

The propolis has been investigated in Brasil mainly for its medical features. BREYER (1996) have suggested that brazilian propolis, mostly in the South, is considered one of the best all over the world due its excellent quality pattern.

SAMPAIO (2000) considered the effective indexes in the economical market of propolis in 1999 about 49 ton of production by year and invoicing of R\$ 3.920.000,00/year, proving the development of the production level to 15% to the pharmaceutical industry, 10% to pharmacies and 75% to exportation.

The quantity of propolis collected by bees has the average sited in the genetic origin, seasons of the year and area (GHISALBERTI, 1979; CRANE, 1990). There are some doubts about whose species have more production of propolis. Some authors attribute this ability to *Apis mellifera caucasica* bees (MOBUS, 1972).

The selection of bees for propolis production was made with success by MANRIQUE and SOARES (2000). They obtained selected hives representing major production and propolis presenting more contents of flavonoids.

According to BANSKOTA et al. (1998), *Baccharis* sp. and *Araucaria heterofila* probably are the major sources of brazilian propolis resins. The propolis presents a complex composition, with flavonoids, which give several activities concerning to the natural immune response and antibacterial activity (BANKOVA et al., 1995; SFORCIN, 1996; SCHELLER et al., 1999)

The propolis productivity is not much studied. In some studies we can find an important mention of the works of PROST-JEAN (1985), PIDEK (1987), IANNUZZI (1993), BREYER (1995), ADOMAR (1996), GARCIA et al. (1997), ALMEIDA et al. (2000), BRIGHENTI and GUIMARÃES (2000), MANRIQUE and SOARES (2000), MOURA et al. (2000), PONTARA et al. (2001).

According to BREYER (2000), the continuous development of research on the investigation of the complex composition of propolis and its application day by day updated in products to human and animal purposes, associated with the marked demands in qualification, have made changes in the application and development of more specialized techniques in the production area.

The goal of this work was to evaluate the production of propolis of africanized *Appis mellifera* bees submitted to four techniques of collection inducing the propolis production in different periods of the year, in the parts of the hive and the total production in 500 days. It was evaluated the correlation of production on feed area, offspring, extra and total, as well the conditions of internal and external maximal and minimal temperatures, relative air moisture maximal and minimal and precipitation.

### Material and Methods

The experiment was conducted in the Apicultural Sector of the Zootechny Department of the State University of Maringá – PR, Brazil in Northeast region of Parana State in an altitude of 542 m and geographical coordinates of 23°25' of latitude South and 51°57' of longitude West from the period of January of 1998 to May 1999. The regional climate is tropical temperate, presenting rainy summers and dry winters. The average in the temperature of the region in the last 19 years was 22,9 °C and pluvial precipitation averaged 1607,6 mm, according to information of the Centro de Meteorologia da UEM (Meteorological Centre at UEM). There were four adaptations to the Langstroth model to propolis production, producing a pattern in the techniques of collection of propolis such as: T1= glass (plaques of transparent glass close to the internal and lateral walls, near the little boxes 1 and 10); T2=Scraping (BREYER, 1995); T3= Intelligent Propolis Collector or CPI=the lateral parts were substituted by mobile slats according to ADOMAR (1996) and T4=Control, with one unique collection in the end of the experiment (BREYER, 1995). To study partial and totally periods, the propolis was collected by techniques T1, T2 and T3, in the last day of the periods I = 12/01 to 23/04/98 (Summer/Fall), II = 24/04 to 27/08/98 (Fall/Winter), III =28/08/98 to 21/01/99 (Winter/Spring/Summer) and IV=22/01 to 27/05/99 (Summer/Fall).

