

EFFECT OF INJURY TO HONEYBEE QUEENS ON EGG LAYING RATE AND COLONY STRENGTH

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S u m m a r y

In the years 1998 - 2001 the effect of injury to honeybee queens on their egg laying rate was tested in Puławy. The observation comprised 225 queens that were naturally or instrumentally inseminated in colonies established in Dadant hives.

The majority of queens (122 individuals, 55%) showed injuries to some of their body parts. Of these, 80 queens accounting for 65% of the damaged ones had mainly arolia injuries (black, dry and inactive arolia or arolia completely or partly missing group B). Thirty-three individuals accounting for 27% of the injured queens sustained more serious injuries such as one or more legs paralyzed, a whole leg or its part missing (group C). Yet another group was distinguished in which queens had damaged antennae (group D 8%). Non-injured queens, group A, accounted for 45% of the total number.

Among naturally inseminated queens 67% were non-injured queens. Conversely, in the artificially inseminated group the injured queens accounted for as many as 68% of the total. There were 52 queen supersedures (23% of the monitored queens). The majority of supersedures were in groups B and C (68%). The supersedure was most frequent in the second year of the queen's life.

Naturally inseminated queens were superseded less frequently (16%) than artificially inseminated queens (31%).

Colonies with non-injured and with injured queens differed but slightly for the number of brood and for the strength as measured during the 1st inspection and in the 3rd decade of June. The differences were not significant.

Also, 72 non-inseminated queens were kept for 7 days in two queenless colonies (queen banks). Once that period passed, queens were evaluated for the kind of injury, percent of injured queens and mortality rate. Injured queens accounted for 84% in one colony and for 57% in the other. Queen mortality rate in the queenless colonies was ca. 34%.

Although the injuries to the queens did not affect significantly their egg-laying rate but they had an impact on the rate of supersedure.

Keywords: honeybee queen, injury, egg-laying rate, supersedure.

INTRODUCTION

Honeybee queens are injured by worker bees that tend them before and after insemination in nurse colonies (queen banks), the legs being injured most frequently (Woyke et al. 1956, Jasiński and Fliszkiewicz 1995, Jasiński 1995). The rate of injury to the queens depends on many factors such as type of cage used, number of reared queens,

size of the opening in the cage through which bees communicate with the queens, age of attendant bees. The number of injured queens may reach as much as 52% (Jasiński 1995).

Rearing the queens outside the colony in cages of various types with different numbers of attendant bees is also no guarantee that the queens will be damage-free. An additional factor that increases the aggres-

siveness of worker bees against the reared queens is infestation of bees by the mite *Varroa destructor* (Jasiński and Trzybiński 1991).

The queens are also injured during their introduction to colonies and to nucleus hives. It applies chiefly to artificially inseminated queens (Jasiński 1977) introduced when they are more than 6 days of age. According to Levchenko and Moskalenko (1978) such queens produce the greatest amounts of queen substance which makes the bees more aggressive to queens. Young queens shortly after emergence produce little queen substance (Butler 1960, Hazan et al. 1989) which makes them better accepted. Injured queens are also found among naturally inseminated queens. In addition, during frequently happening robbery events bees also behave aggressively towards the queens and while clustering them they injure their legs.

Honeybee queens are attractive to bees in spite of the injury and upon introduction to the colonies their acceptance is just as good as that of non-injured queens. (Wilde and Loc 1997). It was found that supersedure of injured queens is more frequent than that of non-injured queens (Gerula et al. 2000). It causes many problems in breeding apiaries since supersedure of breeding queens is tantamount to loss of a valuable genetic stock.

It is suspected that injury to the feet and to the arolia affect negatively the secretion of tharsal gland pheromones thereby increasing the proneness of bees to supersedure (Lensky et al. 1984). The aim of the study was to examine to what extent injuries to honeybee queens put the latter at disadvantage at egg laying and whether the injury affects the longevity of injured queens and lastly, to determine the kind of injury that qualifies the queens to be culled before introducing to colonies.

