CHANGES IN BODY WEIGHT OF HONEYBEE QUEENS DURING THEIR MATURATION

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Summary

In the years 1998-2004 changes in body weight of honeybee queens were investigated in the period from the emergence from queen cells to the beginning of oviposition. A total of 1173 queens were included in the study. In the period from emergence to insemination there was a substantial decline in queen body weight, the most rapid during the first 36 hours of life. During that time the queens lost ca. 40 mg of their body weight. There was a large variability in measurement results. After the onset of oviposition the body weight recovered to the post-emergence level. The weight of the young queens was influenced by their parentage, nursing colony, the position of the queen cell on the grafting frame and by ambient conditions. In each of the rearing series light queens were the first to emerge to be followed by heavier queens.

Keywords: honeybee queen, body weight, changes, rearing conditions.

INTRODUCTION

The body weight of the queen is indicative of her robustness and is the prime element to be considered in her assessment. Heavy queens have ovaries with many ovarioles and the spermatheca of a larger volume (Rachmatov 1967, Woyke 1971, Szabo 1973, Taranov 1973, Eid et al. 1980). They also lay more eggs (Harbo 1986).

There is no unequivocal evidence of the positive correlation between queen body weight and usability. In the opinion of some investigators heavy bodied queens are more attractive to workers (Szabo 1973 and 1974, Taranov 1973), others do not confirm that relationship (Nelson and Gary 1983). Similarly divergent opinions can be found regarding the rate at which the queens mature. Some hold the opinion that higher body weight makes the queens prone to an earlier start of mating flights (Taranov 1973, Taranov 1977), according to others there is no such relationship (Szabo at al. 1987). There is unanimity of opinion that heavier body weight retards oviposition in the queens that have been artificially inseminated (Harbo 1991, Skowronek at al. 2002). High body weight in the queen is indicative of good condition and of potential longevity which was confirmed by laboratory studies (Avietisjan, Kotova 1963).

Body weight of young queens is influenced by the age at which the young larva is grafted (Woyke 1971, Weiss 1974), by genetic factors (Taranov 1973) and, to a large extent, by rearing conditions (Bilasz 1962, Weiss 1967 and 1974, Taranov 1972, Mayer 1975, Skowronek, Skubida 1988). The weight of young queens is subject to large variation, during their maturation it declines substantially (Zachoval and Krieg 1971, Taranov 1973, Eid et al. 1980, Nelson and Gary 1983).

The objective of this study was to investigate the nature and the rate of the changes in the body weight of honeybee queens during their maturation and to verify selected factors influencing that trait.

MATERIAL AND METHODS

The observations were run in the apiary of the Department of Bee Breeding, Apiculture Division, Research Institute of Pomology and Floriculture, Puławy. They involved young Carniolan queens derived from three lines developed in this Department: *Marynka* (*car Mr*), *GR 1* (*car GR 1*) and *Zosia* (*car Zo*). In the years 2003-2004 daughter queens derived from several queens of the above-listed lines were reared simultaneously in several colonies. The age of the larvae grafted in queen cups was a rough estimate but care was taken so that their age was 12-24 hrs. On reaching the cocoon-spinning stage the larvae sealed in queen cells were moved to incubators to be stored at 34°C and relative humidity of ca. 70%. The queen cells were insulated in cages supplied with food. At the expected emergence time the queen cells were inspected every hour and the weight of all emerged queens was measured. Subsequently, the queens were weighed 3-4, 6-8, 10-12, 15-18, 20-24, and 32-36 hours after emergence. After the 20-24-hour old queens were weighed, 3-4 workers were let in to the cages. The cages with the queens and the workers were placed outside the incubators (at a room temperature of ca. 20°C). A similar procedure was followed after the 32-36-hour old queens were weighed. A part of the queens was transferred to mating hives and inseminated when they reached the age of 7-8 days. The queens were re-weighed immediately after insemination and upon the commencement of egg-laying.

