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Breeding honey bees for resistance to *Varroa jacobsoni*: analysis of mite population dynamics

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INTRODUCTION

Understanding the population dynamics of *Varroa jacobsoni* is central to successful control of this honey-bee parasite. Studies on the reproductive ability of *Varroa* have been reported by Choi and Woo (1973), Dölker (1980), Ifantidis (1984), Koeniger and Schultz (1980) and Sulimanović *et al.* (1982). More recently, de Ruijter (pers. com.) has investigated the reproductive capabilities of mites repeatedly transfered from one cell to another.

Our overall objective is to investigate the possibility of producing honey-bee stocks that are resistant to *Varroa* through artificial selection. This approach represents one of the first such attempts (Kulinčević & Rinderer 1985), although others have mentioned such an idea (Ruttner & Marx 1984). Other similar efforts have been initiated in Germany (Drescher pers. com.) and Austria (Pechhacker pers. com.).

In this preliminary report we describe the population dynamics of this mite in worker brood of *Apis mellifera* colonies which may have some resistance to *Varroa*.

MATERIALS AND METHODS

Fourteen colonies of *Apis mellifera carnica*, were used in this study eleven of which were derived from daughters of queens from three colonies which had survived an initial *Varroa* infestation. This invasion caused the loss of most colonies in the apiaries from which the original queens were chosen. Due to this differential survival, it is possible that the original three queens and their progeny had some resistance to *Varroa*. The remaining three colonies were from general stock, and not as likely to have resistent characteristics.

Sealed worker brood (16–17 days old) from these colonies was examined to determine the number of females, males, immatures, and eggs in progeny cohorts. Samples were examined every two weeks from 28 June to 26 September 1985. Brood samples were standardized to contain 100 worker pupae with dark eyes and light brown abdominal chitin (Ifantidis 1984). Progeny of reproductive mite females were classified as mature daughters, mature males, immature stages and eggs. The same methods which Ifantidis (1984) applied were used for identification, except that brood was not frozen before examination.

To keep the infestation at an acceptable level in autumn of 1985, all colonies were treated twice with Varamit®, an acaricide product containing amitraz.

RESULTS

Based on the infestation level some colonies derived from queens suspected of being resistant to *Varroa* showed some evidence of resistance. In one colony (Fig. 1, colony

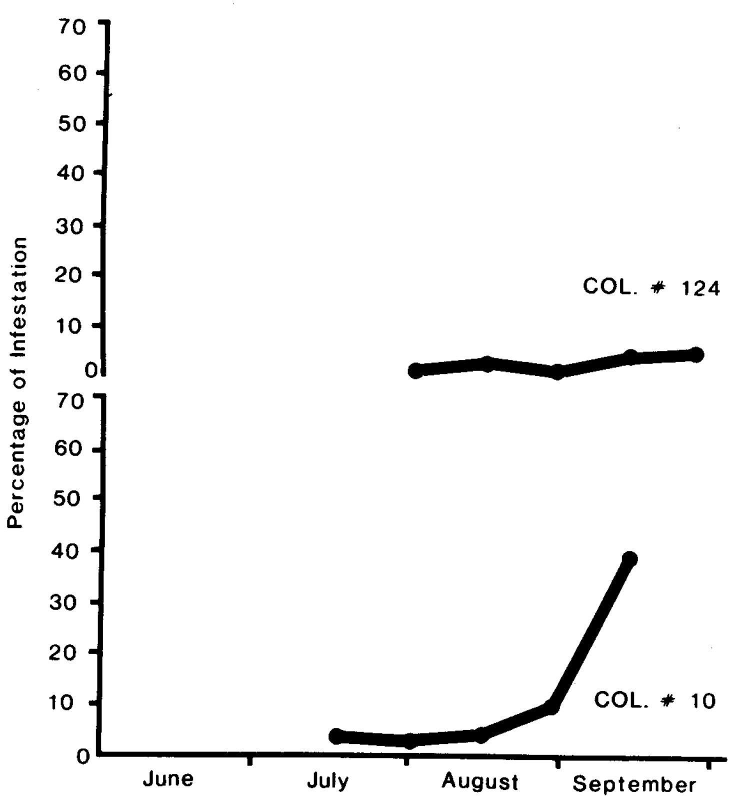

Fig. 1 — Seasonal changes in the percentage of cells infested with *Varroa jacobsoni* in two comparatively weakly infested colonies of a parental population derived from potentially resistant colonies.

124), we found a low level of infestation throughout the season. In another (Fig. 1, colony 10), there was a low level of infestation until August but, at the end of the season, infestation rates rose to 40%. Queens from these two colonies served as parents for the first selected generation of resistant bees.

