DEVELOPMENT AND CONTROL OF THE VARROA (*Varroa destructor*) IN HONEY BEE (*Apis mellifera.*) COLONIES AND EFFECTS ON THE COLONY PRODUCTIVITY

Bal Arısı (*Apis mellifera*) Kolonilerinde Varroa (*Varroa destructor*) Gelişimi, Mücadelesi ve Kolonilerin Verimliliğine Etkisi

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Abstract: This study was carried out to determine the rate of Varroa *(varroa destructor)* infestation of both brood and adult honeybees (*Apis mellifera anatoliaca*), struggle with it and effect on the productivity of the colonies. The rate of varroa infestation, on 15 honeybee colonies in three apiaries, was investigated both at the beginning of the study and during the control period (every 24 days on worker bees, within closed worker and drone brood cells). Varroa infestation rate has continually increased in all groups until the first chemical treatment (26 july 2004). Following chemical treatment, infestation level of *Varroa* has clearly decreased. Until the second chemical application (25th October 2004), Varroa infestation level kept increasing on adult worker bees, within closed worker and drone brood cells. After the second chemical application, Varroa infestation rate has decreased remarkably in all experimental colonies. The average rate of varroa infestation in drone brood cells (24.14% in group I, 59.08% in group II, 81.72% in group III) was found higher than both in Worker brood cells (1.44% in group I, 3.52% in group II, 4.76% in group III) and on adult worker bees (8.88% in group I, 12.54% in group II, 17.32% in group III). The number of Varroa has reached the maximum level after the number of drone cells were the highest. Level of varroa infestation had a negative effect on population growt and honey production of the colonies. Much infested colonies (Group II and III) had lower adult bee populations (10.16±0.46 and 10.10±0.47 number frame/colony) and produced less honey(24.20±2.68 and 26.20±3.70 kg/colony) than Less infested (Group I). colonies (12.80±0.47 number frame adult vorkerbees/colony, and 34.20±8.83 kg/colony honey).

Key Words: Honey bee, *Apis mellifera*, *Varroa Destructor*

Özet: Bu çalışma hem yavru hem de ergin bal arılarında (*Apis mellifera*) varroa (*varroa destructor*) bulaşıklık oranını, yapılan mücadelenin etkinliğini ve kolonilerin verimliliğine etkilerini belirlemek amacıyla yürütülmüştür. Hem çalışma başlangıcında hem de çalışma süresince 24 günlük periodlarla üç arılıktan 15 arı kolonisinde (ergin arılarda, işçi arı gözlerinde ve erkek arı gözlerinde) varroa bulaşıklık oranları belirlendi. İlk ilaç uygulamasına (26 Temmuz 2004) kadar tüm gruplarda varroa bulaşıklık oranı sürekli olarak artış, ilaç uygulamasını takiben ise ani bir düşüş eğilimi göstermiştir. İkinci ilaç uygulamasına (25 Ekim 2004) kadar gerek işçi arı üzerindeki gerekse işçi arı ve erkek arı gözlerindeki pupalar üzererindeki varroa miktarı yine sürekli bir artış göstermiştir. Tüm gruplarda, erkek arı gözlerindeki ortalama varroa bulaşıklığının (grup I'de %24.14, group II'de %59.08 ve group III'te %81.72) hem işçi arı gözlerindeki varroa bulaşıklığından (grup I'de %1.44, grup II'de %3.52 ve grup III'te %4.76) hem de işçi arılar üzerindeki varroa bulaşıklığından (grup

I'de %8.88, grup II'de ,%12.54 ve grup III'te %17.32) daha yüksek olduğu belirlenmiştir. Tüm kolonilerde erkek arı gözlerinin artmasıyla birlikte varroa bulaşıklık oranı da artmış, erkek arı gözlerinin maksimum olduğu dönemden sonraki dönem ise varroa oranı da maksimum olmuştur. Varroa bulaşıklık oranı kolonilerin işçi arı populasyonunu ve bal verimini olumsuz etkilemiştir. Varroa bulaşıklığı yüksek olan kolonilerin (Grup II and III) ergin arı gelişimi (10.16±0.46 ve 10.10±0.47 adet arılı çerçeve /coloni) ve bal verimi (24.20±2.68 and 26.20±3.70 kg/coloni) varroa bulaşıklığı düşük olan kolonilerin(Grup I) ergin arı gelişiminden (12.80±0.47 adet arılı çerçeve /coloni) ve bal veriminden (34.20±8.83 kg/coloni) daha düşük olmuştur.