MATERIAL AND METHODS

The study was run at the Apiculture Division, Research Institute of Pomology and Floriculture, Puławy, Poland, in the years 1998 - 2001. The observations comprised 225 naturally and artificially inseminated honeybee queens reared in colonies established in Dadant hives and 72 queens kept in cages of various kinds in nurse colonies. Three kinds of cages were used: plastic cages with slot dimensions of 26 x 2.6 mm used to isolate queen cells, Zander cages with mesh size of 2.5 x 2.5 mm and mailing cages made by OSP Kraków with slot dimensions of 9 x 1.4 mm.

The queens were unhomogeneous genetically and originated from different rearing series. The artificially inseminated queens were kept in cages with 30 attendant bees before and after insemination, the queens being moved to new cages with new attendant bees after insemination. Following the second CO₂ application the queens were introduced to nucleus hives and, once the egg laying started, were moved to regular colonies. The queens to be inseminated naturally were introduced to nucleus hives either shortly after leaving the queen cells or following a short period in cages with attendant bees. When they started egg laying, the queens were introduced to regular colonies. Ca. 8% of naturally inseminated queens had emerged from the cells in colonies in which they remained for life.

On the arrival to colonies the queens were inspected for injuries and for type of injury. In the first production year, the second year of a queen's life, assessment was made of colony strength, and the propensity to supersede was monitored until the end of the beekeeping season of 2001.

The ability of the queens to brood production was assayed by taking counts of the number of brood-containing combs against the total number of combs covered with bees during the first spring inspection and

during the inspection in the 3rd decade of June.

The checked queens were divided into four groups that differed for the type and extent of injury:

- group A - non-injured queens
- group B - queens with injured arolia
- group C - queens with paralyzed legs or with missing entire legs or parts thereof
- group D - queens with damaged antennae

In addition, during 7 days after leaving the queen cells 72 young queens were kept in two queenless colonies in which they had emerged (queen banks). The injury to queens was evaluated, the percentage of injured queens was calculated and their mortality was scored. Some of the injured queens, upon their introduction to colonies, were used to study the effect of injury on the ability of queens to produce brood. Two queenless colonies were used to rear and to keep queens. In each of the colonies 90 larvae were grafted in beeswax cell cups. The first colony reared 73 queens and the second one 18 queens only. In the first colony shortly before emergence 16 queen cells were isolated in plastic queen cages, 18 in Zander cages and 20 in delivery

cages. The queens were kept for 7 days from emergence.

The data were subjected to ANOVA and the differences were tested for significance using Duncan test at significance level of $p \leq 0.05$

RESULTS

Injuries to queens established in colonies in Dadant hives

Of the total number of 225 queens 46% were naturally and 54% artificially (instrumentally) inseminated. Of these, 122 queens (55%) were injured and 103 queens (45%) were uninjured. Of the naturally inseminated queens only 38% were injured whereas among the instrumentally inseminated queens the injured insects accounted for 68% or twice as many. The percentage of queens in the injury groups for naturally and artificially inseminated queens is shown in Fig. 1.

Among the injured queens 80 (65%) had damaged arolia - group B, in 33 injured queens (27%) the injury consisted in missing parts of the legs or paralyzed legs - group C, the remaining 9 queens (ca 8%) had injured antennae.

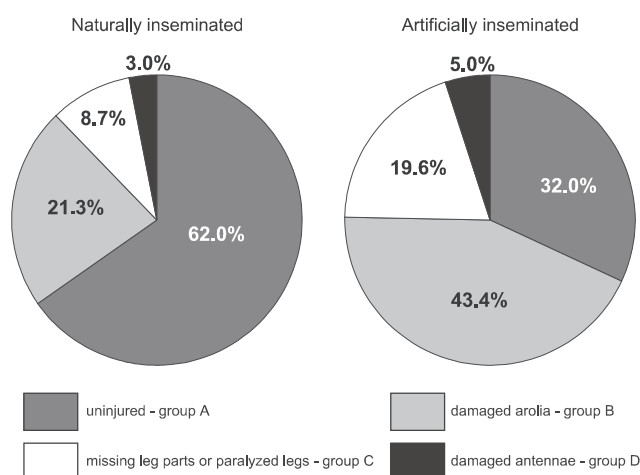


Fig. 1. Percentage of queen injury groups among naturally and artificially inseminated queens.

