AGGRESSIVE REACTION LEVEL OF THE HONEYBEE (*Apis mellifera* L.) TO SMELL AND KNOCK

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Summary

The purpose of this study was to determine aggressive reactions of bees to smells and knock stimuli. Here knock refers to a knock with a metal bar on the exit of the beehive generating trembling and sound. The study was held from April 2006 to August 2006 at the stationary apiary on 8 bees colonies. They were a cross of Carniolan bee and a local bee. The research was carried out 12 times in each colony. Each time 2 stimuli were used: smell and the knock stimuli. Three different smells were used – strong perfume, venom of the poison sac of a few worker bees of the same colony, and venom of the worker bees of the other colony. One knock stimulus was used: 3 knocks with a metal bar on the exit of the beehive. After each stimulus was applied the bees attacking the cardboard boxes placed near the exit were counted. The bee count was taken after 15, 30 and 60 seconds. The aggression level was represented in points. The points represented the amount of bees attacking the given bait. 1 point was for 0-19 bees, 2 points for 20-39 bees, 3 points for 40-69 bees and 4 points for over 70 bees. The abundance of pollen and nectar flow, working activity of bees, colony strength and weather conditions were determined as well.

The bee reaction to smell was slow. After 60 seconds it reached low level of 1.3-1.4 points. No one smell appeared to be a strong stimulus of the aggressive reaction. Stronger aggressive reactions were observed after applying the knock stimulus. The reactions reached 1.9 point (2.9 maximum). In spring or during an abundant nectar flow, the level of aggressive reactions in bee colonies were low (below 1.7 point). In a poor nectar flow period bees were more aggressive (2.4-2.5 points), and their reaction time was shortened to 15-30 seconds. High temperature and low relative humidity caused acceleration of stimuli reactions. The increase in air humidity resulted in acceleration and in an increase of bee aggression. No statistically significant differences were observed in bee reactions to smell stimuli. Statistically significant differences on $p \leq 0.01$ level were observed when describing bee reactions to smell and knock stimuli, and when describing the level of reactions to knock stimulus in different time ranges.

Keywords: honey bee, aggression, activity, aromatic stimuli, sonic-trembling stimuli.

INTRODUCTION

A bee colony is a society which protects its nest. Each external intervention is met with a higher or lower level of aggression. The result is often an attack and stinging. During work activity in the colony structure there are always some worker bees guarding the hive entrance. If necessary, they attack the intruder. Usually 18-21 day old bees are the guards (Breed et al. 2004). The levels of juvenile hormone (JH) and alarm pheromones increase in the third week of a bee's life and that is why these bees are more aggressive (Huang et al. 1994). They are the first to attack the intruder. The other worker bees within the colony usually show aggression only after being stimulated by the guard bees. Bee aggression within the colony is coordinated using the alarm pheromones (Huber 1814, Free 1961, Maschwitz 1964, Allan et al. 1987, Fadl Ali and Morgan 2008, Wang et al. 2008). It is the smell of this pheromone which stimulates the bees to protect their nest and to be aggressive. To disturb and reduce this smell a smoker is used (Visscher et al. 1995, Hunt 2007). The level of the colony's aggression is genetically and environmentally determined. European bees are much less excitable than African or Africanized ones (Giray 2000). Not all of the seasons, however, are characterized by the same level of colony protectiveness. Early spring, when the bees are still weak from winter and the level of the juvenile hormone is low, the bees are calmer (Pearce et al. 2001, Lipiński 2002). During abundant nectar flow, bee aggression is lower. This is due to the fact that most of the worker bees are busy harvesting, processing and storing supplies. Less bees are guarding the entrance of the hive and the external stimulus must be strong to provoke a reaction. During low nectar flow, colony protectiveness increases significantly as the bees guard the earlier collected supplies. Reaction time is shorter even if the stimulus is weaker (Woyke 1992).

The expression of the aggressive reaction is influenced by the kind and strength of the stimulus applied. Bees react to visual, smell, touch, sound and shake stimuli (Hunt 2007). The movement of foreign stimuli - e.g. animal smell, human sweat smell near the entrance to the nest triggers increased aggression (Free 1961, Wager and Breed 2004). Bees react with similarly increased aggression to higher concentrations of carbon dioxide in the air (Crane 1990). During the stinging process the smell of venom is released and in it is the alarm pheromone which stimulates other bees to aggression (Robinson 1987).