Key Words: Bal arısı, *Apis mellifera* L., *Varroa destructor*,

1. INTRODUCTION

The ectoparasitic mite Varroa *(Varroa destructor)* has been known as a major pest of honeybees around the world (Sammataro et al. 2000; Zhang 2000). Varroa damages immature and adult honeybees (*Apis mellifera.*) by feeding their hemolymph, thus greatly weakening or killing the bees (Popa, 1982; Elzen et all. 2000).

The life cycle of the Varroa mite is synchronized with that of its honeybee host (Delfinado-Baker and Peng, 1995; Shimanuki and Knox, 1991). The numbers of mites which are found in a colony of honeybees varies with the season. The lowest mites are found in spring, increases during spring, and is the highest in summer and fall. During spring and early summer, most mites are found on the brood (especially drone brood). In late fall and winter, most mites are found on adult worker bees (Popa 1982; Shimanuki and Knox 1991).

Before April 2000, Varroa was found throughout Asia, Europe, Africa and the Americas, with exception of Australia and New-Zeland (Anderson 2000, Delfinado-Baker and Peng 1995; Popa 1982). Presently, this mite is also found New-Zeland (Zhang 2000).The mite infestation level was different in all regions of the world and appeared to depend on the strength of the colony, the availability of nectar and climatic conditions (Slabezki et al. 1991). On a colony level, the symptoms of a varroa mite infestation depends upon the degree of infestation. When mite numbers are low, there is no obvious effect on the colony and infestation is often unnoticed. In heavy infestations, pupae may not develop into adult bees. The adult that do emerge may have shortened abdomens, misshapen wings and deformed legs and may weigh less than healthy bees (Shimanuki and Knox 1991). In general, infested colonies die within 2 to 3 years without appropriate chemical treatment using insecticides (Martin et al. 2001; Gregorc and Planinc 2002).

Varroa mite was first recorded in Turkey in 1977. This mite has now a wide range of distribution in this country (Mimioğlu and Göksu 1984; Akkaya and Göksu 1990; Doğanay 1993, 1994; Genç 1994, Çakmak, et. al., 2003). Furthermore, it is economically the most important damage causing mite in the beekeeping industry in Turkey. Although Turkey is one of the most suitable countries for beekeeping with its rich flora, suitable ecology and colony population, the honey production of the colonies are lower than the world standarts (Kaftanoğlu et. all., 1995). One of the main reasons of this state may be the high rate of Varroa infestation level and the poor colony management against varroa. The aim of the present study was to determine the rate of varroa infestation of both brood and adult honeybees and effects on productivity of the colonies (*Apis mellifera anatoliaca*) under the migratory beekeeping condition.

2 MATERIAL AND METHODS

2.1 Study Fields

This survey was carried out at three different apiaries, each of them were consisted of five colonies, belonging to three private beekeepers at the Camardi district of the Nigde province (36° 56'28" N longitude, 35° 05'08" E latitude and 1325 m altitute), in the middle of Turkey between April and July 2004. Then, these colonies were moved to Sanliurfa province (38° 02'40" N longitude, 37° 12'30" E latitude and 320 m altitute) in the southeast of Turkey. Survey countinued in this region until late November and finished 28 November 2004.

2.2 Sampling of Honeybee Colonies

For determining of varroa infestation, samples of honeybees were collected every 24 days from three apiaries that consisted of five colonies (total 15 colonies) belonging to three private beekeepers. Prior to our research, fifteen colonies in the survey were equalized in regard to colony strenght (7 frames with bees) and sealed brood area (4 frames). All the survey colonies came from the same genetic origins (*Apis mellifera anatoliaca*) and have queens the same age.

In the beginning of the survey, colonies were divided three groups according to the varroa infestation rate on adult worker bees. Average varroa infestation rate of the first group were 1.20%, the second group were 1.40% and the third group were 1.80% respectively.