Regardless of the observations described above, in the years 1998-2002 all the queens reared and inseminated in this laboratory were weighed. Queen rearing followed the same protocol as that described for the years 2003-2004. The queens were weighed within the first 24 hours after emergence, during the insemination and upon the start of egg-laying. A total of 816 queens were tested. Within the first 36 hours 357 queens were weighed.

The data were subjected to statistical analysis using the Statistica software. The data were analyzed for variability, significance of differences between groups under comparison, and for correlation between selected values.

RESULTS AND DISCUSSION

The average body weight of queens emerged from queen cells was in excess of 220 mg (Table 1) and decreased consistently over the next hours. By the time the detailed measurements were completed i.e. when the queens were 36 hours of age their body weight fell to 188 mg, a body weight loss of nearly 20%. Shown in Table 1, the last line, the body weight data of 0-24-hour old queens refer to individuals tested in the years 1998-2002. Their average body weight was higher than that of the 0-1-hour old queens reared in the years 2003-2004. The lowest body weight as determined by the tests performed in the years 1998-2004 was found in the queens during insemination (Fig.1). Prior to the onset of egg-laying the body weight of queens increased to reach the level approximating that in the queens that were several hours old.

There was a substantial variability of body weight measurements over all the study periods. Measured by the variation coefficient *U* in some cases it exceeded 10%. The lowest variability was among the egg-laying queens followed by that in queens 32-36 hours of age. The variation

Table 1

Mean body weight of queens during their maturation

Queen age [hrs]	Number of measurements [*n*]	Mean weight [*mg*]	Standard deviation [*S*]	Variation coefficient [*u*]
0 - 1	357	226.71	21.72	9.58
3 - 4	344	221.32	22.93	10.36
6 - 8	347	216.18	20.77	9.60
10 - 12	342	211.09	20.16	9.55
15 - 18	332	205.84	20.14	9.78
20 - 24	313	202.54	19.52	9.63
32 - 36	349	188.26	16.89	8.97
0 - 24	652	230.60	24.20	10.49
inseminated	816	178.70	17.23	9.64
laying	587	217.43	18.94	8.71

in body weight of queens tended to decrease with age even though the age bracket of the tested queens widened. The highest variation for body weight in the queens 0-24 hours of age is understandable given the wide differences in age of the tested queens.

The body weight loss during the first 36 hours of the queens' life occurred at a rate of ca. 1 mg per 1 hr (Fig.1) and was close to linear. During the first hours the body weight loss was slightly faster. Over the period from the age of 36 hours to insemination the rate of body weight decrease was small. The queens lost on average ca. 10 mg over the period of 6 to 8 days, a weight loss rate of 1-2 mg per day. The results obtained in this study indicate that decrease of body weight by the queen occurs mainly during her first two days of life and in that period it is faster than assumed earlier and which was estimated by Taranov (1973) at ca. 7 mg per day. Results similar to ours were obtained by Zachoval and Krieg (1971). According to them queens lose weight first of all during the first 48-hours of their life, with the rate of weight loss levelling off afterwards.

A high and significant correlation was found between body weight measurements in the first days of queens' lives. The correlation coefficients between the measurements of body weight in 0-1 hour-old queens and the remaining ones done until the queens reached 36 hours of age varied from *r=0.738* to *r=0.941*. A slightly lower, although significant correlation occurred between the body weight of queens upon emergence against that of inseminated and egg-laying queens, *r=0.607* and *r=0.465*, respectively.

The parentage of the larvae also affected the weight of the queens. All the queens were of the Carniolan race. However, they belonged to three different lines and were descended from 18 different queens. When compared for line of origin (Table 2) the queens of car Mr line were found to have the highest body weight. The average body weight of the queens of the two remaining lines was similar but lower by ca. 20 mg.