Table 1

Type and number of injuries to queens following a period in nurse colonies

Type of injury	number	percentage
change to arolium pigmentation (black)	55	66.3
missing arolia	3	3.7
missing two foot segments	8	9.1
missing three foot segments	5	6.1
missing four foot segments	3	3.7
mutilated wings	4	5.0
shorter antennae	2	2.5
missing claws	3	3.6
Total	83	100.0

A part of the queens (38) were inspected through the microscope in successive years. It was found that 24 of them had more injuries than initially. Therefore, the injuries were not sustained only during queen rearing and their introduction but were inflicted also in the subsequent periods.

Injuries to non-inseminated queens in queenless nurse colonies (queen banks)

The queen losses were 35.2% in the first colony and 27.7% in the second colony, the average being 33.3%. The percentage of injured queens was greater in the nurse colony that reared fewer queens (84.6%) compared to that with more queens (57.1%). All in all, the injured queens

accounted for 64.6% of the total number. Types of injury in both colonies are listed in Table 1.

The highest mortality was observed in plastic cages with the greatest slot dimensions (48%). In Zander cages the mortality was 33.3% and in delivery cages it was only 10.3%. The percentage of injured queens was the highest in delivery cages (70.5%) and it was 61% in the remaining cages.

Queen supersedure

A total of 52 queens were superseded (23% of those monitored). The majority of them (79%) were injured queens. Unfortunately, not all queens were monitored until

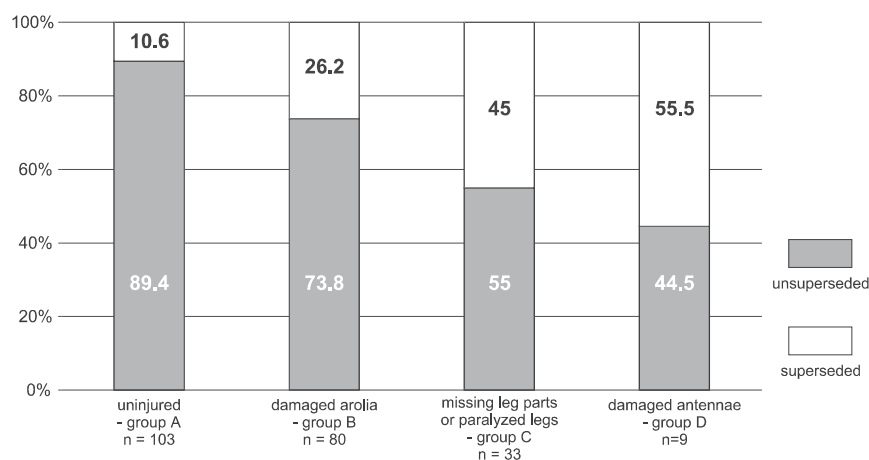


Fig. 2. Percentage of superseded queens in injury groups

their natural death. Some of them due to various reasons were replaced earlier. Artificially inseminated queens were superseded twice as frequently (31% of the total artificially inseminated queens) than naturally inseminated queens (13% of their total number). The relationship was related to the fact that injured queens accounted for a higher percentage of the artificially inseminated queens than naturally inseminated queens indicating a connection between supersedure and queen injury. The percentage of superseded queens increased with extent of injury (Fig. 2).

The majority of queens (51%) were superseded in the second year of their life and 8% were superseded as early as the birth year. Supersedure rate was 31% and 10% in the third and the fourth year, respectively. The queens superseded in the birth year had injuries that qualified them as group C (the severest leg injuries). Among the queens superseded in the second and in the third year were queens of all injury groups. The few queens that were superseded as late as in the fourth year belonged to group B (Fig. 3).