There are groups of cells (tibial organ) in the tibia of the thoracic forelegs receiving trembling stimuli. The shaking foundation stimulates bees to increased activity and nest protectiveness (Demianowicz and Kirkor 1993).

According to Paleolog (2006) bee calmness or irritability is a dominating feature and it is easily improved during the process of bee breeding. However, the level of aggression in different honey bee species and subspecies can be different even with the same stimulus applied. The attacking bees usually follow the intruder a few to several meters from the hive. There are species and subspecies which can chase the “enemy” a few hundred meters. Africanized bees are known to follow and sting their victim for one kilometer or more (Winston 1992, Sherman 1995, Voeller and Nieh 2005).

The aim of this work was to determine the aggressive reaction of bees to aromatic and sonic-trembling (knocking) stimuli on the hive exit. Chosen environmental and external and internal colony features were taken into consideration.

MATERIAL AND METHODS

The research was carried out from April 2006 to August 2006 on 8 bees colonies at the stationary apiary. The apiary consisted of 20 beehives located on the outskirts of the city of Wrocław, Poland. The tested bees were a cross of Carniolan bee queens and the drones of unknown origin. Colonies from different parts of the apiary were chosen. The reason for this was to minimize the influence of the colonies on each other. Twelve field tests were taken every 10-12 days. Each test was a combination of two stimuli (smell and knock stimuli). Three different smells were used for the smell stimulus. They were strong perfume, venom of the poison sac of a few worker bees of the same colony, and venom of the worker bees of the other colony. The sonic-trembling stimuli was a normal knock on the exit of the beehive which generated trembling and sound. Rectangular tissue papers sized 5x8cm were dripped with an aromatic substance, and they were fixed on wooden strips by the hive exit. The bees attacking the bait were counted after 15, 30 and 60 seconds. The knock test consisted of a triple knock on the entrance of the hive with a metal bar and placing the 5x8cm tissue paper attached to the wooden slat near the entrance. The bees attacking the bait were counted after the same time periods used in the smell tests. Each stimulus was applied separately. The elapsed time between the tests using the next stimulus within one colony, was a minimum of 1 hour. Each colony was tested 12 times with an application of each stimulus; that results in 48 measurements (4 stimuli x 12 repetitions). On the whole, the aggressive reaction of bees was tested 96 times (1 stimulus x 8 colonies x 12 repetitions). There were 384 measurements taken altogether (8 colonies x 4 stimuli x 12 repetitions).

The level of aggression was shown in points based on the number of bees attacking the bait as follows:

1. low – 0-19 bees–1 point
2. medium – 20-39 bees – 2 points
3. medium high – 40-69 bees–3 points
4. high – more than 70 bees–4 points

The reaction speed was described as follows:

1. fast–15 seconds
2. medium–30 seconds
3. slow–60 seconds

Throughout all the research the monitoring hive was placed on an apiary scale. Based on the daily weight increase, the abundance of nectar flow was determined. This point scale was used:

1 point – very poor = a daily weight increase up to 0.50 kg

2 points–poor=0.51-1.00 kg

3 points–medium=1.01-2.00 kg

4 points–heavy=2.01-3.00 kg

5 points–very heavy=more than 3.01 kg.

Bee activeness was described based on the number of worker bees exiting the beehive in a period of 5 minutes. This measurement was taken each time just before the application of the disruptive stimulus. The activeness was described in points as follows:

1 point – weak activeness (0-50 bees exiting the hive within a 5 minute period)

2 points – medium activeness (51-100 bees)

3 points – high activeness (more than 100 bees).

An inspection of bee colonies was conducted in April. The inspection was focused on the number of combs covered by bees.

The strength was described as follows:

1 point – weak colony (7-8, and the number of combs with brood 3)

2 points – medium strength colony (9-10, and the number of combs with brood 4)

3 points – strong colony (11-12, and the number of combs with brood 5-6)

The estimation of the strength of the colony was corrected during the research during which continuous observation took place.

