An observation study on the effects of queen age on some characteristics of honey bee colonies

Ethem Akyol1, Halil Yeninar2, Ali Korkmaz3, İbrahim Çakmak4

1Ulukışla Meslek Yüksekokulu. Niğde Üniversitesi, Turkey
2Zootekni Bölümü. Kahramanmaraş Sütçü. İmam Üniversitesi, Turkey
3Tarım İl Müdürlüğü çiftçi Eğitim ve Yayım Şubesı. Samsun, Turkey
4Zootekni Bölümü. Ziraat Fakültesi, Bursa, Turkey

ABSTRACT

This study was conducted to determine the effects of the queen’s age on performance of the honeybee (A. mellifera anatoliaca) colonies at nomad beekeeping conditions. Performances of the colonies, which had 0, 1, 2 and 3 year-old queens, were compared. The number of combs, brood areas, wintering ability survival rate and honey yield were determined as performance criteria. The average number of combs with bees throughout the experiment in Group I, Group II, Group III and Group IV was 10.92±0.78, 14.68±0.55, 10.10±0.60, 7.88±0.45 number combs/colony; the average of brood areas was 3078±372.5 cm², 3668±460.3 cm², 2215±294.0 cm², 1665.38±241.8 cm²; the average of wintering ability was 84.3±2.9%, 88.0±3.7%, 46.6±19.0%, 26.8±16.5%; the survival rate was 100%, 100%, 60%, 40%; and the average of honey yields was 31.4±1.89 kg, 41.5±1.05 kg, 20.4±2.62 kg and 12.0±1.41 kg per colony, respectively. A significant and negative correlation between queen age and brood production (r=-80.2), colony strength (r=-62.5), wintering ability (r=-66) and honey yield (r=-75.6) were calculated (P<0.01). The colonies headed by young queens had more brood areas, longer worker colony population, better wintering ability and greater honey yield in comparison to colonies headed by old queens.

Key words: Colony population, Brood area, Wintering ability, Survival rates, Honey yield.

RIASSUNTO

EFFETTI DELL’ETÀ DELLA REGINA SU ALCUNE CARATTERISTICHE DELLE COLONIE DI API MELLIFERE

Questo studio è stato condotto al fine di determinare gli effetti dell’età della regina sulle performance delle colonie di api mellifere (A. mellifera anatoliaca) in apicoltura nomade. Sono state confrontate le performance di colonie con api regine di 0, 1, 2 e 3 anni di età. I parametri presi in esame sono stati: numero di favi per colonia, estensione della zona di riproduzione (covata), capacità di sopravvivenza invernale e quantità di miele prodotto. Il numero medio di favi per colonia rilevati durante l’esperimento sono stati 10,92±0,78 nel Gruppo I, 14,68±0,55 nel Gruppo II, 10,10±0,60 nel Gruppo III e 7,88±0,45 nel Gruppo IV; l’estensione media della zona di riproduzione è stata per i quattro gruppi rispettivamente 3078±372,5 cm², 3668±460,3 cm²,
Introduction

Queen quality is an important factor that influences not only the brood production, but also productivity of the colonies (Kaftanoğlu et al., 1988; Laidlaw, 1992). Genetic structure, emerging weight of the queen, number of the ovariols in the queen's ovaries and volume of the spermatheca of the queen, number of grafted larvae in one starter and feeder colony, larval age, rearing methods, rearing season, strength of starter-finisher and nuclei colonies determine the queen quality (Laidlaw, 1992; Kaftanoğlu et al., 2000). The characteristics of honeybee colonies are determined by the queen and her fecundating drones. Approximately one million spermatozoa are released per year to fertilize eggs (Kaftanoğlu et al., 1988; Laidlaw, 1992). When the number of spermatozoa decrease in a queen's spermatheca, the rate of unfertilized eggs laid increases (Inci, 1999). Although queens can live 4 or 5 years, fertile eggs production declines every year. Replacing older queens with young ones is one of the essential procedures to increase the productivity of the honeybee colonies (Kaftanoğlu et al., 1988; Genç, 1992; Laidlaw, 1992). Colonies, which have a one year old queen have been reported to have a greater colony population and produce 27-30% more honey yield than colonies which have old queens (Woyke, 1984; Genç, 1992; Inci, 1999). Old queens lay insufficient eggs to produce enough young workers for winter and overwinter colonies. The old worker bee population in colonies dies off in late winter or early spring (Kaftanoğlu, 1987; Genç, 1992; Tarpy et al., 2000). Due to the queen's age, beekeepers lose a lot of colonies in winter and most of their colonies begin the spring season with weak colony population sizes. Queen age is as important as other characteristics for colony productivity (Woyke, 1984; Tarpy et al., 2000).