Other colonies were apparently less resistant. Colony 39 (Fig. 2) experienced a

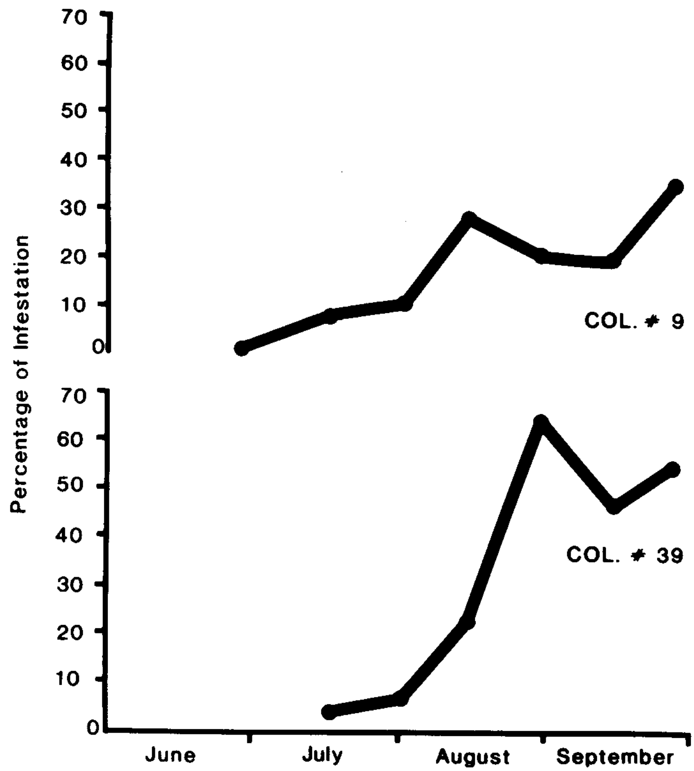

Fig. 2 — Seasonal changes in the percentage of cells infested with *Varroa jacobsoni* in two comparatively strongly infested colonies of a population derived from potentially resistent colonies.

dramatic increase in the infestation rate during August, rising to over 60% by the months end. Similarly (Fig. 2), by the middle of July colony 9 had an increase which continued into August, by the end of September the infestation rate had risen to 40%.

Seasonal changes in the infestation rates for control colonies are shown in Fig. 3. All of the colonies experienced increasing infestation rates, however two of them (colony 125, colony 12) showed particularly rapid increases.

Numbers of fertile females and progeny classes, and estimates of reproductive rates for seven colonies of the selected parental generation are given in Table 1. At

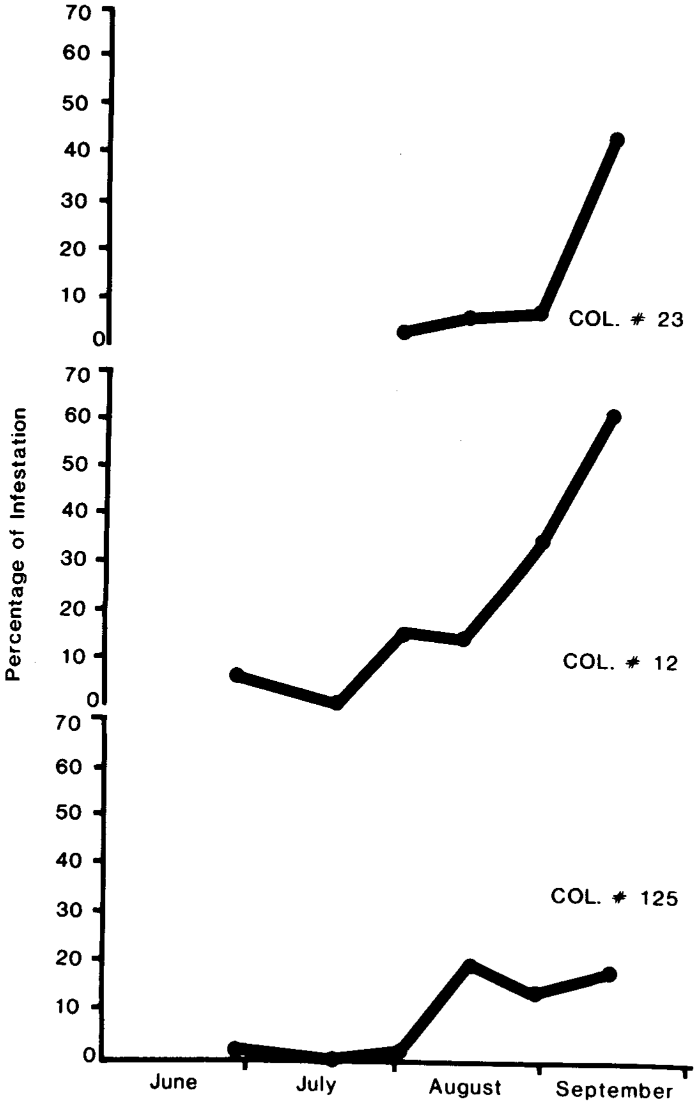

Fig. 3 — Seasonal changes in the percentage of cells infested with *Varroa jacobsoni* in three colonies of unselected (control) stock.