In the beginning of each period, every box of the three techniques was substituted in the same day by free propolis boxes, took to the laboratory to propolis collection of the following parts and the little boxes

were collected in field. The global production (500 days) of propolis was summed individually to the productions of the techniques T1, T2 and T3, in the periods I, II, III, IV and compared to the control technique, making the collection only in the last period (IV). To determinate the internal areas of the hives (food, offspring, extra and total) in each period, a mapping was made using the modified method of FREIRE (1997) and adapting to the geographical information system (ASSUNÇÃO et al., 1990) together with the program named Sistema de Processamento de Informações Geocodificadas – SPRING (INPE, 1999), developed by the Instituto Nacional de Pesquisas Espaciais - INPE. This proceeding summed 2000 drawing honeycombs and the number of hexagons containing pollen found in other different areas were included in the counting and noticed, according COUTO (1991), where each 4 cm<sup>2</sup> square was considered as an average of 13 cells. The area obtained was reduced by the place where it was included and added to the pollen class. It was established a data bank whose concept of structure presented one category only (thematic) with thirteen classes. The internal maximal and minimal temperature of the boxes were collected weekly, and daily they observed the external climatic conditions according to the Meteorological Centre at FEI/UEM the experiment were developed in a randomised way using four techniques of propolis collection and five repetitions totalising 20 hives. The studies of partial and total production in the periods of I, II, III and IV were developed in a subdivided parcel strategy. The statistical analysis was made using the GLM proceeding (Sas, 1996), where mean were compared to Tukey Test (P<0,05).

## Results and Discussion

There was a significant difference to the technique of propolis collection (T), period (P) and to the technique interaction X period (TP) and presented effect of the period of the year (Table I). In the periods I (P<0,05) and II (P<0,01) the CPI results in a bigger production related on other techniques (Table II and Figure 1) and in the periods III and IV, this technique was equivalent to the others. During colder periods, oscillating of 4,05° and 25,00°C, the CPI was superior, probably because the bees were stimulated to produce more propolis to keep the temperature stable (homeotherm). It is interesting to observe that less production of T3 (187,50g) obtained in the period II was 12,61%, superior to the bigger production observed in other two techniques which were obtained in T1 (166,5 g) in the period IV. The productivity of propolis in the three techniques was conducted in a similar behaviour, where CPI was superior in every period, including 171,8% superior to the technique of scraping (Figure 1).

Table I

Values of F and coefficient of variation of propolis productions (g) of africanized *Apis mellifera* hives submitted by three techniques and four periods

Statistics	Propolis production
F to techniques (T)	39,15**
F to Period (P)	14,19**
F to interaction (TP)	4,33**
CV parcel (%)	28,50
CV sub-parcel (%)	40,56

\*\* - Significance to 1% of probability

When is established a comparison of CPI and average production of the other two techniques statistically similar (Table II), the superiority was 151,45%. Garcia et al. (1997) noticed a superiority of 76,95% of CPI related on scraping during Spring. It was noted low productivity in every technique of propolis collection during Fall/Winter, although T3 (187,50g) presented 6,98 time superior of average of other techniques (26,85g), 6,92 times superior to the average of other techniques (26,85 g), including keeping the internal temperature of the hive.

Table II

Mean propolis productivity of propolis (g) in the hives of africanized *Apis mellifera* workers bees submitted to three techniques of collection in the periods I= Summer/Fall, II= Fall/Winter, III= Winter/Spring/Summer and IV= Summer/Fall

Period	Propolis Techniques of Collection						GENERAL	
	Glass		Scraping		CPI		Means	SD
	Means	SD	Means	SD	Means	SD		
I	126,90 bAB	69,72	133,06 bA	52,41	440,00 aA	70,51	219,56	156,90
II	31,20 bB	12,04	22,50 bB	9,28	187,50 aB	127,71	72,75	97,58
III	133,16 aA	46,19	121,40 aAB	21,72	224,93 aB	73,92	155,18	64,69
IV	166,50 aA	39,46	117,00 aAB	33,01	218,38 aB	69,47	163,64	60,74
GENERAL	114,44	67,08	98,49	54,66	267,70	130,70	152,78	112,67

Means followed by different letters, case ones in the lines and capital ones in the column, present a difference by the test of Tukey (P<.05). I = 01/12 a 04/23/98, II = 04/24 a 08/27/98, III = 08/28/98 a 01/21/99 e IV = 01/22 a 05/27/99.

