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Apiculture Division, Warmia and Mazury University, Olsztyn

JERZY WILDE, JANUSZ BRATKOWSKI, MACIEJ SIUDA

Defensive Behavior of Three Breeds of Apis mellifera L.

Zachowania obronne trzech podgatunków pszczół *Apis mellifera*

The honeybee subspecies *Apis mellifera mellifera* was formerly widespread throughout Poland's territory. However, it was displaced by other bee subspecies, first of all by *A. m. caucasica* and *A. m. carnica* (2,3,5). The reason behind it was the desire of beekeepers to have bees of better usable characteristics than the Central European bee. The Central European bee is not inferior to the Caucassian and Carniolan bees for usable traits (4). Prabucki and Chuda-Mickiewicz (8) consider it to be a very good crossbreeding component. It stands out for its higher resistance to Nosema disease than in other races (4). Muszyńska and Konopacka (7) found that the bees of that race showed better wintering performance than the Carniolan and Caucassian bees.

An undesirable trait of *A. m. mellifera* is its particularly strong defensive behaviour. It makes the bees difficult to handle and causes a nuisance to the people living nearby so that few beekepers are willing to keep them. However, the problem has not been studied in detail. Therefore, the aim of this experiment was to determine the intensity of the defensive behaviour of *A. m. mellifera* as compared to that of the other bee races kept in Poland, i.e. the Carniolan and the Caucassian bees.

MATERIAL AND METHODS

Three bee races were chosen for the experiment: *A. m. mellifera* (line Augustowska), *A. m. caucasica* (line Woźnica) and *A. m. carnica* (line Willy). The queens were instrumentally insemi-

nated of drones of the same race. Each group always consisted of three colonies of different strength: strong, medium-strong and weak. The measurements of defensive behaviour (11) were based on the number of stingers left in a leather ball 5 cm in diameter placed 30 cm away from the beehive entrance and agitated for l min. The measurements were taken three times a day, at 8:00 a.m., at noon (12:00) and at 5:00 in the afternoon. Before the balls were placed in the position bees, returning to the beehive were counted for 5 minutes. Before the first measurement was taken, the ball was exposed to stinging by bees from other beehives and in the intervals it was kept in a plastic bag to prevent the venom smell from dissipating. Measurements were taken seven times. Following each measurement the stingers were removed with a pair of tweezers. Temperature and air humidity were recorded during the measurements. In the experiment „the stinging coefficient" was introduced – a number of stingers per 100 incoming bees. It was calculated from the formula SC = number of stingers • 100/number of incoming bees. The results were verified statistically applying the chi-square test, one-way ANOVA and the Duncan multiple range test using the software Statistica.

RESULTS AND DISCUSSION

DEFENSIVE BEHAVIOUR QUANTIFIED IN THREE BREEDS OF BEES

During the entire duration of the experiment the Central European left significantly more stingers on the surface of the leather ball bees than the remaining two bee races – Carniolan and Caucassian (Table 1). The Central European bees were found to show the highest amount of flying activity before the ball was administered and it was comparable to that of the Carniolan bees. In these both races the values were significantly higher than those in the Caucasian race.

Table 1. The number of incoming bees within five minutes and the number of stings left in the leather ball as well as the value of stinging coefficient measured for three breeds during the experiment

Race	Number of incoming bees		Number of stingers		Stinging coefficient
	mean	range	mean	range	
A. m. mellifera	261. 9^{B}	43-434	13.8^{B}	0-190	6.2^{B}
A. m. carnica	234.6^{B}	16-632	4.0^{A}	0-33	2.0^{A}
A. m. caucasica	167.5^{A}	5-498	4.3^{A}	0-19	4.9

When followed by different characters, the means are statistically different p=0.01

Stinging propensity as expressed by the stinging coefficient was also the highest in that race but it differed significantly only from that characteristic in the Carniolan bees. The coefficient's value for the Caucasian race was relatively high but statistically it did not differ from the respective values for the races Carniolan and Caucasian. The stinging coefficient (SC) introduced in the study

allows a more accurate assessment of the defensive behaviour because it is an absolute value that takes account of the stinging bees in relation to the incoming individuals (11).