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Table 2

Body weight of 0-1 hour-old queens as affected by their origin

Race and line	Number of measurements [*n*]	Mean weight [*mg*]	Standard deviation [*S*]
car GR1	144	219.43 a	16.99
car Mr	103	241.07 b	25.74
car Zo	91	222.33 a	15.56
Total	338	226.80	21.88

Large variation in the body weight of the queens prompted us to look for the sources of that variation. One of the factors to be checked were the differences in body weight of the queens reared in different years. A comparison showed (Table 3) that the weight of the queens varied over the two years of the study. The rearing conditions of 2003 caused the average body weight of 0-1 hour-old queens to be more that 10 mg higher that of the queens reared in 2004.

Another factor of potential impact on the weight of queens were the conditions in the nursing colony such as colony strength, the percentage of feeding workers, availability of food. In order to check that impact the body weight of queens reared in different colonies were compared. Only those colonies were taken for analysis in which at least 10 queens were obtained per rearing series. Average body weights of the queens obtained from different colonies differed substantially (Table 4) and varied from 210 mg in colony M1 to 262 mg in colony AH. Some of the differences turned out to be statistically valid. The analysis of those data failed to show an effect of the number of queens reared per colony on body weight. The

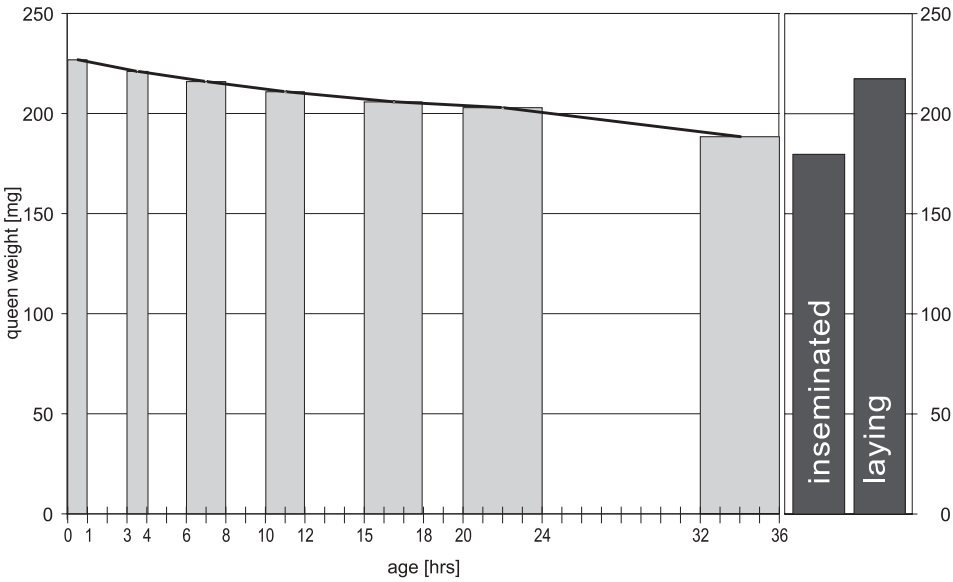

Figure 1. Changes in body weight of queens during their maturation

Table 3

Body weight of 0-1 hour-old queens as affected by year of study

Year of study	Number of measurements [*n*]	Mean weight [*mg*]	Standard deviation [*S*]
2003	162	232.39 a	23.85
2004	195	221.99 b	18.56
Total	357	226.71	21.72

Table 4

Body weight of 0-1 hour-old queens as affected by nursing colony

Nursing colony	Number of measurements [*n*]	Mean weight [*mg*]	Standard deviation [*S*]
M1	12	210.08 a	16.17
DF	26	212.54 ab	15.48
F1	26	214.77 abc	25.10
38	20	216.00 abc	15.19
FI	28	217.25 abc	12.46
H1	26	220.96 abc	19.56
313	31	222.84 abcd	13.90
44	20	224.45 abcd	18.01
L1	24	224.67 abcd	16.61
DK	15	224.93 abcd	14.68
16	14	226.64 abcd	20.08
G1	13	230.31 bcde	9.73
B	22	245.86 efg	13.53
C	14	248.21 fg	20.66
AH	21	262.43 g	17.85
Total	312	225.97	21.68

lightest queens were obtained both in colonies with a small (M1) and with a large number of reared queens and the same was true of the heaviest queens.