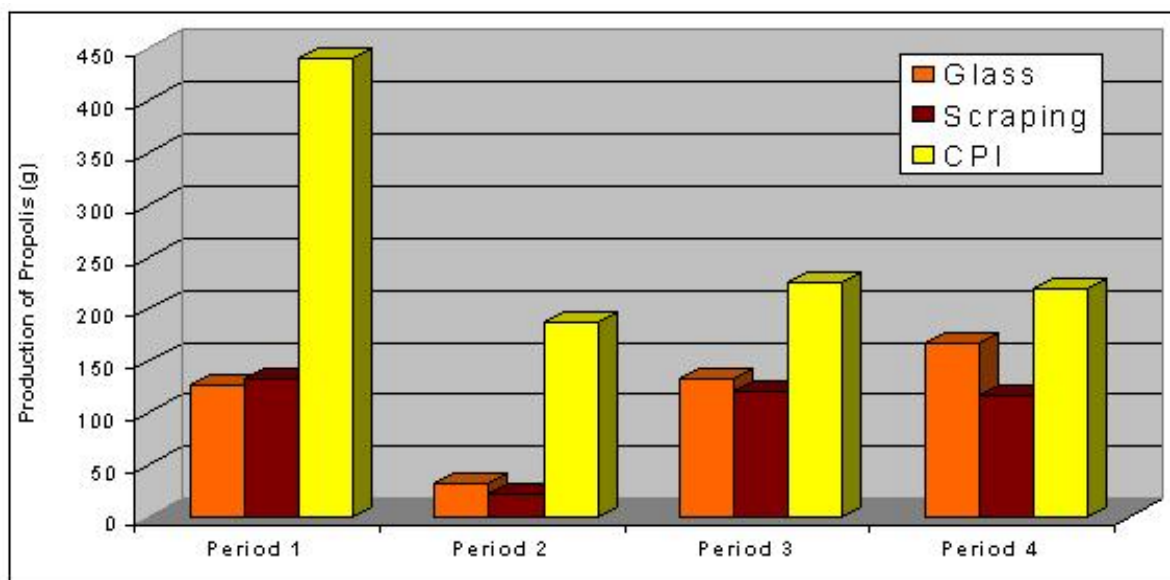


Figure 1 - Means of propolis productivity in three techniques of collection (glass, scraping and CPI) in the periods I=01/12 to 04/23/98 (Summer/Fall), II=04/24 to 08/27/98 (Fall/Winter), III=08/28/98 to 01/21/99 (Winter/Spring/Summer) and IV=01/22 to 05/27/99(Summer/Fall)

The best productivity of propolis in the region of Maringá – Pr (South of Brazil), was obtained in the hottest period of the year (19,71° e 31,0°C), agreeing with the studies of MANRIQUE and SOARES (2000) in the State of São Paulo and BREYER (2000) in the State of Paraná, who consider as the most productive period of propolis from January to April, although during the following months of May, June and July it was related a decrease of 66,64; 20,26 and 13,10%, respectively, of the similar behaviour to this experiment. The average production of propolis in the period II (80,4 g) was 65,54% inferior to the period I, 49,70% inferior to the period III and 51,94% inferior to the period IV (Figure 1).

The analysis of variance of production in different parts of the hive, presented a significant difference to the techniques, in a level of 5% of probability to bottom and little box, and in a level of 1% to cover and wall. To the period it presented a significant difference (P<0,01) to alvado, cover, wall and little box. To interaction between techniques and periods, it was presented a significant difference (P<0,05) to hole and wall, and in a level of 1%, to the cover (Table III).

Table III

Values of F and coefficient of variation of propolis production in parts of africanized *Apis mellifera* hives submitted by three techniques and four periods

Statistics	Hole	Bottom	Cover	Wall	Little box
F to techniques	1,73	4,80*	15,27**	23,39**	6,23*
F to period	10,04**	1,22	9,56**	6,47**	15,81**
F to interaction	2,69*	1,10	6,12**	2,37*	1,53
CV parcel (%)	96,77	39,26	33,29	87,49	45,10
CV sub parcel (%)	95,81	64,63	46,46	71,35	66,33

\* - Significance at 5% of probability / \*\* - significance at 1% of probability

MOURA et al. (2000) made an evaluation to a global average of propolis productivity collected in the hole (14,88 g), bottom of the hive (13,72 g), cover (18,63 g), little box of the nest (10,97 g), little box of honey deposition (17,23 g), in the honey deposition (20,78 g) and total (98,63 g), in the Summer, did not present significant differences (P>0,05). There was a significant difference in the test F, related on propolis collected in the nest (P=0,0249).

