Sociobiology 60(4): 466-470 (2013) DOI: 10.13102/sociobiology.v60i4.466-470

Sociobiology
An international journal on social insects

RESEARCH ARTICLE - WASPS

Effects of Colors and Appearance of the Potential Aggressor on Defensive Behavior of *Vespa crabro* L. (Hymenoptera: Vespidae) Colonies

J Nadolski

University of Łódź, Kilińskiego, Łódź, Poland

Article History
Edited by:
Gilberto M. M. Santos, UEFS, Brazil
Received 17 June 2013
Initial acceptance 11 July 2013
Final acceptance 02 August 2013

Keywords: Social wasps; defensive behavior; The European hornet

Corresponding author
Jerzy Nadolski
Faculty of Biology and Environmental Protection
Natural History Museum
University of Łódź
Kilińskiego 101, 90–011 Łódź, Poland
E-Mail: nadolski@biol.uni.lodz.pl

Abstract

Defensive behavior of the European hornet *Vespa crabro* colonies were studied using the dummy and balloons in different colors. The strong aggressiveness level of hornet's workers was caused by dark colors (black and brown) and orange. The colors white and green did not cause their attack. However, the strongest reactions of hornets were caused by dummy with the animal snout and dark hair on the head. Thus people who are near wasp colonies should have clothes in white or green and hair obscured but when the whole nest is eliminate, they have to have a safe outfit properly constructed.

Introduction

The presence of the European hornet (*Vespa crabro*, Linnaeus 1758), the largest wasp in Europe in different areas inhabited by humans is commonly known (Haeseler, 1982; Skibińska, 1982; Ahrné, 2008) and it is observed , that their colonies more and more often are established in the cities (Nadolski, 2001). Unfortunately, it is a species that is troublesome for the people. Their colonies always cause significant concerns among the people because sizes of hornets' individuals and their societies are very large (Nadolski, 2012) and furthermore many factors may cause the increasing aggression of these insects and their attack on the people. People often do not know how to behave in the vicinity of the colony of hornets and what to dress to avoid their attack. It has been shown that stinging of hornets is not more dangerous than bees and some other species of wasps (Nadolski 2000). Moreover outside of the nest area hornets never attack groundlessly. The main reason for the attack of wasps' societies is defending their colonies. The each external factor, which could undermine structure of the nest and threaten the whole colony or even a single individual, may lead to the uneasiness among these insects. Thus, the seemingly trifling cause, as a shadow cast on the entrance of the nest, sudden or even delicate jolt due to closing or to opening of a window or a door, may induce an attack of hornets on their alleged aggressor. In the event of an attack on humans, the smell of the person, the type of clothes, and even sex can become a cause of aggression (Notman & Beggs, 1993) and the first stinging by the wasp causes the release the alarm pheromones that are contained in the venom (Veith et al., 1984; Moritz & Bürgin, 1987) causing attack of the whole colony.

Ability to see colors and shapes are key features to enable orientation in space for insects. In studies of distinguishing colors by wasps a significant similarity between different species of social wasps were shown (Chittka et al., 1992) and also that the temperature and light have a major influence on their speed (Spievok & Schmolz, 2006). These skills allow them to determine the direction of flight, the search for food, and proper assessment of the possible threat. Individuals of *V.*

Open access journal: http://periodicos.uefs.br/ojs/index.php/sociobiology
ISSN: 0361-6525

crabro can to see in the dark (Kelber et al., 2011) and often they arrive to light in the home at night.

The purpose of this study was to assess the impact of colors and shapes on defensive behavior of urban colonies of *V. crabro* using very simple and uncomplicated test methods. These studied issues, can be certainly relevant for the safety of the human population, but the complete assessment of all risks arising from the presence of hornets in urban areas is beyond the scope of this short study.