It was also checked if the position of the queen cell on the grafting frame could be of any impact on the body weight of the emerging queen (Table 5). The analysis showed that the least-developed queens were obtained when the queen cell was on the upper bar of the frame, significantly heavier queens being obtained from the middle and the bottom bar.

Larvae grafted in queen cups in each

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Table 5

Body weight of 0-1 hour-old queens as affected by position of the queen cell on the grafting frame

Position on the frame	Number of measurements [*n*]	Mean weight [*mg*]	Standard deviation [*S*]
Bottom	66	224.23 b	18.64
Mid-position	64	224.28 b	17.93
Top	65	217.46 a	18.54
Total	195	221.99	18.56

Table 6

Body weight of 0-1 hour-old queens as affected by order of emergence

Order of emergence	Number of measurements [*n*]	Mean weight [*mg*]	Standard deviation [*S*]
0-6 hr	21	217.52 a	18.09
7-12 hr	36	220.08 a	18.49
13-18 hr	42	223.76 a	16.54
19-24 hr	37	224.03 a	17.76
25-30 hr	21	219.29 a	23.54
31-36 hr	15	228.07 a	18.05
37+ hr	4	233.25 a	11.87
Total	177	222.45	18.37

rearing series were usually derived from one comb and their estimated age could vary up to 12 hrs. The emergence of queens from those queen cells lasted for up to 36 hrs. Any lengthening of the emergence period was related to the conditions prevailing in the nursing colony. This notwithstanding, it was to be expected that the order in which the queens would emerge should be dependent on the age of the grafted larva: queens derived from older larvae should emerge earlier which, in line with the previous study by Woyke (1971) should result in lighter queens emerging earlier. To confirm that relationship the body weight of queens was compared in the function of emergence date (Table 6). The analysis did not show significant differences in the body weight of queens emerging on different dates. When the average body weights are compared, though, it is apparent that earlier emerged queens have lower weight than those emerged on a later date.

No correlation was found between queen weight and the length of queen cell. In 195 queen cell measurements length of queen cell as measured from the base to the tip varied from 19 to 31 mm averaging 24.9 mm. The correlation of length of queen cell against the weight of the 0-1 hr old queen that emerged from it was *r=-0.0056*.

CONCLUSIONS

A steady body weight decline occurs in queens emerged from queen cells. During the first 36 hrs it proceeds at a rate of ca. 1 mg per 1 hr and is close to linear. Later on, the rate of body weight decline is slower ranging from 1 to 2 mg per 1 day.

The determination of body weight in queens should be done once they have reached the age of ca. 2 days, earlier measurements carry a substantial error due to a large variation in weight at that time.

Body weight of queens is significantly affected by inherited characters as well as by rearing conditions such as seasonal differences, nursing colony and the position of the queen cell on the grafting frame.

REFERENCES

Avietisjan G.A., Kotova G.N. (1963)- Sodierzanie matok zimoj vnie kluba pczel. *Pčelovodctvo*, 40(9):9-14.

Bilasz G.D. (1962)– Sposoby vyraščivannia matok w gniezdach s otkytym raspłodom. *Pčelovodctvo*, 39(2):27-30.

Eid M.A.A., Ewies M.A., Nasr M.S. (1980)– The weight of the newly emerged honeybee queens as an index of its potential productivity. *Bulletin of Faculty of Agriculture, University of Cairo*, 29:91-111.

Harbo J.,R. (1986)– Oviposition rates of instrumentally inseminated and naturally mated queen honey bees (*Hymenoptera: Apidae*). *Annals of the Entomological Society of America*, 79:112-115.

Harbo J.,R. (1991)– Effect of pupal weight and insemination volume on oviposition of queen bees. *Bee Science*, 1(3):155-158.