Table IV

**Means propolis production (g) of the parts of wall, hole and cover referred to the africanized *Apis mellifera* hives submitted to three techniques of collection in the periods of I = Summer/Fall, II = Fall/Winter, III = Winter/Spring/Summer and IV = Summer/Fall**

Periods	Techniques					
	Glass		Scraping		CPI	
	Means	SD	Means	SD	Means	SD
----- Wall -----						
I	37,80bA	59,98	53,90bA	57,38	271,50aA	79,38
II	0,00aA	0,00	0,00aA	0,00	93,60aB	31,47
III	56,87aA	17,87	47,72aA	16,40	135,30aB	35,58
IV	52,00abA	22,36	36,90bA	14,19	157,10aB	41,09
----- Hole -----						
I	14,90aB	12,22	21,40aA	14,49	25,20aA	21,57
II	4,50aB	10,06	0,00aA	0,00	0,00aB	0,00
III	8,52aB	9,08	9,54aA	6,62	6,05aAB	13,54
IV	41,10aA	20,24	22,25abA	14,24	7,60bAB	10,43
----- Cover -----						
I	17,20bAB	6,88	27,50bA	10,47	63,10aA	9,55
II	9,90aB	4,80	12,10aA	6,57	22,63aB	9,73
III	26,30aA	9,57	21,45aA	7,56	19,07aB	5,64
IV	24,40aAB	5,17	17,20aA	4,38	23,50aB	9,19

Different letters, referred to the same part of the hive, case letters in the lines and capital letters in the columns, present difference by the Tukey Test (P<0.05)  
 I = Summer/Fall, II = Fall/Winter, III = Winter/Spring/Summer and IV = Summer/Fall

Unfolding grades of liberty of interaction to hole, cover and wall is showed in the Table IV. In the techniques, the propolis production in the wall of CPI was 618,25% superior (P<0,05) than glass and 403,71% the scraping in the period I. GARCIA et al. (1997) observed during the spring, equivalence to the period III of this experiment, and superiority of CPI in 315,45% when compared to scraping.

Related to the values of F to the period, the areas referred to food (AAL), extra (AE) and total (AT) studied in this experiment, with values of 3,60, 4,01 and 6,55 respectively, and the offspring area (AC) with 2,64, showed difference (P<0,05) to the interaction between techniques and the periods (TP).

The averaged value of three techniques of propolis collection related on the food area (Table V) presented its bigger average (9489,812 cm<sup>2</sup>) during the period of summer/fall, gradually decreasing until reach the lower average value (5353,544 cm<sup>2</sup>) in the period of summer/fall/99 (P<0,05). A not significant reversal tendency (P<0,05) in the offspring area happened. This behaviour was expected since the bigger offspring area, bigger the food consumption.

Table V

**Means values of food, breeding, extra and total areas (cm<sup>2</sup>) of the africanized *Apis mellifera* hives, submitted to three techniques of collection and four periods.**

Periods	Areas			
	Food	Breed	Extras	Total
I	9489,812 a	5781,171 a	8685,856 a	23955,840 a
II	8577,465 ab	7865,058 a	11559,867 ab	28002,389 ab
III	8344,310 ab	6728,610 a	15587,328 b	30660,246 b
IV	5353,544 b	8786,960 a	8550,378 b	22690,878 a

Means followed by different letters, same column, present difference by the Tukey Test (P<0,05).  
 I=01/12 at 04/23/98 (Summer/Fall), II=04/24 at 08/27/98 (Fall/Winter), III=08/28/98 at 01/21/99 (Winter/Spring/Summer), IV=01/22 at 05/27/99 (Summer/Fall).