2.3 Preparation and application of Chemical

In order to reduce to damage of Varroa on colonies, Flumetrin was applied to all groups. The first chemical application was carried out at the 26th of July in Nigde. For this reason, a chemical called Flumetrin was used (1/10 dissolved in sunflower seed oil), it was absorbed to the wooden sticks (4x30x200 mm) and these sticks were kept in a shade place. Then, these were put among frames consisting bees in the colonies for 15 days. The second chemical application of all groups were applied with same insecticide (Flumetrin) at the 25 October 2004.

2.4. Determination of Varroa Infestation Level

In order to identify the level of varroa population both at the beginning of the study and during the control period, approximately 200 worker bees was sampled from all experiment colonies. These bees carrying varroa were put with help of a funnel in to jars containing detergent solution then, the mites on bees were dislodged by shaking the jars. The jars with bees were poured on a cotton cloth which is used for filteration, the remaining mites and bees were counted and recorded. The Varroa infestation rate was calculated, by using varroa infestation rate formula (%)=number of varroa on worker bees/ number of worker bees x 100 (Kaftanoğlu et al. 1995). Varroa infestation rate was calculated every 24 days on worker bees, within closed worker brood cells and drone brood cells. At each counting period, 200 worker and 200 drone brood cells were opened by means of forceps. The varroas on larva in those cells were counted and recorded, to determine the rate of varroa infestation. Infestation rate in closed brood cells was calculated by using Infestation proportion formula (%)=Varroa number / Brood cell number of counted Varroa.

The acaricides were applied to worker bee when the rate of varroa infestation was over 20-25 %. At the 26th of July in Nigde and 25th of October in Sanliurfa.

We made two honey harvest from the colonies of our present study. For the honey harvest, we have used combs of which 2/3 were sealed. (Doğaroğlu et al., 1992). Before honey harvest, colonies were weighed, hive numbers were written on the frames and recorded. Honey was extracted from the frames. These frames were put again in the same hives and the hives were weighed again. The weight of the hives after the honey harvest was substracted from the weight of the hives before the honey harvest. So we calculated the honey yield.

2.5 Statistical Analysis

Statistical analysis of colony characteristics (number of frames with bee, brood areas) and Varroa infestation in worker and drone brood cells and on adult worker bees were analysed by Repeated Measure, honey yield was performed randomized plot design (ANOVA). Group comparisons among the means were done with Duncan's multiple range test and different statistical groups shown that different letters in tables I and II.

3. RESULTS

The rate of varroa infestation during the survey are summarized in Table I. and Table II. The average rate of varroa infestation in drone brood cells (24.14 % in group I, 59.08 % in group II, 81.72 % in group III) was found higher than both in worker brood cells (1.44 % in group I, 3.52 % in group II, and 4.76 % in group III) and on adult worker bees (8.88 % in group I, 12.54 % in group II, 17.32 % in group III).

Significant differences were found among the groups on varroa level in drone brood cells, in worker brood cells and on adult worker bees ($P<0.05$) All groups were taken in different statistical groups. The number of Varroa has reached the maximum level in mid July before the first chemical aplication. In addition, following the start of the survey the number of frames with bee had risen and reached the maximum level in late July.

Table I: *Varroa destructor* in Worker Brood Cells(%), in Drone Brood Cell(%) and on Adult Worker Bees(%),Number of Frames with Worker Bees of Survey Groups Throughout the Experiment.