We conducted this experiment to determine the effects of queen age on some physiological characteristics (survival rate, wintering ability, brood production, worker-bee population and honey yields) of the honeybee colonies under nomad beekeeping conditions in Turkey.

Material and methods

This study was carried out at three different locations in the Republic of Turkey. Apis mellifera anatoliaca colonies, the native honey bee genotype in central Anatolia (Adam, 1983; Güler and Kaftanoğlu, 1999), were used in this experiment. Experimental colonies were housed in standard Langstrooth hives and equalized with respect to colony strength, sealed brood

Parole chiave: Colonia, Area di riproduzione, Capacità di svernamento, Percentuale di sopravvivenza, Produzione di miele.
area and food stocks in early May. Each group consisted of 5 colonies and the queen age combinations were denoted as Group I (reared in April of the same year), Group II (reared one year earlier), Group III (reared two years earlier) and Group IV (reared three years earlier). All queens were reared by grafting one day old larva and placing them in a queenless feeder colony as described by Laidlaw (1979), in the same apiary and from the same genotype (Apis mellifera anatoliaca) but in different years. The queens of each group were sisters. The queens of all groups were reared from the same genotype and exactly known that all queens were close relatives. The same management applications were applied to all colonies through the experiments. All queens were marked with a queen marker to insure the same queens were used throughout the experiment. A different color queen marker had been used for each year to ensure the queens were alive.

Experimental colonies were checked regularly by counting the number of combs covered with bees and brood area were recorded at 21-day intervals. All counting, measuring and records were done at the same time (between 1000 and 1200h) in a day. No measurements were done in the over-winter season. The amount of brood area (cm²) was calculated by using the Puchta method (Fresnaye and Lensky, 1961). The development of the colony was estimated by counting the number of combs covered with bees. Colonies were weighed before and after the harvest to determine the honey yield for each colony as described by Dogarog˘lu, et al. (1992). The first honey harvest was taken in central Anatolia (Nigde) from wild flowers in late July; the second harvest was taken at southeastern Anatolia (Urfa) from cotton (Gossypium spp.) fields in middle of August; and the third harvest was taken in the East-Mediterranean (Hatay) from western heath-garrigues (Erica manipuliflora) in late November.

We could not continue to pick up the data in the second year because most of the queens older than two years had died.

Colony characteristics were statistically analyzed by Repeated Measure (GLM), honey yield and wintering ability analyses were performed using a randomized plot design (ANOVA). Group comparisons among the means were done with Duncan’s multiple range test. Analysis of survival rate between queen age groups was performed by Chi Square (χ²) tests. (Cooley and Lohnes, 1971; Bek et al. 1989; Genç et al. 1999; Görgülü and Şahinler, 2006).

**Results and discussion**

**Adult bee population**

The average numbers of combs with adult bees of the groups are shown in Figure 1. The average numbers of combs with bees were found to be 10.92±0.78 in group I, 14.68±0.55 in group II, 10.10±0.60 in group III and 7.88±0.45 number/comb in group IV, respectively. Differences among the groups of adult bee populations (df=3, M.S.=321.5, F=42.5, P<0.01, Duncan M.S.(Error)=0.94, N=5, α=0.05) were found to be significant (P<0.01). Group II reached the highest and group IV reached the lowest colony population. The number of combs with bees for the group II was 90% higher than group IV and 30% higher than group I and group III. The results of this research regarding the number of combs
Figure 1. Average number of frame with bees through the experiment.

Number of frames which were covered with bees

Observation Dates

with bees were found to be in agreement with previously reported data (Woyke, 1984; Kaftanoğlu et al., 1988; Genç, 1992; Dodoloğlu and Genç, 2001; Akyol et al., 2007).

Brood production
Average brood production of the experimental groups is shown in Figure 2.
Average brood areas of group I, group II, group III and group IV were 3078±372.5; 3668±460.3; 2215±294.0; 1665.38±241.8 cm² per colony, respectively. Differences among the groups on brood production (df=3, M.S.=31733552.9, F=165.9, P<0.01, Duncan M S. Error=23902.6, N=5, α=0.05) were found to be significant (P<0.01). The groups with young queens (0 and 1 year old) were found to be more prolific than the groups headed by older queens. The brood production of group II was found to be 65% higher than group III and 125% higher than group IV. Brood productions of the groups that have young queens were found to be similar to prior research results (Woyke, 1984; Kaftanoğlu et al., 1988; Doğaroğlu et al., 1992; Genç, 1992; Akyol et al., 1999, 2007; Genç et al., 1999, Akyol and Kaftanoğlu, 2001; Dodoloğlu and Genç, 2001).

