EFFECT OF SOME FACTORS ON BROOD SURVIVAL IN A BEE COLONY

Cezary Kruk, Wojciech Skowronek
Research Institute of Pomology and Floriculture, Apiculture Division,
ul. Kazimierska 2, 24-100 Pulawy, Poland, e-mail: wojciech.skowronek@man.pulawy.pl
Received 14 October 2001; accepted 12 December 2001

Summary

The effect of different genetic and environmental factors on the survival rate of brood in honeybee colonies was assessed. The survival rate assessment was made in 2 - 3 day-old and in 7-8 day-old larvae and in pupae the day before the bees emerged from the comb.

The survival rate of brood was not found to be significantly affected by season of brood rearing, breed or queen age even though a slightly higher survival rate was recorded for the brood reared from the eggs laid by queens of younger age and of the Caucasian breed. There was a significant beneficial effect of increased brood compactness and of increased number of eggs laid in the comb. The queens laid eggs in the comb cells with the foundation-supporting wire threaded underneath but more than half of the young brood was removed from the cells by worker bees.

Keywords: brood rearing, survival, environmental factors.

INTRODUCTION

The number of reared bees in the colony is the outcome of colony strength, queen fertility, and brood survival rate, the latter being affected by different genetic and environmental conditions. Well known is the reduction in brood survival rate brought about by the homozygosity of sex alleles (Woyke 1963, 1984, 1996, Page, Laidlaw, Erickson 1981). Among the environmental factors the shortage or poor quality of food, (Taber 1977, Skowronek 1979, Woyke 1979, Soszka 1996), the failure to maintain the right nest temperature (Stoner et al. 1979), and a contamination of the environment (Gromisz M. 1999, Gromisz Z., Gromisz M. 1996) are the most frequent causes of reduced brood survival.

The aim of the study was to examine the factors that may influence the survival of honeybee brood. Attention was also paid to other less known or unknown factors that might affect brood survival.

MATERIAL AND METHODS

The study was conducted in the apiaries of the Apiculture Division, Research Institute of Pomology and Floriculture, in the years 1998 - 2000. Two honeybee breeds were included in the study: Caucasian (A. m. caucasica) and Carniolan (A. m. carnica). Alongside with that a comparison was made of the survival of brood hatched from the eggs laid by one-year old vs. two-year old queens. The brood was scored for survival rate in three different periods of the season: intensive colony development (eggs laid in the second half of May), intensive nectar flow (second half of June) and after the nectar flow ends (end of July and August). A total of 92 honeybee colonies were assessed for brood survival.

The experimental brood was obtained by isolating the queen with an excluder
screen for 24 hrs on an empty comb placed in the brood nest center. Upon the queen’s release the eggs and after five days the 2 -3-day old larvae hatched therefrom were counted. The number of eggs laid by the isolated queen varied over the replications from 225 to 1156. Once the assessment was made the experiment comb was taken out of the excluder and left in the nest among other brood-containing combs. If left in the excluder the brood would not have had proper conditions for its development. In order to prevent the queen from laying additional eggs on the assessment comb she was separated on other combs. The subsequent assessment of brood survival was made after the next 5 days when the larvae reached the age of 7 - 8 days (sealed brood). The final records of brood survival were taken a day before the expected date of emergence from the cells.

RESULTS AND DISCUSSION

The brood survival rate assessed for the whole period of development and based upon all observations was 75.1% (Fig. 1). The greatest brood losses occurred from egg laying to the stage of 2-3 day old larva (17.4%) and they included non-hatched eggs and young larvae removed from the cells. Among those losses are also young larvae eaten by the bees as the result of the homozygosity for sex alleles. Another 6.9% of the larvae perished in the stage before brood sealing. During the sealed brood stage the losses were minimal (0.6%). It may be expected that some losses will occur also at the stage of bee emergence. However, that could not be demonstrated because of technical difficulties. Attempts to estimate the numbers of emerging bees by placing the comb in an incubator shortly before the expected date of completed development failed to yield positive results. Under laboratory conditions a certain number of well-developed individuals failed to cut their way out of the cells. However, in a beehive situation, assisted by their fellow bees present on the comb, those individuals would have emerged as fully capable adults. On the other hand there is also a certain error involved when combs remaining in the beehive are assessed for bee emergence rate - counts of emerged individuals might include those that died in the cells and were subsequently removed. Because of those considerations the assessment of brood survival rate was ended with a count of pupae on the last day before the expected date of adult bee emergence.

![Surviving rate of the brood developing stages in relation to the number of laid eggs.](image)

Fig. 1. Surviving rate of the brood developing stages in relation to the number of laid eggs. Przeżywalność czewiu w różnych stadiach rozwojowych w stosunku do liczby złożonych jaj.
There were no remarkable differences in brood survival rate between different breeds (Table 1). Although the observed survival rates for the brood hatched from the eggs laid by Caucasian queens were consistently higher in all development stages the superiority was not statistically significant. It was due to a high variability of results within replications. It is reasonable to suppose that should the numbers of observations had been higher those differences could have proven to be significant.