Control Dates	Number of Varroa in Workerbee cells (%)			Number of Varroa in Drone Cells (%)			Number of Varroa on Adult Worker Bees (%)			Number of Frames with Bees		
	Apiaries			Apiaries			Apiaries			Apiaries		
	1(n=5)	2(n=5)	3(n=5)	1(n=5)	2(n=5)	3(n=5)	1(n=5)	2(n=5)	3(n=5)	1(n=5)	2(n=5)	3(n=5)
	X±Sx	X±Sx	X±Sx	X±Sx	X±Sx	X±Sx	X±Sx	X±Sx	X±Sx	X±Sx	X ±Sx	X±Sx
10.04.04	0.20± 0.30	1.00± 0.00	2.00± 0.28	3.80± 0.20	9.4± 0.90	14.80± 0.87	1.20± 0.28	1.40± 0.27	1.80± 0.30	7.20± 0.34	7.40± 0.33	7.20± 0.34
04.05.04	0.60± 0.50	1.40± 0.50	2.50± 0.32	6.20± 1.00	11.20± 1.20	17.40± 0.90	2.00± 0.37	2.70± 0.35	3.45± 0.45	9.20± 0.37	9.00± 0.36	8.40± 0.39
28.05.04	1.40± 0.70	2.60± 0.75	3.40± 0.32	14.80± 1.2	15.3± 1.35	20.20± 0.98	5.60± 0.74	4.40± 0.38	6.40± 0.40	11.60± 0.4	9.80± 0.37	10.00± 0.38
21.06.04	3.40± 1.07	4.10± 0.65	5.60± 0.33	40.60± 3.7	20.2± 1.34	27.60± 1.17	16.0± 1.74	9.20± 0.75	13.80± 0.8	13.60± 0.6	11.20± 0.6	11.80± 0.58
15.07.04	4.60± 0.64	5.60± 0.46	7.80± 0.57	91.80± 3.4	59.8± 2.45	80.80± 3.63	41.4± 2.35	23.60± 1.7	32.00± 1.6	14.80± 0.5	12.00± 0.5	12.20± 0.51
09.08.04	0.20± 0.50	2.80± 0.63	2.80± 0.42	5.20± 1.90	29.20± 2.70	41.20± 3.34	0.60± 0.40	1.60± 2.36	2.20± 2.10	16.20± 0.7	13.20± 0.7	13.40± 0.68
03.09.04	0.60± 0.36	4.40± 0.60	4.70± 0.38	9.80± 4.00	86.2± 3.60	113.60 ± 4.0	1.80± 0.76	4.50± 0.80	7.80± 0.80	17.00± 0.7	13.80± 0.7	14.40± 0.63
27.09.04	1.20± 0.77	5.30± 0.66	6.80± 0.40	27.20± 6.7	193.4± 3.9	286.00 ± 6.7	4.80± 1.80	15.80± 1.9	27.85± 1.8	13.20± 0.4	9.40± 0.42	9.60± 0.41
20.10.04	2.00± 0.23	6.60± 0.38	10.40± 0.5	41.60± 5.3	184.5± 2.8	220.40 ±5.4	15.0± 3.85	55.40± 3.7	76.90± 3.5	10.20± 0.4	9.00± 0.36	8.00± 0.38
14.11.04	0.20± 0.93	1.40± 0.44	1.60± 0.22	0.40± 0.25	1.40± 0.45	1.60±0 .24	0.40± 0.32	0.60± 0.20	1.00± 0.32	8.80± 0.36	6.80± 0.35	6.00± 0.36
General Means	**1.44± 0.50c**	**3.52± 0.55b**	**4.76± 0.38a***	**24.14± 2.75c**	**59.08± 1.97b**	**81.72± 2.71a***	**8.88± 1.26c**	**12.54± 1.28b**	**17.32± 1.18a***	**12.80± 0.47a**	**10.16± 0.46b**	**10.10± 0.47b***

**Different letter indicate significant differences among the means (*: P<0.05).*

26.07.2004: First drug application and **25.10.2004** second drug application were applied to all groups.

Table: II: Honey Yield of the Experimental Groups.

APİARİES	Honey Yield					
	n	I. Harvest	II. Harvest	Total	Min.	Max.
Group I	5	15.60±2.70 a	18.60±4.16 a	34.20±6.83 a*	28	45
Group II	5	10.60±1.34 b	13.60±1.34 b	24.20±2.68 b	21	27
Group III	5	11.46±1.82 b	14.60±1.92 b	26.20±3.70 b	21	30

**Different letter indicate significant differences among the means (* P<0.01)*

An average of 34.20±6.83 kg honey was harvested from group I. In comparison, an average of 24.20±2.68kg and 26.20±3.70kg honey were harvested group II and group III, respectively. It was found a statistical significant(P<0.01) among the apiaries on honey production and adult bee population(number of frame) Group I was taken in to first statistical group, group II and group III were taken in to second statistical group.