Wintering ability and survival rates
The wintering ability and survival rates of the age groups are summarized in Table 1. Differences among the groups, on wintering ability (df=3, M.S.=4415.76, F=5.39, P<0.01, Duncan, N=5, α=0.05) and survival rates (Likelihood Ratio Value=9.033, df=3, Asymp. Sig. (2-sided)=0.029, The minimum expected count=1.25), were found to be significant (P<0.01). The colonies headed by young queens showed better wintering ability.
and survival rates than colonies headed by old queens. The wintering ability of Group I and Group II was found to be similar to previous research results (Genç et al., 1999; Güler and Kaftanoğlu, 1999; Akyol and Kaftanoğlu, 2001). The survival rate of the colonies headed by young queens is similar with other research data (Genç, 1992; Akyol and Kaftanoğlu, 2001).

**Honey yield**

The average honey yield of the group I, II, III and IV was found to be 31.4±1.89, 41.5±1.05, 20.4±2.62 and 12.0±1.41 kg/colony respectively. Group II produced the most honey and group IV produced the least honey (Table 1).

Differences among the groups on honey yield (df=3, M.S.=827.2, F=48.9, P<0.01, Duncan, N=5, α=0.05), were found to be significant (P<0.01). The average honey yield of group II was found to be 104% higher than group III and 350% higher than group IV. The honey yield of group I and group II were found to be similar to some reported research data (Doğaroğlu et al., 1992; Genç, 1992; Genç et al., 1999; Güler and Kaftanoğlu, 1999; Akyol and Kaftanoğlu, 2001) and was found higher than Akyol et al. (2007) results.

The main reason for the differences among the groups in the current study could be the age of the queens, but it also could be affected by the sample size of colonies in each group. Similarities and differences were found between the current study and the previous studies on wintering ability, survival rates, brood production, adult bee populations and honey yields. The main reasons for these differences among the different studies could be altitude, climatic conditions, geographic region, flora of experiment areas, years, source of genotypes and different...
management conditions (Pankiw and Page, 2001).

### Conclusions

The results of this study support the previous data that the queen’s age is one of the most important factors affecting the productivity of colonies (Woyke, 1971;GENÇ, 1992; AKYOL et al., 2007). The best results were obtained from group I and group II which had younger queens than other groups. It was also calculated that there was a strong relationship between the queen age and brood production ($r=-80.2$), colony strength ($r=-62.5$), honey yield ($r=-75.6$), and decrease of colony population in winter ($r=66$). A positive and high correlation between honey yield and colony strength ($r=99.5$) and brood production ($r=97.5$) was also found.

Colonies headed by young queens produced nearly 150% more honey than the national average. Perhaps the use of old queens is one of the main reasons for low honey production per colony in Turkey. Old queens should be replaced, especially after the second year in nomad beekeeping conditions.

### Table 1. Wintering ability, survival rate and honey yield of the experimental groups.

| Groups | Wintering ability (%) | Survival rate (%) | Honey yield (kg/colony) |
|--------|-----------------------|-------------------|-------------------------|
|        | $\bar{x} \pm SE$     |                   | $\bar{x} \pm SE$       |
| I      | 84.3 ± 2.9$^{ab*}$    | 100               | 31.4 ± 1.89$(5)^{b*}$  |
| II     | 88.0 ± 3.7$^a$        | 100               | 41.5 ± 1.05$(5)^{a}$   |
| III    | 46.6 ± 19.0$^{bc}$    | 60                | 20.4 ± 2.62$(5)^{c}$   |
| IV     | 26.8 ± 16.5$^{c}$     | 40                | 12.0 ± 1.41$(5)^{d}$   |
|        | **Average**           | **75**            | **26.3 ± 2.69(20)**    |

*Different letters indicate significant differences among the means ($P<0.01$).

df=3; MS=4415.76; F=5.39, P < 0.01; Duncan, N=5, alpha=0.05
df=3; MS=827.25; F=48.95, P < 0.01; Duncan, N=5, alpha=0.05

### REFERENCES

Adam, B., 1983. In Search of the Best Strains. Northern Bee Books, Hebden Bride, UK.

AKYOL, E., ÖZKÖK, D., Kaya, M.A., 1999. A Study on Determination to the most Suitable Honeybee (A. mellifera) Genotype for Hadim region, with Comparison to Mugla, Local and Caucasian genotypes. J. Tech. Beekeeping 64:10-15.