Material and methods

The study of defense behavior of hornet's societies was carried out in 2006 -2009 in August and September, because in temperate climates colonies of *V. crabro* are the largest in these months. Because there is the positive correlation between the number of attackers of hornets and the total number of adults (Bichara Filho et al. 2006) as well as between the size of the nest and the number of individuals in the colony (Nadolski 2012), for these studies 8 colonies of hornets of similar size and at the same stage of development (7 combs) were used. In subsequent analysis of their nests it was confirmed. The aggressiveness level showed by the colonies of *Vespa crabro* was tested using methodology described by Stort (1974) expanded and adapted in order to be used in hornets for this study. As a safety measure, the observer wore special suits and mask every time he approached the nests. Studied hornet's nests were established in the same wooden nesting boxes for birds with dimensions of 13 x 13 x 36 cm with an entrance hole with diameter of 29 mm situated 29 cm above the bottom of the box. The same size of boxes ensured that the size of nests were similar. Boxes were located in few areas in the city of Łódź in Poland inter alia: Botanic and Zoological Garden (51045'N 19024'E (84 ha) located in the western part of the city and Łagiewniki Forest (51050N 19029'E) located N-E of Łódź. These activities were correlated with the studies on breeding of birds (Alabrudzińska et al. 2003, Marciniak et al. 2007) and on structure of nests and sizes of wasps colonies (Nadolski 2001, 2012).

In studies of the influence of colors on defensive behavior, different balloons with a diameter of about 30 cm in various colors were used: blue, black, brown, red, yellow, orange, green and white, which were singly placed in the immediate vicinity (30-50 cm) of the exit of the box. The wasps were vexed by three vigorous strokes with a stick in the nesting box. The behavior and number of workers of hornet flying out from the nest was observed. The degree of defensive activity was assessed based on the number of the attacking individuals and the time of their attack (the time was counted from the moment of hitting with a stick until the moment when the balloon ceased to be of interest to hornets). The result was rounded to 1 minute. Every experiment was conducted in the hours before noon and in the rainless days, with an air temperature of about 20 - 25° C, with breaks (2-5 days) between successive tests for the same societies, because too often disturbing the peace of colonies increases aggressiveness of wasps (author's own observations). Their response to a particular color was tested twice on the same colony. Thus, a total of 16 tests were performed for each color. The following criteria for assessing the degree of defensive activity were accepted (Table 1).

For studies of the effect of the aggressor's appearance on defensive behavior, similar methods were used which were based on the same criteria as in the previous experiment and with the use of hornet colonies also located in nesting boxes. However, instead of the balloons, the white dummy mounted on a stick with visible head devoid of any facial features were used, to which the wig with dark hair or the mask looks like an big animal muzzle could be assumed. Graphics and statistical analyses were made using STATISTICA 9 (StatSoft, Inc. 2009).

Results and Discussion

The results of conducted studies determining the influence of colors on the level of defensive activity of *V. crabro* workers were subjected to statistical assessments. Figure 1 presents results of these analysis for the activity time of colonies (ANOVA nonparametric Kruskal-Wallis test $H_{6,112} = 86.8$ $p<0.0001$). In Figure 2 results of analysis for the number of attacking workers (ANOVA nonparametric Kruskal-Wallis test $H_{6,112} = 90.2$ $p<0.0001$) are presented. From them it can be concluded that the strong defensive activity was induced by dark colors especially black and brown, and bright (especially orange). Reactions of hornet's workers on green and white colors were weak or were no response.

The analysis of multiple comparisons for Kruskal-Wallis test demonstrated that there are statistically significant

Table 1. The criteria for assessing the degree of defensive activity of *Vespa crabro* colonies.

Number of attacking workers	Symbol	Time of attack (min)	Degree of defensive activity
up to 5	E	to 3	inaktivity
6-10	D	3-4	weak activity
11-15	C	4-5	average activity
16-20	B	5-6	high activity
over 20	A	more than 6	very high activity