Although the analysis of the variance on offspring area presents a significant difference (P=0,0316) to the interaction between techniques and periods (TP), the unfolding of the liberty grades did not showed any difference on level of 5% of probability. The difference observed was 7,58% (P= 0,0758) between techniques in the period of fall/winter. This condition makes 165,51% superior to the technique CPI (4191,19 cm<sup>2</sup>), the offspring area which used the scraping technique (11127,83 cm<sup>2</sup>) during the period of fall/winter the offspring area which used the technique of glass (8276,15 cm<sup>2</sup>) did not present difference related to the other ones.

In the period fall/winter the technique scraping obtained a food area 44,90% superior when compared to CPI (10019,18 and 6914,58 cm<sup>2</sup>, respectively), but the propolis production was 733,33% superior in CPI (CPI=187,5 and Scraping=22,5 g). The internal temperatures of boxes in two techniques

were kept constant (homeotherm) in this period. In the period of fall/winter/98, when external maximal and minimal and averaged temperatures were the smaller, it was not the size of the swarm the factor which influenced propolis production but the applied technique. Studying the correlation (Table VI) between propolis production and the controlled variables, it was observed a positive and significant coefficient of correlation of Pearson ( $P < 0,01$ ) to the following techniques T1 and T2, in the variable maximal and external temperature (MAEXT), presenting coefficients of 0,68022 and  $P = 0,010$  and 0,79206 and  $P = 0,0001$ , respectively. The same condition was observed to the external and minimal temperature (MINEXT), obtaining a coefficient of 0,65520 and  $P = 0,0017$  and 0,80850 and  $P = 0,0001$  respectively. The T2 obtained a significant coefficients of correlation to the external and minimal temperature (MININT) with values of 0,46172 and  $P = 0,0404$  and to the precipitation too (PREC) with 0,67574 and  $P = 0,0011$ . The technique which obtained the biggest and significant coefficients of correlation of Pearson was T3 and to it, the food area – AAL was of 0,63541 and  $P = 0,0082$ , MAXEXT – external and maximal temperature (0,54561  $P = 0,0288$ ), MINEXT – external and minimal temperature (0,57742 and  $P = 0,0192$ ), URAMAX – Maximal relative air moisture (0,56089 and  $P = 0,0238$ ), URAMIN – Relative air moisture and PREC - Precipitation (0,57519 and  $P = 0,0198$ ). By the study of correlation it was possible to observe that the production of propolis was more affected by the conditions of the environment than the grade of development of the colony, showed in the food area used, the coefficient of 0,063541 and  $P = 0,0082$ .

Table VI

**Correlation coefficient of Pearson between propolis production with the following variables: food, offspring, extra and total areas, maximal internal and minimal internal temperatures (°C), maximal and minimal relative air moisture (%) and precipitation by treatment**

Variables	Techniques of propolis collection					
	Glass		Scraping		CPI	
	Coefficient	Probabil.	Coefficient	Probabil.	Coefficient	Probabil.
AAL	0,25699	0,2740	-0,08874	0,7099	0,63541	0,0082**
AC	-0,01597	0,9467	-0,31917	0,1702	-0,11084	0,6828
AE	-0,13630	0,5667	0,18219	0,4420	-0,31492	0,2348
AT	0,01602	0,9465	-0,09147	0,7013	-0,11886	0,6611
MAXINT	0,08096	0,7344	0,37427	0,1040	0,10223	0,7064
MININT	0,39398	0,0856	0,46172	0,0404*	0,28728	0,2807
MAXEXT	0,68022	0,0010**	0,79206	0,0001**	0,54561	0,0288*
MINEXT	0,65520	0,0017**	0,80850	0,0001**	0,57742	0,0192*
URAMAX	-0,24950	0,2888	-0,10229	0,6678	0,56089	0,0238*
URAMIN	-0,42307	0,0631	-0,16383	0,4901	0,51548	0,0410*
PREC	0,39778	0,0824	0,67574	0,0011**	0,57519	0,0198*

\* - Significance at 5% of probability - \*\* - significance at 1% of probability

Related to the value of F, coefficient of variation and the average test to total propolis production during the period from 12/1/98 to 27/05/99 in four techniques of collection, the use of the technique CPI (T3) generated a significantly superior propolis production ( $1070,79 \pm 108,77g$ ) ( $P < 0,01$ ) to the techniques of glass (T1), scraping (T2) and control (T4), which obtained total production of  $457,74 \pm 75,42g$ ,  $393,93 \pm 78,94g$  and  $340 \pm 111,79g$ , respectively to the period of 500 days.