4. DISCUSSION

Varroatosis caused by *Varroa destructor* on honey bee(*Apis mellifera L.)*, has become serious problem to veterinarians and bee-keepers in many countries of the world (Haragsim and Samsinak 1986; Anderson and Trueman 2000).

In Turkey, different infestation rates of Varroa*(varroa destructor)* on honey bees have been reported. According to these studies the average Varroa infestation rates on honey bees was determined between 10.5 %-15.1 % in Aegean region (Ilikler and Yuzbasi 1980), 2.9%-15.9% in

Istanbul (Akkaya 1996, Akkaya and Vurusaner 1996) ,13.32% in Cukurova region (Kumova 2001). and 2.17% in Turkey (Çakmak, et al. 2003). In the present study, average varroa infestation rate was found to be 8.88 % in group I, 12.54 % in group II and 17.32% in group III. The Varroa infestastion rate in this study in accordance with the results obtained by İlikler and Yuzbası (1980), Akkaya (1996), Akkaya and Vurusaner (1996) and Kumova (2001). İlikler and Yuzbası (1980) reported that, the average varroa infestation rate in drone brood cell was found between 31%-44%. The same researchers (İlikler and Yüzbaş 80) found average Varroa infestation rate in worker brood cell was found between 12,7%-16,6%. Differences between these results and our study results may be related with conducting the study on different geographical locations and honeybee genotypes.

In this study, average Varroa infestation rate in drone cells was significantly higher than both worker brood cells and on adult worker bees. This event can be explained that mites prefer to breed in drone brood cells. Because the reproduction of mite on honey bee is positively correlated with the duration of its host's closed stage, which is the longest term for drone. So Varroa mite have more time to reproduce and mature within drone brood cells (Doğanay 1994; Shimanuki and Knox 1991; Berkelaar et al. 2001).

The present study, the number of Varroa has reached the maximum level in June and July after the number of drone brood cells were the highest. In addition, following the start of the survey the number of frames with bee had risen and reached the maximum level in late July. From then, it started to decrease until the final of experiment. This indicates, if the amount of brood cells especially drone brood cells and colony population increases, varroa infestation level increases as well (Slabezki et al. 1991). The rate of the varroa infestation level is one of the most important factor that influences the level of colony population and honey production of the colonies. This high honey yield in group I might be related to lower Varroa infestastion level. If a good struggle against mite is made the loss and weakeness of bees can be decreased and productivity of the colonies can be increased.

5. REFERENCES

Akkaya, H. 1996. Balarısı kolonilerinin Varroatosis'ine Flumethrin'in etkisi. *T. Parazitol. Derg.*, 20 (3–4): S.457–460.

Akkaya, H., Göksu, K. 1990. Balarısı kolonilerinin Varroatosis'ine karşı Perizin ve Folbex-VA ile karşılaştırmalı denemeler. *T. Parazitol. Derg.*, 14 (1): S.107–116.

Akkaya, H., Vurusaner, C. 1996. Flumethrin (Bayvarol-Strips) ve Fluvalinate'ın (Apitan şerit) balarılarının Varroatosis'ine karşı etkilerinin sahada belirlenmesi. *T. Parazitol. Derg.*, 20 (3–4): S.461–466.

Anderson, D.L. 2000. Variation in the parasitic bee mite *Varroa jacobsoni* Oud. *Apidologie*, 31: S.281–292.

Anderson, D.L., Trueman, J. W. 2000. *Varroa jacobsoni* (Acari: Varroidae) is more than one species. *Exp. Appl. Acarol.*, 24. (3): S.165–189

Berkelaar, D, Davis, K., Cox, D. 2001. Control of mites in honey bees. *ECHO Development Notes*, 73: S.1–3.

Cakmak, I., Aydın, L.,Gulegen, E., Wells, H. 2003. Varroa (*varroa destructor*) tracheal mite (*Acarapis woodi*) incidence in the Republic of Turkey. *Journal of Apicultural research*, 42(4): S.57–60.

Delfinado-Baker, M., Peng, C. Y. S. 1995. *Varroa jacobsoni* and *Tropilaelaps clareae*: A perspective of life history and why Asian bee–mites preferred European honey bees. *American Bee Journal*, 135 (6): S.415–-420.