AKYOL, E.; KAFTANOĞLU, O., 2001. Colony characteristics and the performance of Caucasian (Apis mellifera caucasica) and Mugla (Apis mellifera anatoliaca) bees and their reciprocal crosses. J. Apicult. Res. 40:3-4.

AKYOL, E.; YENİNAR, H.; KARATEPE, M.; KARATEPE, B., ÖZKÖK, D., 2007. Effects of queen ages on Varroa (Varroa destructor) infestation level in honey bee (Apis mellifera caucasica) colonies and colony performance. Ital. J. Anim. Sci. 6:143-149.

Bek, Y., Sabancı, A., İŞIK, A., 1989. Discriminant
QUEEN AGE AND COLONY CHARACTERISTICS

Analysis of Anthropometric Data, pp 335-346 in Proc. 2nd Nat. Ergonomy Congr., National Productivity Center, Ankara, Turkey, Publ. Number 379.

Cooloey, W.W., Lohnes, R.R., 1971. Multivariate Data Analysis. John Wiley and Sons Inc., New York, NY, USA.

Dodoloğlu, A., Genç, F., 2001. Comparison of Some Characteristics of Queens Reared from different Honeybee (Apis mellifera) Genotypes. Mellifera. 1:2-7.

Doğaroğlu, M., Özdemir, M., Polat, C., 1992. Comparisons on performance of important Turkish honeybee (A. mellifera) races and ecotypes in the Thrace region. Turk. J. Vet. Anim. Sci. 16:403-414.

Fresnaye, J., Lensky, Y., 1961. Methods 'Appreciation des Surfaces de vain Dans les colonies Abeilles. Ann.Abeille. 4:369-376.

Genç, F., Dülger, C., Dodaloğlu, A., Kutluca, S., 1999. Comparison of some Physiological Characteristics of Caucasica, Middle Anatolian and Erzurum Honeybee (Apis mellifera) Genotypes. Turk. J. Vet. Anim. Sci. 23:645-650.

Genç, F., 1992. A study on determination of the effects of using different ages queens on colony performance. pp 76-95 in Proc. 1st Beekeeping Seminar East Anatolia, Erzurum, Turkey.

Görgülü, Ö., Şahinler, S., 2006. Repeated measures analysis and some experimental design considerations in Animal Science, Kyrgyzstan - Turkey "Manas" University Journal of Science 7:77-97.

Güler, A., Kaftanoğlu, O., 1999. Determination of Performances of some important races and ecotypes of Turkish Honeybees (Apis mellifera L.) under migratory beekeeping condition. Turk J. Vet. Anim. Sci. 23:577-581.

İnd, A., 1999. Ana Arı Üretimi. Önder Matbaacılık Ltd. Şirketi, Ankara, Turkey.

Kaftanoğlu, O., 1987. Arıcılığın temel prensipleri. J. Tech. Beekeeping 10:7-11.

Kaftanoğlu, O., Düzenli, A., Kumova, U., 1988. A study on determination the effects of queen rearing season on queen quality under Cukurova region conditions. Turk. J. Vet. Anim. Sci. 16:567-577.

Kaftanoğlu, O., Akyol, E., Yeninar, H., 2000. The effect of juvenile hormone analog on the development time and the quality of queen honeybees (Apis mellifera L.) pp 351-357 in Proc. 2nd Int. Conf. Africanized Honey Bees and Bee Mites, Arizona, AZ, USA.

Laidlaw, H.H., 1992. Production of queens and package bees. In: J.H Graham (ed.) The hive and the honey bee. Dadant and Sons Inc., Hamilton, IL, USA, pp 989-1042.

Laidlaw, H.H., 1979. Contemporary queen rearing. Dadant and Sons Inc., Hamilton, IL, USA.

Pankiw, T., Page, R.E.Jr., 2001. Genotype and colony environment affect honeybee (Apis mellifera L.) development and foraging behavior. Behav. Ecol. Sociobiol. 51:87-94.

Woyke, J., 1984. Correlation and interaction between population, length of worker life and honey production by honeybees in a temperate region. J. Apicult. Res. 23:148-156.

Woyke, J., 1971. Correlation between the age at which honeybee brood was grafted characteristic of the resultant queens, and result of insemination. J. Apicult. Res. 10:45-55.

Tarpy, D.R., Hatch, S., Flecher, D.C., 2000. The Influence of Queen Age and Quality During Queen Replacement in Honeybee Colonies. Anim. Behav. 59:97-101