Likewise, no significant differences were observed in the survival rate of the brood hatched from eggs laid by queens of different age (Table 2). Nevertheless, the differences in favour of the brood hatched from eggs laid by younger queens were noticeable being more than 4% at the stage immediately prior to emergence. As in the case of the breed-related differences there are reasons to believe that those differences might have been significant should the number of observations had been higher.

No significant differences were found for brood survival over different times of the season (Table 3). The differences in survival rate were slightly increased for young larvae. As the larval development progressed those differences levelled off.

Apart from the survival rate affecting factors that were included in the planning stage of the study other factors were noticed during the observations that clearly influenced brood survival. One of them was brood compactness. When the brood combs were grouped into those in which all cells carried the brood and those in which cells

Table 1
Brood survival rate as affected by breed.
Przeżywalność czerwia u różnych ras pszczoł.

<table>
<thead>
<tr>
<th>Breed Rasa</th>
<th>N Liczba obserwacji</th>
<th>0-24 h eggs 0-24 h jaja (%)</th>
<th>2-3 day old larvae 2-3 dn. larwy (%)</th>
<th>7-8 day old larvae 7-8 dn. larwy (%)</th>
<th>Brood before emergency Czerw przed wygrzywieniem (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caucasian Kaukaska</td>
<td>51</td>
<td>100.0</td>
<td>84.9 a</td>
<td>79.9 a</td>
<td>79.3 a</td>
</tr>
<tr>
<td>Carniolan Kraňska</td>
<td>41</td>
<td>100.0</td>
<td>80.6 a</td>
<td>72.1 a</td>
<td>71.6 a</td>
</tr>
</tbody>
</table>

Significant differences at P<0.05

Table 2
Brood survival rate as affected by queen age.
Przeżywalność czerwia w zależności od wieku matki.

<table>
<thead>
<tr>
<th>Queen age Wiek matki</th>
<th>N Liczba obserwacji</th>
<th>0-24 h eggs 0-24 h jaja (%)</th>
<th>2-3 day old larvae 2-3 dn. larwy (%)</th>
<th>7-8 day old larvae 7-8 dn. larwy (%)</th>
<th>Brood before emergency Czerw przed wygrzywieniem (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>One-year old Jeden rok</td>
<td>51</td>
<td>100.0</td>
<td>83.7 a</td>
<td>77.6 a</td>
<td>77.0 a</td>
</tr>
<tr>
<td>Two-year old Dwa lata</td>
<td>41</td>
<td>100.0</td>
<td>81.2 a</td>
<td>73.3 a</td>
<td>72.8 a</td>
</tr>
</tbody>
</table>

Significant differences at P<0.05
Brood survival rate as affected by time of season.
Przeżywalność czerwiu w zależności od pory roku.

<table>
<thead>
<tr>
<th>Time of season</th>
<th>N Liczba obserwacji</th>
<th>0-24 h eggs 0-24 h jaja (%)</th>
<th>2-3 day old larvae 2-3 dni larwy (%)</th>
<th>7-8 day old larvae 7-8 dni larwy (%)</th>
<th>Brood before emergency Czerw przed wygryzieniem (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>May Maj</td>
<td>31</td>
<td>100.0</td>
<td>81.7 a</td>
<td>75.9 a</td>
<td>75.4 a</td>
</tr>
<tr>
<td>June Czerwiec</td>
<td>30</td>
<td>100.0</td>
<td>79.7 a</td>
<td>74.6 a</td>
<td>74.4 a</td>
</tr>
<tr>
<td>July Lipiec</td>
<td>31</td>
<td>100.0</td>
<td>85.4 a</td>
<td>76.2 a</td>
<td>75.4 a</td>
</tr>
</tbody>
</table>

Significant differences at $P<0.05$

Brood survival rate as affected by compactness of oviposition.
Przeżywalność czerwiu w zależności od zawartości zasiewu.

<table>
<thead>
<tr>
<th>Compactness of the oviposition Zawartość zasiewu</th>
<th>N Liczba obserwacji</th>
<th>0-24 h eggs 0-24 h jaja (%)</th>
<th>2-3 day old larvae 2-3 dni larwy (%)</th>
<th>7-8 day old larvae 7-8 dni larwy (%)</th>
<th>Brood before emergency Czerw przed wygryzieniem (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tight Zwarty</td>
<td>32</td>
<td>100.0</td>
<td>86.6 a</td>
<td>77.6 a</td>
<td>81.0 a</td>
</tr>
<tr>
<td>Loose Rozstrzelony</td>
<td>30</td>
<td>100.0</td>
<td>71.2 b</td>
<td>65.4 b</td>
<td>64.9 b</td>
</tr>
</tbody>
</table>

Significant differences at $P<0.05$

with eggs were interspersed with empty cells it became apparent that the compact brood showed a higher survival rate (Table 4). Assessed after cell capping the survival rate of the tightly spaced brood was more than 16% higher than that of the loose brood. The differences proved to be statistically valid over all development stages.