The age of the queen bees was described in years as follows:

1 – one year old queen bee

2 – two year old queen bee

3 – three year old queen bee

Weather conditions (temperature and relative humidity) were noted, and data collected on the apiary premises on the day of the field tests. Electronic Mini Weather Station WM-918 “HUGER” was used.

The results of the tests were worked out statistically using Statgraphics ver. 5.1. Mean values, standard deviations and correlations between the level of bee aggression and air temperature, air humidity, level of nectar flow, bee activeness, the colony strength and queens age, were all taken into account. The Duncan test was used to asses the differences between features tested.

RESULTS AND DISCUSSION

The study revealed the differences between the levels of aggression among the bee colonies. The highest level of aggression was exhibited after application of the knock stimulus. This consisted of a knock on the entrance to the beehive generating the trembling and the sound. An average aggression level after an application of this stimulus was 1.9 point, i.e. about 20 bees attacked the bait. The speed of the aggressive attack was also faster with this stimulus. On the average, the bees attacked the bait after 26 seconds (Table 1). Paleolog and Borsuk (2002) showed that the time which elapsed between the knock and the sting of the bait was from 2.9 to 37.6 seconds depending on the genetic composition of the colony. Another test with the same stimulus showed, however, a more diverse time of aggressive reactions (Borsuk and Paleolog 2005). In the first series of tests the time was from 36.6 to 75.3 seconds, in second series it was from 7.9 to 17.0 seconds. Knock stimulus influenced aggressive reactions as the time increased. After an application of this stimulus the statistically high differences (on $p\leq0.01$ level) in the level of aggression after 15, 30 and 60 seconds were shown (Table 3). Similar results were obtained by Paleolog and Borsuk (2002) who also determined that the aggressive reactions were increasing in time, after the knock on the entrance to the beehive. They observed that after 15 seconds 5 bees stung the bait, after 30 seconds 9 bees, and after 60 seconds 11 bees. The strongest aggressive reaction to the knock on the entrance to the beehive was expressed by colony number 7 – with an average level of 2.2 points. The weakest aggressive reaction was expressed by colony number 6 – with an average level of 1.4 points (Table 3). Research carried out by Paleolog and Borsuk (2002), Borsuk and Paleolog (2005) and by Borsuk (2006) prove that the level of aggressive bee reaction depended on their breed. Giray et al. (2000) came to similar conclusions after researching European and Africanized bees.

Smell stimuli used in the tests resulted in a much weaker aggressive reaction than the knock stimulus. Bees reacted slowly to the baits with smells and only after 60 seconds their reaction reached the average level of 1.2-1.3 point (Table 3). Only two bee colonies (numbers 1 and 4) exhibited faster aggressive reactions, from 1.0 point after 15 seconds to 1.8 points after 60 seconds. No significant differences in the aggression level connected to a particular smell applied were observed (Table 3). On the whole it was observed that the average level of aggressive reactions to smells reached 1.4 point, i.e. about 11 bees attacked the bait (Table 1). These results differ from those collected by Hunt (2007). He determined strong aggressive reaction to smell stimuli. According to him bees exhibited the strongest reaction to the smell of bee venom – more specifically to its main component isoamyl acetate. Wang et al. (2008) came to analogical conclusions. They assessed sensitivity and reactiveness to the smell of pheromones found in bee venom on honey bee workers. In 1814 Huber confirmed that the fresh stomachs of bees placed near the entrance to the beehive stimulated the guardian bees to protection and attack. Free (1961)

Table 1

The mean level of aggressive bee reaction to chosen stimuli in relation to external conditions.