The values to total propolis production by technique, corrected to 365 days were 334,15g, 287,57g, 781,68g and 248,71g to T1, T2, T3 e T4, respectively.

The total average productivity of propolis in the four techniques tested during the period of 500 days is presented in the Figure 2. The averages of total production of propolis obtained in the technique T1 (334,15 g/year), T2 (287,57 g/year) and T4 (248,71 g/year) were close to the cited values by PROST-JEAN (1985), who obtained 300g/hive/year.

The productivity of T3 of 781,68g/hive/year obtained in this experiment, agrees with the results of BREYER (1995) who registered an average production of 700 g/hive/year and the results of CONAP (1996) too, which presented an average of 700 g/hive/year. GARCIA et al. (1997) showed hives productivity adapted from the conventional patterns Langstroth, named Collector of Intelligent propolis (CPI), which produced in only two seasons values of 560 g on average. The smallest productivity was of 228,50 g/hives/year and the biggest one was 1231,80 g/hive/year, an inferior number in 69,20% of the reported values by ADOMAR (1996), who showed 4,0 kg/hive/year. It was noticed between techniques and in the same technique the great heterogeneity of response to productivity, confirming the results of PIDEK (1987) who obtained results of propolis collection in four hives of 6,4g, 16,6g, 7,2g and 77,4g.

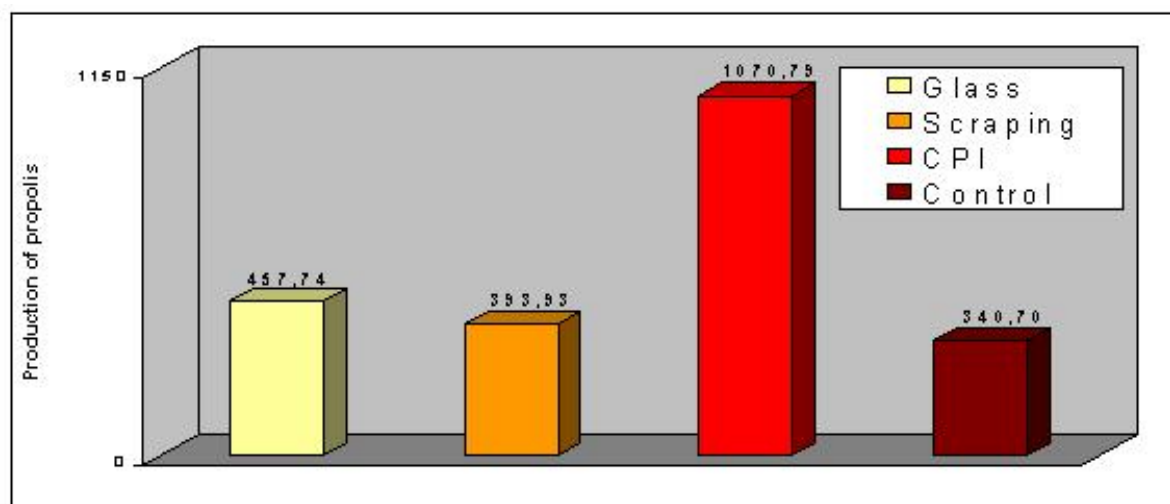


Figure 2 - Total propolis production means of africanized *Apis mellifera* hives submitted to four techniques of collection in the period from 12/01/1998 to 27/05/1999

## Conclusion

The results found in this experiment showed superiority in technique CPI, related on the other treatments.

The propolis production is more affected by the conditions of the environment than by the grade of development of the colony and the biggest productivity in experimental conditions occurred during the hottest periods and smaller productivity during the colder periods.

During the colder periods, the CPI produced more propolis than the other treatments, in comparison to offspring and food areas and it was superior concerning production.

The technique of propolis collection and the period of the year interfered in the propolis deposition in different parts of the box such as the alvado, bottom, cover, wall and little box.

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