Table 2. The number of stingers, the number of incoming bees and the values of the stinging coefficient for three bee races at different times of the day: in the morning (8:00), at midday (12:00) and in the afternoon (5:00)

Race	8:00 hour			12:00 hour			17:00 hour		
	incoming bees	stingers	SC	incoming bees	stingers	SC	incoming bees	stingers	SC
A. m. mellifera	212.5	19.7	3.1	312.8^{B}	15.0^{B}	5.7	260.5^{bB}	6.7^{B}	2.7^{b}
A. m. carnica	215.6	5.7	3.9	308.6^{B}	5.2A	1.6	179.5^{a}	1.0^{A}	0.5^{a}
A. m. caucasica	153.4	5.1	8.5	188.6^{A}	5.9A	4.7	160.4^{aA}	1.9^{A}	1.6

When followed by different characters, the means are statistically different, SC – stinging coefficient

Table 3. The number of incoming bees of the three races, the number of the stingers left in the target at different temperature ranges

Race	<20°C			20-25°C			>25°C		
	incoming bees	stingers	SC	incoming bees	stingers	SC	incoming bees	stingers	SC
A. m. mellifera	192.7^{B}	11.5^{b}	7.5	260.6	15.3	6.0	332.5^{B}	14.6^{B}	5.3^{B}
A. m. carnica	153.1	2.9^{a}	2.7	269.6	5.7	2.0	281.0	3.3^{A}	1.4^{A}
A. m. caucasica	97.0^{A}	6.1	10.0	200.5	3.7	3.2	205.0^{A}	3.1^{A}	2.0^{A}

When followed by different characters, the means are statistically different, SC – stinging coefficient

THE EFFECT OF TIME OF THE DAY ON THE DEFENSIVE BEHAVIOUR

At any time of the day it was the Central European bees that stung most frequently. Even though the differences between the Central European bees and the remaining races were substantial they could not be proved statistically. Towards midday the race-to-race differences diminished but, none-the-less, they remained highly significant between the Central European bees (15.0) and the remaining races: Carniolan and Caucasian. A substantially lower number of stingers was left by the bees in the afternoon when compared to the earlier times of the day. At that time of the day the Central European bees showed the highest stinging

behaviour – significantly higher than that shown by the Carniolan and the Caucasian bees (Table 2).

Statistical differences in the number of flights were recorded only at midday and in the afternoon. At 12:00 the Central European bees showed the highest flying activity to be followed by the Carniolan bees heavily outdoing the Caucasian bees in this respect. In the afternoon (5:00) the highest number of incoming flights was recorded for the mellifera colonies and the lowest in the Caucasian colonies ($p = 0.01$). On the other hand, the Carniolan bees were significantly less active only when compared to the Central European bess (Table 2).

A comparison of the mean values is insufficient and may be doubtful as it is the case in Table 3. At 12:00 very high statistically valid differences for the number of left stingers in favour of the Central European bees are not confirmed by the values of the stinging coefficient. Likewise, in the afternoon hours the stinging coefficient values for the three races provide an indication that the stinging propensity of the Caucasian bees is similar to that of the Central European bees.

The mean stinging coefficient values did not show differences in bee defensive behaviour measured in the morning and at midday. The differences turned up for the afternoon measurements but only for those involving the means for *A. m. mellifera* and *A. m. carnica* ($p = 0.05$).

The test for the relationship between flying activity and stinging behaviour made using the chi-square test indicates that it was only the Central European bees that stung at any time of the day regardless of their flying activity as opposed to the Carniolan bees. The Caucasian bees showed aggressive behaviour in the morning hours by stinging regardless of their flying activity but the relationship changed later in the day. The Central European bees proved to be the most active fliers at any time of the day on record. It gives them an edge in the utilization of the available flows and seems contradictory to a widespread opinion that those bees are inferior with respect to centrifuged honey output (9). Indeed, it turns out that stinging propensity in that race is unrelated to flying activity, such a relationship being confirmed for the Carniolan bees. Woyke (11) demonstrated a positive correlation between the two characteristics.

EFFECT OF TEMPERATURE ON THE DEFENSIVE BEHAVIOUR

At the temperature below 20°C the stinging propensity shown by the Central European bees was high, whereas the Carniolan bees were the least apt to sting. There was a statistically sigificant difference between the two groups. For the temperature range from 20 to 25°C the differences came within the ex-

perimental error. As the temperatures rose above 25°C the most aggressive mellifera bees left 14.6 stingers in the ball, which was significantly higher than the number of stingers left by the Caucasian and Carniolan bees, 3.1 and 3.3 stingers, respectively (Table 3). Ambient temperature influenced the flying intensity of bees. At the temperatures below 20°C the Central European bees showed the highest flying activity of all the three races. The smallest number of incoming bees was recorded for the Caucasian colonies. Only the differences between the two races were confirmed statistically ($p = 0.01$). In the temperature range from 20 to 25°C the differences came within the experimental error.