Month	Measurments		Abundance of nectar flow in points	Mean meteorological data		Reaction on stimuli					
						Knocks (n_1=8)			Smells - at once (n_2=24)		
	Days of meansurments	Number of colonies		Temperature °C	Humidity %	Number of bees (in head)	Number of points	Time of reaction [s]	Number of bees (in head)	Number of points	Time of reaction [s]
IV	1	8	2.0	19	35	12	1.4	60	9	1.3	60
V	2	8	3.5	17	48	11	1.4	30	11	1.4	60
	3	8	5.0	17	33	13	1.5	30	9	1.3	30
	4	8	4.0	17	32	15	1.6	30	13	1.5	30
VI	5	8	4.0	26	40	16	1.7	30	12	1.4	30
	6	8	3.5	29	42	10	1.3	60	5	1.1	30
	7	8	3.0	31	46	34	2.7	15	18	1.8	15
VII	8	8	3.0	29	33	38	2.9	15	13	1.5	15
	9	8	2.0	28	24	19	1.9	15	6	1.1	15
	10	8	2.0	33	23	18	1.9	30	5	1.1	60
VIII	11	8	1.0	16	81	32	2.6	15	13	1.5	15
	12	8	1.0	20	52	27	2.4	15	11	1.4	30
	$\bar{x}$		**2.8**	**23.3**	**40.8**	**20**[a]	**1.9**[a]	**26**	**11**[b]	**1.4**[b]	**35**
	sd		1.22	6.34	15.62	10.30	0.59	x	3.46	0.19	x

a, b (a,b) – differences significant on a level of $p \leq 0.05$ between stimuli applied
n_1 – number of measurements carried out each day after the application of the stimulus
n_2 – number of measurements carried out each day after the application of the stimuli (8 colonies x 3 types of smells)

Table 2

The mean level of aggressive bee reaction in relation to conditions within a colony.

Month	Days of meansurments	Colony strength		Activity of bees		Abundance of nectar flows in points	Aggressive reaction (for both stimuli - n=32)	
		points	SD	points	SD		Number of bees (in head)	Number of points
IV	1	2.0	0.75	1.5	0.46	2.0	9	1.3
V	2	2.3	0.68	1.6	0.98	3.5	11	1.4
	3	2.4	0.74	2.8	0.88	5.0	11	1.4
	4	2.4	0.74	2.5	0.91	4.0	14	1.6
VI	5	2.4	0.74	2.8	0.75	4.0	14	1.6
	6	2.3	0.70	2.0	0.50	3.5	8	1.2
	7	2.3	0.65	2.3	0.65	3.0	27	2.4
VII	8	2.1	0.64	1.8	0.71	3.0	29	2.5
	9	2.1	0.25	1.5	0.68	2.0	13	1.5
	10	2.0	0.00	1.3	0.77	2.0	12	1.5
VIII	11	2.0	0.00	1.8	0.00	1.0	23	2.1
	12	2.0	0.00	1.8	0.00	1.0	19	1.9
$\bar{x}$		**2.2**	**x**	**2.0**	**x**	**2.8**	**16**	**1.7**
SD		0.17	x	0.53	x	1.25	7.08	0.43

n – number of measurements carried out each day = (3 smell stimuli + 1 knock stimulus) x 8 colonies stated that cotton balls with bee stings placed in them were attacked more often than the monitoring cotton balls with no stings. He also showed that the smell of the venom from the bees own colony was a stronger stimulus than the smell of the venom from another colony. This was not confirmed in this study. Statistically significant differences (on $p \le 0.01$ level) only between the level of aggression after an application of smell and knock stimuli were shown (Table 3).

The bees used in this study - a cross between the Carniolan bee queen and the local drone (Car x M), were rather calm. None of the colonies exhibited the maximum value point level of aggression. The observations showed that the lowest level of aggression was found within colonies with 2 year old queens. The average reaction level in these colonies to smells was 1 point (regardless of the smell used) and 1.8 points to the knock stimulus (Table 3). The colonies with 1 year old queens and 3 year old queens showed a slightly higher level of aggression – 1.2 and 2.1 points (smell and knock) and 1.3 and 2.1 (smell and knock) respectively. However the significance of the differences between the colonies with 1 year old and 3 year old queens were not confirmed statistically.

The knock stimulus was connected with the movement of the metal bar. Wager and Breed (2004) described the intensity that the bees attacked the moving object as usually doubled. Free (1961) also confirmed that faster moving objects are stung more frequently than the slower moving ones. Collins (1985) holds that Africanized bees attack a non-moving object 2.4 times faster than the European ones and a moving object is attacked 30 times faster by Africanized than by European bees.