Injury to queens vs. colony strength

On the first inspection that carried out in the third decade of June colonies with natu-

rally inseminated queens were found to be superior to colonies with artificially inseminated queens with regard to number of brood and number of occupied combs. The differences were highly significant (Table 2).

Averaged for the injury groups colonies with naturally inseminated queens had from 2.3 to 2.6 brood combs on the first inspection and from 6.5 to 7.6 combs in June (Fig. 4). Colonies with instrumentally inseminated queens had slightly less brood within groups averaging from 1.7 to 2.1 brood combs on the first inspection and from 4.3 to 5.8 brood combs in June. The group to group differences within the same insemination treatment were not significant.

The amount of brood in the colony reflected the colony strength expressed as the number of combs covered by bees. Colonies with naturally inseminated queens occupied from 4.6 to 5.0 combs on the first inspection and from 10.7 to 11.0 combs in June. Colonies with artificially inseminated queens were slightly weaker since they occupied from 4.4 to 4.8 combs on the first inspection and from 8.8 to 10.2 combs in June. The group-to group differences were not proved statistically (Fig. 5).

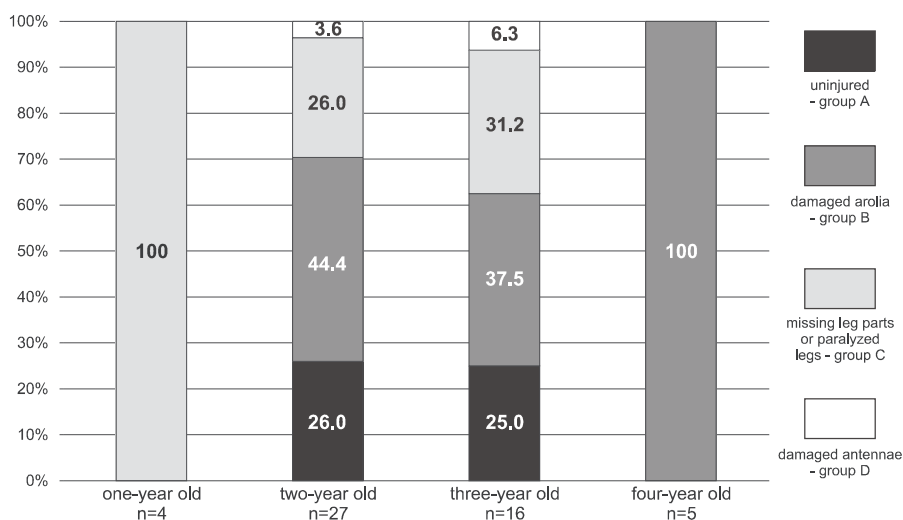


Fig. 3. Percentages of queens belonging to different injury groups at the age of 1, 2, 3, and 4 years

Table 2
Mean number of brood-containing combs and total number of combs in colonies with naturally and artificially inseminated queens

Insemination	Characteristics			
	Number of brood combs		Total number of combs covered with bees	
	First inspection	3rd decade of June	First inspection	3rd decade of June
natural	2.5 a	6.7 a	4.9 a	10.8 a
instrumental	2.0 b	5.7 b	4.5 b	9.9 b

means in the columns followed by different characters are significantly different