Once the temperature rose above 25°C the flights of the Central European bees were most frequent and the frequency was significantly higher than that recorded for the Caucasian bees. Although the differences in stinging coefficient were substantial they were not confirmed statistically below 20°C and within the range of 20 to 25°C. It is only when the temperature rose above 25°C that the stinging coefficient value for the Central European bees became significantly higher ($p = 0.01$) than that for the Carniolan and Caucasian races.

Assessment of the relationship between flights and stinging behaviour revealed that the stinging behaviour of Central European bees was unrelated to incoming flight frequency as opposed to the stinging behaviour of the Carniolan bees (Table 3). In the Caucasian bees stinging propensity was independent of their flying activity only at temperatures below 20°C.

No factors, therefore, came into play which may have justified the excitation of the bees nor can the phenomenon be accounted for by stress (6). Southwick and Moritz (10) attach great importance to weather factors. However, during the test no records were taken on rainy and overcast days when the bees could be particularly ill-tempered. The flow situation during the test was moderate, the bees collected pollen and nectar. It could be a factor that made the Central European bees more disposed to sting. However, such behaviour is more likely to occur in African bees, which are more ill-tempered during foraging than the European races (11). In the case under consideration one may be inclined to propose that in the breeding of that race the expression of defensive behaviour was given a selective advantage as ill temper was a preferred trait intrinsic to that bee. The remaining tested races showed defensive behaviour characteristic of European bees. Solely the Caucasian bees at temperatures below 20°C showed defensive behaviour unrelated to flying activities, which put them close to Central European bees.

A subjective impression was that the Carniolan and the Caucassian bees were mild-tempered during the test, whereas the Central European bees were characterized by much higher agressiveness, which did not change over meas-

urements regardless of the time of the day and the temperature. Nearly every time the ball in front of the beehive entrance attacked with ferocity. The *A. m. mellifera* bees also penetrated a much larger area than did the bees of the remaining races and the attacking bees frequently flew at the faces and legs of the persons who took the measurements even though the persons were behind the beehive and hidden from view of the bees. So it can be acknowledged that particular stages of defensive behaviour were expressed remarkably rapidly in that race (1). That trait can be thus recognized as characteristic of that race.

CONCLUSIONS

1. At any time of the day *A. m. mellifera* bees showed the highest flying activity and the most intense defensive behaviour that manifested itself in stinging at any time and at any temperature range.

2. The defensive behaviour of *A. m. mellifera* was not related to flying activity of the bees.

3. The *A. m. carnica* bees were characterized by flying activity comparable to that of the Central European bees but their defensive behaviour was close to that observed in Caucasian bees.

4. The stinging propensity of the Carniolan bees was always related to their flying activity. *A. m. cucasica* bees were characterized by the lowest flying activity. Their defensive behaviour was not related to flying activity in the morning and at temperatures below 20°C.

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STRESZCZENIE

W doświadczeniu określono nasilenie zachowań obronnych *A. m. mellifera* w porównaniu z pszczołami kraińską i kaukaską na podstawie liczby żądeł pozostawionych w skórzanej kuli (ø = 5 cm), umieszczonej 30 cm przed wylotem ula. Oszacowano też aktywność lotów i współczynnik żądlenia.

Stwierdzono, że pszczoły *A. m. mellifera* latały najbardziej aktywnie o każdej porze dnia i przejawiały najwyższe zachowania obronne, manifestujące się żądleniem w każdym czasie i zakresie temperatur, a ich zachowania obronne nie zależały od aktywności lotnej. Pszczoły *A. m. carnica* charakteryzowały się porównywalną z pszczołami środkowoeuropejskimi aktywnością lotną, ale ich zachowania obronne były zawsze zależne od aktywności lotnej. Pszczoły *A.m. caucasica* charakteryzowała najniższa aktywność lotna o każdej porze dnia i zakresie temperatur, zaś ich zachowania obronne nie zależały od aktywności lotnej przed południem i temperatur poniżej 20°C.