The time of the season influences the aggressive reaction level of bees (Fig. 1). At the beginning of the season from April to May the level of reactions to the stimuli was described as low and was ascribed 1.3-1.4 points. A similarly low reaction level (Tables 1 and 2) was during an abundant nectar flow (the season given 4-5 points). This confirmed the results collected by Gromisz et al. (1978) and Paleolog (2006). In spring there are less worker bees in the hive and the queen is increasing her oviposition. At that time one feeding bee has more brood to feed and the worker bees are more busy feeding and taking care of the future generations. During an abundant nectar flow the bees are stimulated to collecting, processing and storing the material and thus the aggressive reactions of bees during this season are lower and weaker (Gromisz et al. 1978, Paleolog 2006). Kigatiira (1998) claimed that the bees with a full honey sac are much worse “fighters” than hungry bees. This rule could also be applied to the poor nectar flow. This is when bees are more excitable and show a much higher level of aggression. This situation was observed in June and July when the nectar flow is below an average level (3 points) and in August when nectar flow is slight (up to 1.0 point). Bees became more aggressive and the reaction time shortened to 15 seconds. The aggression level was described as medium. It reached 2.7-2.9 points in June and July and 2.4-2.6 in August. In August the reaction time was also shortened to 15-30 seconds (Table 2). The slowing down and reduction of the aggressive reactions was observed in the middle of June when the swarming impulse could be noticed (measurement 6) – Tables 1 and 2. Lipiński (2002) claims that for the duration of the swarming impulse the bees aggressive reactions disappear. And they do not react with aggression when met with a stressful agent, but they drink honey (Winston 1987).

Table 3

The mean level and speed of aggressive reaction to chosen stimuli in bee colonies.

Colony number	Age of Queen	Aggressive reaction level																
		Smell stimuli													Knock stimulus (n=12)			
		Perfume (n=12)				Own venom (n=12)				Foreign venom (n=12)				$\bar{x}$				
		15 s	30 s	60 s	$\bar{x}$	15 s	30 s	60 s	$\bar{x}$	15 s	30 s	60 s	$\bar{x}$		15 s	30 s	60 s	$\bar{x}$
3	1			1.0	1.0			1.0	1.0			1.0	1.0	1.0	1.4	2.1	2.8	2.1
4	1	1.0	1.4	1.4	1.4	1.0	1.4	1.8	1.4	1.0	1.3	1.8	1.4	1.4	1.5	2.0	2.8	2.1
7	1			1.0	1.0			1.0	1.0			1.0	1.0	1.0	1.4	1.9	3.2	2.2
$\bar{x}$		**1.0**	**1.4**	**1.3**	**1.2**$^{\underline{A}}$	**1.0**	**1.4**	**1.3**	**1.2**$^{\underline{A}}$	**1.0**	**1.3**	**1.2**	**1.2**	**1.1**$^{\underline{A}}$	**1.4**^{A}	**2.0**^{B}	**2.9**^{C}	**2.1**$^{\underline{B}}$
2	2			1.0	1.0			1.0	1.0			1.0	1.0	1.0	1.5	1.9	2.7	2.0
5	2			1.0	1.0			1.0	1.0			1.0	1.0	1.0	1.4	1.8	2.8	2.0
6	2			1.0	1.0			1.0	1.0			1.0	1.0	1.0	1.0	1.3	1.8	1.4
$\bar{x}$		**-**	**-**	**1.0**	**1.0**$^{\underline{A}}$	**-**	**-**	**1.0**	**1.0**$^{\underline{A}}$	**-**	**-**	**1.0**	**1.0**	**1.0**$^{\underline{A}}$	**1.3**^{A}	**1.7**^{B}	**2.4**^{C}	**1.8**$^{\underline{B}}$
1	3	1.0	1.3	1.8	1.4	1.0	1.4	1.8	1.4	1.1	1.2	1.8	1.4	1.4	1.5	1.9	3.0	2.1
8	3			1.0	1.0			1.0	1.3			1.0	1.0	1.0	1.3	1.9	3.0	2.1
$\bar{x}$		**1.0**	**1.3**	**1.4**	**1.3**$^{\underline{A}}$	**1.0**	**1.4**	**1.4**	**1.3**$^{\underline{A}}$	**1.1**	**1.2**	**1.4**	**1.4**	**1.4**$^{\underline{A}}$	**1.4**^{A}	**1.9**^{B}	**2.8**^{C}	**2.1**$^{\underline{B}}$