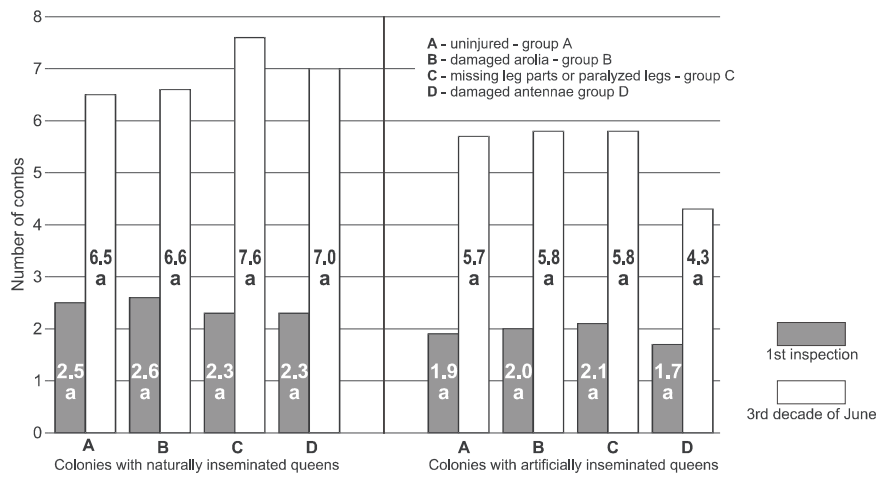


Fig. 4. Mean number of brood combs in colonies with naturally and artificially inseminated queens

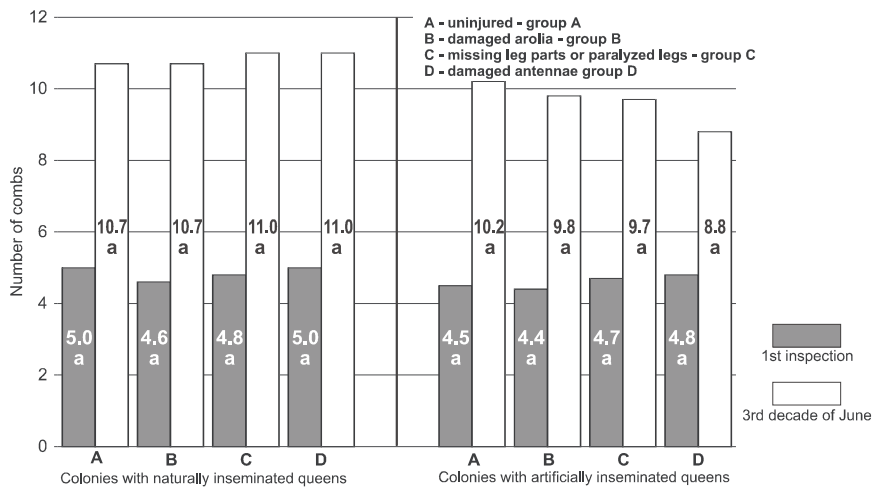


Fig. 5. Mean number of combs covered by bees in colonies with naturally and artificially inseminated queens

DISCUSSION

The data from this study are remarkable for large differences between artificially and naturally inseminated queens for the number of injured individuals. It seems that the differences were related to the way in which both queen categories were handled from the emergence from queen cells to the acceptance by regular colonies and, first of all, they were related to how many times the queens came into contact with bees which were new to them. The naturally inseminated queens came into contact with new bees fewer times (0 to 3) than the artificially inseminated queens (3 - 5). This observation is supported by the research data of Jasiński (1995), Jasiński and Fliszkiewicz (1995) and Jasiński and Trzybiński (1991). Those results give evidence that queens caged in colonies (queen banks) or introduced in colonies are very often damaged by bees strange to them. However, there is an opinion expressed by Jasiński (1977) that artificially inseminated queens are accepted less willingly by worker bees than naturally inseminated queens. Therefore, it can be suspected that queen injuries described in this study came about only when the queens were introduced to nucleus hives or to regular beehives.

This study demonstrated that the supersedure of artificially inseminated queens was more frequent than that of naturally inseminated queens. It is probably related to a much higher percentage of injured queens among artificially inseminated queens. Admittedly, Wilde and Loc (1997) argued that injured queens were accepted just as well as uninjured queens but those investigators did not keep track of further fate of those queens. The argument that queen injury affected supersedure is backed up by a very high percentage of supersedure of severely damaged queens, damage to antennae being qualified as such. Likewise, paralysis of an entire leg or an

entire foot missing prevented a queen from normally functioning in the colony, 45% of such queens having been superseded soon after they started egg laying. The relatively high rate of supersedure among injury-free queens points to the effect of factors other than injuries on supersedure.

Injuries to arolia are, according to Jasiński (1995), debilitating injuries. The results from this study support that opinion to a certain extent. Supersedure rate in that group was 25% which was 1.5 times more than in the uninjured group whereas in groups C and D superseded queens accounted for 45 and 55.5% of the total number of queens which was 4.5 and 5.5 times more than in the uninjured group.