Doğanay, A. 1993. Varroatosis (*Varroa jacobsoni*). *Turk Vet Hek Derg*., 5 (3): S.34–35, S.58–61.

Doğanay, A. 1994. Varroa Hastalığı, Varroatosis. *T.Parazitol Derg*., 18 (2): S.229–239.

Doğaroğlu, M., Özdemir, M., ve Polat, C., 1992. Türkiye'deki Önemli Balarısı (*Apis mellifera L.*) Irk ve Ekotiplerinin Trakya Koşullarında Performanslarının Karşılaştırılması. Doğa-Tr. J. of Veterinary and Animal Sci., 16, S.403–414, Ankara.

Elzen, P.J., Baxter, J.R., Spivak, M., Wilson, W.T. 2000. Control of *Varroa jacobsoni* Oud. resistant to fluvalinate and amitraz using coumaphos. *Apidologie*, 31: S.437–441.

Genç, F. 1994. Türkiye'de arı akarı (*Varroa jacobsoni* Qud) ile mücadelede kullanılan bazı ilaçların etkinliklerinin karşılaştırılması. *Atatürk Ü. Zir. Fak. Derg.* 25 (3): S.414–423.

Gregorc, A., Planinc, I. 2002. The control of *Varroa destructor* using oxalic acid. *Vet J.*, 163: S.306-310.

Haragsim, O., Samsinak, K. 1986. Developmental stages of the mite *Varroa jacobsoni* Oudemans, 1904 (Acari: Dermanyssidae). *Vet Med*, 31 (2): S.105–112.

İlikler, İ., Yüzbaş, A. 1980. Ege bölgesi arı akarı (*Varroa jacobsoni* Oudemans, 1904) ve savaşımı üzerinde araştırmalar. Türkiye I. Arıcılık Kongresi, Ankara 22–24 Ocak.

Kaftanoğlu, O., Kumova, U., Yeninar, H. 1995. Effectiveness of drugs commonly used againist *Varroa jacobsoni* and their effects on honeybees (*Apis mellifera*). Apimondia XXXIVth. International Apiculturel Congress, 15-19 August, Lousanne, Sweden, Pp: 180.

Kumova, U. 2001. *Varroa jacobsoni* kontrolünde ülkemizde kullanılan bazı ilaçların etkinliğinin araştırılması. *Turk. J. Vet. Anim. Sci*., 25: S.597–602.

Martin, C., Salvy, M., Provost, E., Bagneres, A.G., Roux, M., Crauser, D., Clement, J.L., Conte, Y.L. 2001. Variations in chemical mimicry by the ectoparazitic mite *Varroa jacobsoni* according to the developmental stage of the host honey-bee *Apis mellifera*. *Insect Biochemistry and Molecular Biology*, 31: S.365–379.

Mimioğlu, M.M., Göksu, K. 1984. Arıcılığımızı yok olma tehlikesi ile karşı karşıya getiren asalak *Varroa jacobsoni* (Oudemans, 1904). Tarım Orman ve Köyişleri Bakanlığı, Yetiştirici Broşürleri Serisi. S.45, Ankara.

Popa, A. 1982. Varroa disease of bees, A threat to world apiculture, *Revista Mundial de Zootecnia*, 42: S.2–10.

Sammataro, D., Gerson, U., Needham, G. 2000. Parasitic mites of honey bees: Life history, implications and impact. *Annual Review of Entomology*, 45: S.519–548.

Shimanuki, H., Knox, D.A: 1991. Diagnosis of Honey Bee Diseases. United States Department of Agriculture. Agriculture Handbook Number 690.

Slabezki, Y., Gal, H., Lensky, Y. 1991. The effect of Fluvalinate application in bee colonies on population levels of *Varroa jacobsoni* and honey bees (*Apis mellifera L*.) and on residues in honey and wax. *Bee Science*, 1 (4): S.189–195.

Zhang, Z. Q. 2000. Notes on *Varroa destructor* (Acari: Varroidae) parasitic on honey bees in New Zealand. *Systematic & Applied Acarology Special Publications*, 5: S.9–14.