A, B, C – differences significant on a level of $p \leq 0.01$ between reaction speed

$\underline{A}$, $\underline{B}$ – differences significant on a level of $p \leq 0.01$ between the stimuli

Empty space indicates lack of reaction to a stimulus in the specific time.

n – number of measurements carried out in each colony

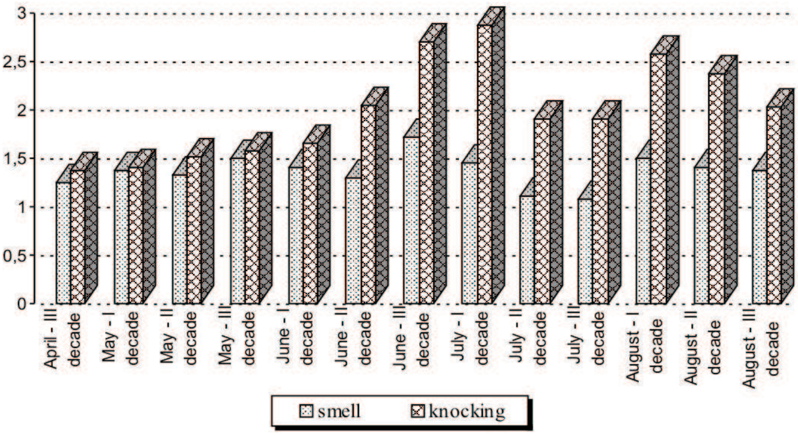

Fig. 1. Level of aggressive bee reaction after applying chosen stimuli (in points)

Table 4

Correlation of the level of aggressive bee reaction after a stimuli application, weather conditions and colony factors.

Stimulus	Correlation coefficient (r)					
	Nectar sources level	Air temperature	Air humidity	Activeness of bees	Colony strength	Age of Queen
Knocks	-0.385	0.252	0.343	-0.602*	-0.405	-0.137
Smells	0.217	-0.217	0.501*	0.524*	-0.274	0.082

* - the correlation coefficient values are significant on the level of $p<0.05$ between aggression level and factor specified

Similarly the influence of the external agents stimulates them to drink not to express aggression.

The results collected during this research confirmed that bee aggressive reaction levels are determined not only genetically but also depend on other factors including weather conditions (Southwick 1987). When the temperature was 28-33°C and the air humidity was not higher than 40% the bees came out of the hive and attached to what is called the "beard" under the entrance to the hive. During high temperatures reaction time was longer (measurements 9 and 10) but when the reaction took place it was intense and long-lasting (Table 1).The correlation between the level of aggressive reactions and the relative air humidity was observed ($r=0.501$ with $p\leq0.05$). It was confirmed that higher air humidity speeds up the aggressive reaction (Tables 1 and 4). Lipiński (2002) claimed that the higher humidity makes it easier for the alarm pheromones to spread as the water vapor is a good carrier of smells. The temperature, however, has much less influence on the level of aggression which was confirmed in this study. Winston (1987) stated that the bees sensitivity to the external stimuli depended on the humidity and on the temperature. Stabentheiner et al. (2002) established that the guard bees, when identifying a strange bee approaching the hive, raise their body temperature which makes their ability to recognize stronger. It additionally confirms that higher air temperature influences the sensitivity of the bees and their reception to external stimuli. The increase in air temperature causes an increase in insect metabolism which is also the reason for the increase of bee activeness and reactiveness (Lipiński 2002, Volynchik et al. 2006). Collins (1981) observed that the high temperature causes an increase in the probability of reaction as well as the increase of intensity and lasting time of reaction as the answer to the smell of the alarm pheromones. Our own studies confirmed that when the humidity level was higher than 50% with temperatures from 28-33°C, the level of the aggressive reaction was higher and the reaction was faster (Table 1).

The higher level of aggressive reaction to the knock stimuli can be explained by the fact that the trembling sensation is felt by the whole colony and thus more bees are stimulated to act. The smell stimuli, however, reaches the inside of the beehive very slowly or sometimes with difficulty, for example, during heavy hive ventilation. During the complete study period differences between reactions to particular smells were not shown. A significantly high difference ($p \leq 0.01$) in the level of reaction was established between reactions to the knock and the smells (Table 3). Statistically significant differences ($p \leq 0.01$) were observed after an application of the knock stimulus in respective time ranges (15, 30 and 60 seconds).