The rate of injury to queens in nurse colonies also depended on the individual attitude taken by bees in these colonies towards the queens. The percentage of injured and dead queens differed at the end of the retaining period in both colonies. The data from this study bore out those obtained by Jasiński (1995) who found Zander cages to be the most suitable to raise queens in colonies. However, the number of injured queens was higher in this study,

CONCLUSIONS

1. Naturally inseminated queens sustain injuries less frequently than artificially inseminated queens.
2. Supersedure of artificially inseminated queens is twice as frequent as that of naturally inseminated queens.
3. A relatively high rate of supersedure of uninjured queens indicates that the impact of factors other than injury is involved.
4. More than half the cases of supersedure occur in the second year of queen life.
5. Queens with a paralyzed leg, missing leg or missing a leg part are superseded already in the birth year.

6. Colonies with naturally inseminated queens produce more brood and make stronger colonies than those with artificially inseminated queens.
 7. With regard to colony strength indicators it is only in the artificially inseminated group that colonies with injured queens are but slightly inferior to colonies with injury-free queens
 8. Queens with paralyzed legs, with missing legs or parts thereof and with damaged antennae should be culled due to a high probability of supersedure even as early as in the birth year.
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WPLYW USZKODZEŃ MATEK PSZCZELICH NA INTENSYWNOŚĆ ICH CZERWIENIA I SIŁĘ RODZIN PSZCZELICH

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

W latach 1998-2001 w Puławach sprawdzono wpływ uszkodzeń matek pszczelich na ich zdolność do intensywnego czerwienia. Obserwacjami objęto 225 matek pszczelich naturalnie i sztucznie unasienionych w rodzinach osadzonych w ulach Dadanta.

Większość matek 122 sztuki (55%) miały uszkodzenia niektórych części ciała. Wśród nich 80 matek (65% uszkodzonych) miała głównie uszkodzone przyłgi (czarne, suche i nieaktywne, częściowy lub całkowity ich brak grupa B). 33 sztuki (27% uszkodzonych) miały poważniejsze uszkodzenia jak paraliż jednej lub więcej nóg czy brak całej nogi lub jej części (grupa C). Wyodrębniono jeszcze jedną grupę gdzie matki miały uszkodzone czułki grupa D (8%). Matki nieuszkodzone grupa A stanowiły 45%.

Wśród matek naturalnie unasienionych 67% stanowiły matki nieuszkodzone. Inaczej było w grupie matek unasienionych sztucznie gdzie uszkodzonych było aż 68%. Pszczoły wymieniły 52 matki (23% poddanych obserwacji). Najwięcej było wśród nich matek z grup B i C (68% wymienionych). Wymiana miała miejsce najczęściej w 2 roku ich życia.

Matki pszczele naturalnie unasienione były rzadziej wymieniane przez pszczoły (16%) niż matki sztucznie inseminowane (31%).

Rodziny pszczele z matkami nieuszkodzonymi i uszkodzonymi różniły się tylko nieznacznie między sobą pod względem ilości posiadanego czerwiu i siły mierzonej podczas 1 przeglądu i w 3 dekadzie czerwca. Różnice te były nieistotne.

Przechowywano również 72 matki nieunasienione przez 7 dni w 2 osieroconych rodzinach pszczelich (bankach matek). Po tym okresie oceniono rodzaj uszkodzeń matek i obliczono procent matek uszkodzonych i ich śmiertelność. Matki uszkodzone stanowiły 84% w jednej i 57% w drugiej rodzinie. Śmiertelność matek przechowywanych w rodzinach przechowujących wynosiła średnio 34%.

Uszkodzenia matek wprawdzie nie wpłynęły znacząco na ich zdolność do intensywnego czerwienia jednak przyczyniły się do tego, iż takie matki były częściej wymieniane przez pszczoły.

Słowa kluczowe: matka pszczoła, uszkodzenia, czerwienie, cicha wymiana matki.