The other factor that was shown to influence brood survival rate was the number of eggs deposited by the queen on a separated comb. More eggs laid by the queen resulted in an increased survival of the brood whereas fewer eggs resulted in reduced survival. When all the combs were divided into high and low egg number combs the differences proved to be substantial and significant (Table 5). The greatest differences were for the survival of eggs and young larvae (9%) being only 7% at more advanced development stages.

The effect of the amount and the compactness of the brood on its survival rate can be explained by factors inherent in the queens themselves and by the conditions of brood development. A queen that oviposits intensely and in all the cells (compact brood) is more likely to lay better developed eggs and to use more sperm cells to fertilize them. Supposedly, a larger surface of compact brood ensures better thermal conditions for the developing larvae and pupae.
Brood survival rate as affected by amount of oviposition.
Przeżywalność czerw w zależności od wielkości powierzchni zasiewu.

<table>
<thead>
<tr>
<th>Amount of oviposition Powierzchnia zasiewu</th>
<th>N Liczba obserwacji</th>
<th>0-24 h eggs 0-24 h jaja (%)</th>
<th>2-3 day old larvae 2-3 dn. larwy (%)</th>
<th>7-8 day old larvae 7-8 dn. larwy (%)</th>
<th>Brood before emergency Czerw przed wygrzywieniem (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>46</td>
<td>100.0</td>
<td>87.5 a</td>
<td>80.1 a</td>
<td>79.9 a</td>
</tr>
<tr>
<td>Large</td>
<td>46</td>
<td>100.0</td>
<td>78.3 b</td>
<td>73.2 b</td>
<td>72.9 b</td>
</tr>
</tbody>
</table>

Significant differences at P<0.05

Brood survival rate as affected by the wire passed trough a cell.
Przeżywalność czerw w komórkach plastra nad drutami wzmacniającymi wężę.

<table>
<thead>
<tr>
<th></th>
<th>N Liczba obserwacji</th>
<th>0-24 h eggs 0-24 h jaja (%)</th>
<th>2-3 day old larvae 2-3 dn. larwy (%)</th>
<th>7-8 day old larvae 7-8 dn. larwy (%)</th>
<th>Brood before emergency Czerw przed wygrzywieniem (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>With wire Nad drutem</td>
<td>92</td>
<td>100.0</td>
<td>84.6 a</td>
<td>77.7 a</td>
<td>77.1 a</td>
</tr>
<tr>
<td>Without wire Bez drutu</td>
<td>92</td>
<td>100.0</td>
<td>44.2 b</td>
<td>36.7 b</td>
<td>35.8 b</td>
</tr>
</tbody>
</table>

Significant differences at P<0.05

An explanation was provided for the mechanism of brood losses from those sites on the comb where a wire that supports the foundation embedded into the frames passes through the cells. Brood survival rates were compared in cells with and without the wire. The brood survival rates in the cells with the wire threaded underneath were consistently significantly lower. The fact is generally known but is believed to be caused by the reluctance on part of the queen to lay the eggs to the cells above the wire. However, it turned out that the queen lays the eggs to all the cells and it is the bees that removed a large part of the young brood from the cells under which a wire was threaded.

CONCLUSIONS

Of the individuals that hatched from the eggs laid by the queen in comb cells only 3/4 reached the stage of a fully developed pupa. The remaining 1/4 died at different development stages most frequently at the beginning of the larval stage.

Brood survival rate is little affected by time of season, breed involved, and age of the egg-laying queen. This notwithstanding, more brood was hatched from the eggs laid by young and Caucasian queens.

Brood compactness and number of eggs laid in the comb have a significant impact on brood survival. Brood survival rates were reduced on the combs with loose brood and with fewer eggs.
The number of brood reared in the cells with a foundation supporting wire threaded underneath was significantly reduced. Rather than being the results of omission during oviposition as is generally believed the reduction was due to the removal of young brood by worker bees.

REFERENCES


WPŁYW NIEKTÓRYCH CZYNNIKÓW NA PRZEŻYWALNOŚĆ CZERWIU W RODZINIE PSZCZEŁEJ

C. Kruk, W. Skowronek

Streszczenie

Oceniano wpływ różnych czynników genetycznych i środowiskowych na przeżywalność czerwiu w rodzinach pszczel. Przeżywalność oceniano po osiągnięciu przez larwy wieku 2-3 dni, następnie 7-8 dni i u poczwarku na około jeden dzień przed wygrzywaniem się pszczół z komórki piasdra.

Nie stwierdzono istotnego wpływu na przeżywalność czerwiu pory sezonu wychowy, rasy pszczół i wieku matki, aczkolwiek z jej składanych przez matki młodsze i rasy kaukaskiej czerw rozwijają się w nieco wyższym procencie. Korzystnie, w istotnym stopniu wpływała na przeżywalność czerwiu jego zwartej oraz duża liczba aj złożonych na piaszcz. Komórki piasdra, pod którymi przebiegał drut utrzymujący węze były zaczerywiane przez matki jednak ponad polowa młodego czerwię była usuwana z nich przez pszczoly robotnice.
Słowa kluczowe: wychów czerwiu, przeżywalność, warunki środowiska.