A statistically significant ($p \leq 0.05$) negative correlation ($r = -0.602$) between flight activity of bees and their reaction to the knock stimulus was observed. Coefficient correlation between flight activity and the reaction to smell stimuli was positive ($r = 0.524$) and statistically significant ($p \leq 0.05$). Similarly, a statistically significant ($p \leq 0.05$) positive correlation ($r = 0.501$) was shown between aggressive reaction and air humidity (Table 4).

CONCLUSIONS

1. The level of aggressive bee reaction to smell stimuli was low and none of the smells appeared to be a strong stimulus.
2. The fastest and strongest aggressive reaction was achieved by the knock stimulus (This consisted of a knock at the entrance to the beehive generating trembling and sound).
3. The level and speed of aggressive reactions was significantly influenced by the air humidity.
4. During the increased flight activity the level of reactions decreased.

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WPŁYW WYBRANYCH CZYNNIKÓW NA POZIOM AGRESYWNYCH REAKCJI PSZCZOŁY MIODNEJ

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Streszczenie

Celem pracy było określenie poziomu agresywnej reakcji pszczół na bodźce zapachowe i drżeniowo-dźwiękowe (stuknięcie w wylot ula). Badania przeprowadzono w okresie od kwietnia do sierpnia 2006 r., w pasiece stacjonarnej, na 8. rodzinach pszczelich – mieszańcach pszczoły kraińskiej z miejscową. W każdej rodzinie badania przeprowadzono w 12 powtórzeniach. Każde powtórzenie obejmowało zastosowanie dwóch rodzajów bodźców: zapachowych i drżeniowo-dźwiękowych. Wykorzystano 3 bodźce zapachowe: perfumy o mocnym zapachu, jad z aparatów żądłowych kilku robotnic z danej rodziny i jad robotnic z obcej rodziny oraz 1 bodziec drżeniowo-dźwiękowy (3-krotne stuknięcie prętem w wylot ula). Po zastosowaniu danego bodźca liczono pszczoły atakujące kartoniki wystawione na wylocie ula w ciągu 15, 30 i 60 sekund. Poziom agresji określono w punktach na podstawie liczby pszczół atakujących poddany wabik: 1 pkt. – 0-19 pszczół, 2 pkt. – 20-39 pszczół, 3 pkt. – 40-69 pszczół i 4 pkt. – powyżej 70 pszczół. W czasie trwania badań określono obfitość występujących pożytków, aktywność lotną pszczół, siłę rodziny i warunki pogodowe.

Reakcja pszczół na zapachy była powolna i po 60 sekundach osiągała poziom niski – średnio 1,3-1,4 pkt. Żaden z zapachów nie okazał się wyraźnie silniejszym bodźcem do podjęcia reakcji agresywnych. Intensywniej pszczoły reagowały agresją na stuknięcia w wylot ula – średnio 1,9 pkt. (max. 2,9 pkt.). Wiosną oraz w trakcie obfitego pożytku poziom reakcji agresywnych rodzin pszczelich był niski (poniżej 1,7 pkt.). W okresie ubogich pożytków pszczoły były bardziej agresywne (2,4-2,5 pkt.), a czas ich reakcji skrócił się do 15-30 sekund. Wysoka temperatura i niska wilgotność względna powietrza wpływały na spowolnienie reakcji na bodźce zewnętrzne. Wzrost wilgotności powietrza powodował przyspieszenie i wzrost agresji pszczół. Nie wykazano statystycznie istotnych różnic w poziomie agresywnych reakcji pszczół po zastosowaniu kolejnych zapachów. Różnice statystycznie istotne na poziomie $p<0,01$ wykazano między reakcją pszczół na bodziec drżeniowo-dźwiękowy i bodźcami zapachowymi, a także między poziomem reakcji pszczół na bodziec drżeniowo-dźwiękowy w kolejnych przedziałach czasowych.

Słowa kluczowe: pszczoła miodna, agresja, reaktywność, bodźce zapachowe, bodźce drżeniowo-dźwiękowe.