Meyer W. (1975)– Jungkönigin, EWK und Insebegstelle. *Allg. Dt. Imkerztg*., 9(6):151-152.

Nelson D.L., Gary N.E. (1983)– Honey productivity of honeybee colonies in relation to body weight, attractiveness and fecundity of the queen. *J. apic. Res*., 22(4):209-213.

Rakhmatov K.K. (1967)– Relation between external and internal characteristics of queen honeybees. *Doklady Moskovsko Selsko-khozaystveno Akademii im. K.A. Timiriazewa*, 132:337-341.

Skowronek W., Kruk C., Kłopot J. (2002)– Factors affecting oviposition of artifically inseminated honeybee queens. *Journal of Apicultural Science*, 46(2):85-95.

Skowronek W., Skubida P. (1988)– Wpływ warunków wewnętrznych rodziny wychowującej i sposobu poddawania larw na liczbę i jakość uzyskanych matek. *Pszczeln. Zesz. Nauk.*, 32:3-18.

Szabo T.I. (1973)– Relationship between weight of honey-bee queens (*Apis Mellifera* L.) at emergence and at the cassation of egg laying. *Am. Bee J*., 113(7):250-251.

Szabo T.I. (1974)– Behavioral studies on queen introduction in the honeybee 2. Effect of age and storage conditions of virgin queens on their attractiveness to workers. *J. apic. Res*., 13(2):127-135.

Szabo T.I., Mills P.F., Heikel D.T. (1987)– Effect of honeybee queen weight and air temperature on the initiation of oviposition. *J. apic. Res*., 26(2):73-78.

Taranov G.F. (1972)– Privivka ličinok. Pčelovodctvo, 51(4);11-12.

Taranov G.F. (1973)– Ves matok i ich kačestvo. *Pčelovodctvo*, 52(1):27-29.

Taranov G.F. (1977)– Ablegerbildung und Einweiselung in grossen Zuchtbetrieben. *Apiacta*, 12(1):5-10.

Weiss K. (1967)– Über den Einfluss verschidenartigen weiaelwiegen auf die Annahme und das Königinnengewicht in der Künstlichen Nachschaffugszucht. *Z. Bienenforch.*, 9(3):121-134.

Weiss K. (1974)– The weight of honeybee queens seen in dependance of the larva's grafting age and its food supply. *Apidologie*, 5(2):127-147.

Woyke J. (1971)– Correlations between the age at which honeybee brood was grafted, characteristics of the resultant queens, and results of insemination. *J. apic. Res.*, 10(1): 45-55.

Zachoval J., Krieg P. (1971)– Zmena vahy matek po vylihnuti. *Vcelarstvi*, 24(1):10-11.

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ZMIANY MASY CIAŁA MATEK PSZCZELICH W OKRESIE ICH DOJRZEWANIA

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S t r e s z c z e n i e

W latach 1998=2004 badano zmiany masy ciała matek w okresie od wygryzienia z mateczników do rozpoczęcia przez nie czerwienia. Obserwacjom takim poddano w sumie 1173 matki, wszystkie rasy kraińskiej z 3 linii selekcjonowanych w Oddziale Pszczelnictwa ISK w Puławach. W okresie od wygryzienia do inseminacji następował u matek znaczny ubytek masy ciała, najszybszy podczas pierwszych 36 godzin życia. W tym czasie matki traciły około 40 mg masy ciała. Występowała duża zmienność w wynikach pomiarów. Po rozpoczęciu czerwienia masa ciała matek zwiększała do poziomu po wygryzieniu. Na masę ciała młodych matek miał istotny wpływ ich pochodzenie, rodzina wychowująca, miejsce matecznika w ramce wychowującej i warunki środowiskowe podczas wychowu. Nie stwierdzono korelacji między długością matecznika a masą wychowywanej w nim matki. W poszczególnych seriach wychowu wcześniej wygryzały się matki lżejsze w dalszej kolejności matki cięższe.

Słowa kluczowe: matka, masa ciała, zmiany, warunki wychowu.