first inspection, only three of seven colonies had detectable mites, with an average of 1.41 offspring (including immature stages) per reproductive female. On average, one daughter was found per reproductive female. At that time, there were no males or unhatched eggs. Twenty days later males and eggs appeared at rates of 0.26 and 0.60 per reproductive female, respectively. The mean of 1.16 adult daughters at the second sampling was similar to the first sampling. By the third examination, the mean number of daughters was similar (1.01), males had increased to 0.57, and eggs had

Table 1 — Numbers of reproductive females, mean numbers of progeny in four classes and estimated reproductive rates for *Varroa jacobsoni* in the worker brood of seven colonies of the selected parental generation in 1985

Examination date	n/ Inspection	Reproductive females	Progeny classes				Reproductive rate
			Daughters	Males	Immature stages	Eggs	
June 28	100	6	1.00	0.00	0.41	0.00	1.41
July 18	100	18	1.16	0.26	0.75	0.60	2.75
August 1	100	38	1.01	0.57	0.85	0.28	2.63
August 15	100	89	1.62	0.83	0.80	0.10	3.40
August 29	100	129	1.65	0.80	1.04	0.10	3.53
September 14	100	264	1.70	0.73	1.05	0.10	3.61
September 26	100	168	1.27	0.32	1.29	0.21	3.09

decreased to 0.28. The total reproductive rate was similar to that found in the second examination. The third, fourth and fifth samplings (8/15; 8/29 and 9/14, 1985) showed strong increases in infestation rates from 38 to 89, 129 and 264 egg-producing females. This last value is 44 times greater than the initial population of 6 reproductive female mites. Through this sampling period, increases in the production of daughters and males were apparent. Total reproductive rates ranged from 3.40 to 3.61. By the last examination (9/26), reproductive rates had decreased to 3.09 while the numbers of daughters and males decreased and immature stages and eggs increased.

Numbers of fertile females, progeny classes and estimates of reproductive rates for *Varroa* are given in Table 2. These colonies constitute the parental generation used in the selection of resistant and susceptible lines. Reproductive rates ranged from 3.01 to 3.80. The mean number of daughters per reproductive female mite for the entire parental generation was 1.44, males 0.60, immature stages 1.14, and eggs 0.20.

Table 3 contains the same type of data collected from the unselected control colonies. The mean number of fertile females was somewhat larger than observed for the selected parental generation, although the classification of their progeny is similar.

Table 4 shows the results of treatment with Varamit®. The number of fertile females and daughters (1.01) was reduced by Varamit® treatment when compared to either the parental or the control group (Table 4). The total reproductive rate was also less.

DISCUSSION

Quite clearly not all worker brood was equally infested with *Varroa jacobsoni.* Futhermore, rates of infestation were not the same in all colonies. Generally, infestation rates increased rapidly in August and September. Although checking mature worker brood may lack some precision for determining degrees of infestation (Fuchs & Koeniger 1984), we observed rapid population expansions during the second half of August and the first half of September. In less than three months, the number of infested worker-brood cells increased 44 times. Mite progeny resulting from the parasitism of drone brood during the spring and the first half of summer are likely to be an important source of parents for this increase.

Treatment of colonies with Varamit® in the second half of July efficiently decreased mite populations, thus preventing severe damage during August and September. This improved the chances of these colonies overwintering.

The reproductive rates for *Varroa* in our conditions ranged from 1.41 to 3.61 (Table 1). The mean reproductive rate of 2.92 was less than that estimated by Ifantidis (1984) for infestations of *Apis mellifera cecropia.* In the second half of August and the first half of September our reproductive data coincided with the mean values reported by Infantidis (1984) and Pilecka (1982). Our progeny classification results were not in agreement. Numbers of daughters in July and at the beginning of August were similar to those estimated by Ifantidis (1984). However, from the second half of August onward we observed an increase in the mean number of daughters. The variation in progeny classes and reproductive rates is likely due to

Table 2 — Numbers of reproductive females, mean numbers of progeny in four classes and estimated reproductive rates for *Varroa jacobsoni* in the worker brood of the selected parental generation. Values are seasonal means from seven inspections made from 28 June to 26 September

Ser. No.	Colony number	n/ Inspection	Repro-ductive females	Progeny classes				Reproductive rate
				Daughters	Males	Immature stages	Eggs	
1.	15	100	40	1.82	0.8	1.15	0.1	3.80
2.	39	100	195	1.58	0.6	1.21	0.3	3.69
3.	13	100	44	1.62	0.7	1.00	0.3	3.62
4.	10	100	66	1.53	0.6	1.38	0.1	3.61
5.	12	100	37	1.72	0.4	1.24	0.1	3.46
6.	11	100	57	1.82	0.7	0.91	0.2	3.43
7.	5	100	34	1.00	0.6	1.34	0.4	3.34
8.	8	100	53	1.06	0.6	1.19	0.2	3.15
9.	124	100	19	1.62	0.5	0.81	0.2	3.13
10.	9	100	140	1.00	0.7	1.19	0.2	3.09
11.	118	100	94	1.14	0.5	1.17	0.2	3.01
Means			70.81	1.44	0.6	1.14	0.2	3.39

Table 3 — Numbers of reproductive females, mean numbers of progeny in four classes and estimated reproductive rates for *Varroa jacobsoni* in the worker brood of three control colonies. Values are seasonal means from seven inspections made from 28 June to 26 September

Ser. No.	Colony number	n/ Inspection	Repro-ductive females	Progeny classes				Reproductive rate
				Daughters	Males	Immature stages	Eggs	
1.	12	100	156	1.65	0.9	1.04	0.2	3.79
2.	125	100	63	1.25	0.4	1.37	0.2	3.22
3.	23	100	73	1.32	0.6	0.84	0.3	3.06
Means			97.33	1.41	0.6	1.08	0.2	3.36

Table 4 — Numbers of reproductive females, mean numbers of progeny in four classes and estimated reproductive rates for *Varroa jacobsoni* in the worker brood of three colonies treated with Varamit® in early July. Values are means of four inspections from early July after treatment to 26 September

Ser. No.	Colony number	n/ Inspection	Repro-ductive females	Progeny classes				Reproductive rate
				Daughters	Males	Immature stages	Eggs	
1.	264	100	14	1.45	0.7	1.18	0.3	3.63
2.	265	100	7	0.75	1.0	1.50	0.0	3.25
3.	268	100	13	1.00	0.6	0.86	0.6	3.06
Means			11.33	1.01	0.8	1.18	0.3	3.31

our ecological conditions in August and the first half of September where we see an expression of the maximum reproductive potential for *Varroa jacobsoni.* During this portion of the season females reproduce at a higher rate than at any other time. It is also possible that a higher percentage of females reproduce more than once. Most certainly, non-reproducing females decreased proportionally from July to August. However, since some cells contain more than one potential parental female and their progeny, it could not be established with certainty if all of them had reproduced. This can only be imprecisely estimated from the number of offspring.

The extreme range of infestation rates from over 60% (colony 39) to under 5% (colony 124) is especially interesting. This variation may reflect a heritable attribute of honey bees. It it does, selecting for stocks of bees which only support smaller populations of *Varroa jacobsoni* may prove feasible (Kulinčević & Rinderer 1985). This breeding experiment is now in the first generation of selection. Thus, it is too early to expect significant differences between lines. However, certain statistically significant differences between lines already exist which suggest that further differences may appear in future generations.

SUMMARY

As part of a program to select for resistance to *Varroa jacobsoni,* the population dynamics and progeny structure of this parasite were studied in potentially resistant control colonies. Samples of 100 cells of sealed worker brood (16–17 days old) were examined from each of 14 colonies every two weeks from 28 June until 26 September, 1985. Three colonies were from general stock, and 11 were derived from daughters of queens from three colonies which had survived an initial infestation by *Varroa.* These infestations caused the loss of most colonies in the apiaries from which the original queens were chosen.

Mite infestation levels were generally low until the middle of July 1985. Subsequently, and sometimes as late as the middle of September, most colonies experienced a very rapid increase in the mite population. Correspondingly, there was a decrease in the number of non-reproducing female mites.

ACKNOWLEDGEMENTS

This research was funded in part by grant YO-ARS-81-JB-97 from the Joint Board of Yugoslavia and USDA/OICD. We thank Ljiljana Šerf, Cindy Dies, and G. Lorraine Davis for assistance in manuscript preparation. The research was conducted in cooperation with Louisiana Agricultural Experiment Station.

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