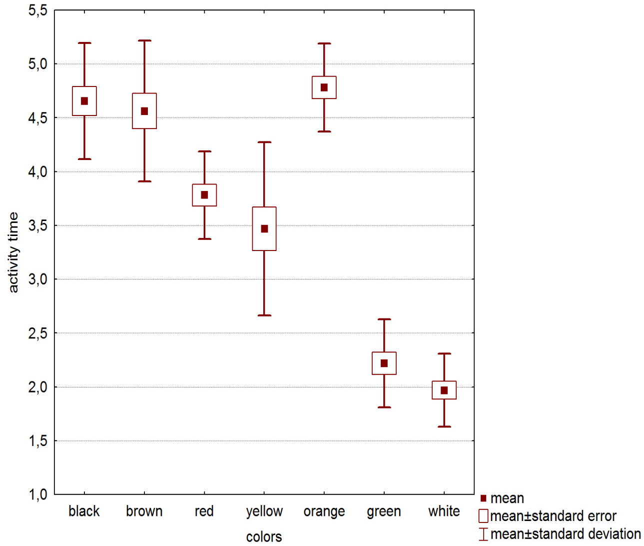

Figure 1. The influence of colors on the level of defensive activity of workers of *Vespa crabro* measured by an activity time.

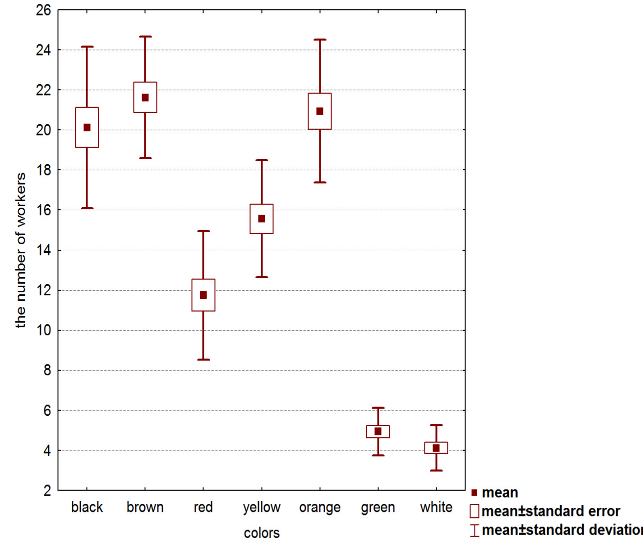

Figure 2. The influence of colors on the level of defensive activity of *Vespa crabro* measured by the number of attacking workers.

differences of rank for the activity time between analyses variables (p-values for multiple comparisons <0.05), except between the dark colors (black, brown) and orange as well as between red and yellow and between white and green (p=1).

Result of the study of the influence of the aggressor's looks on the defensive activity of *V. crabro* colonies showed, that most intense attacks in colonies defense by hornets were caused when the colony was disturbed by the presence of an individual with dark hair. The same contour of animal muzzle without hair did not cause such a strong concern. These received results (Table 2), could not be subjected to statistical analysis.

In recent years greatly increased the scope of various activities for reducing the populations of social wasps especially in urban areas (Nadolski, 2001). Publicizing information on the risks arising from the presence of colonies of wasps causes that people massively want to destroy nests of wasps, but they are not prepared for this type of dangerous actions. In their opinion the main element to protect against stinging of wasps and hornets is plastic bags worn on the head and mosquito spray or deodorants, as effective wasps' deterrents. Such "heroic" acts usually end up in hospital, often in the Medical ICU. There were also cases of necessity and the evacuation of whole families from their homes after such "experiments". Simultaneously, different municipal departments including the Fire Brigade are very often involved to remove nests of bees or wasps. The scale of these phenomena is so serious, that in Poland, the Fire Brigade Headquarters had to develop special procedures to be used for these types of threats (Łyszkiewicz & Nadolski 2009). Based on the information about the behavior of wasps, methods of removing colonies of wasps and bees as well as technical measures for these actions were developed. Studies of *V. crabro* defensive behavior were helped in understanding simple reactions of hornets caused by the presence of potential aggressor.

Defensive behavior in social wasps is similar for different species and involves two steps (Jeanne, 1981): first, in response to jarring of the nest, large numbers of adults are recruited rapidly to the outer surface of the envelope. Second, a fraction of these wasps may fly out to attack the intruder. Outside the nest, the odor of venom greatly reduces the threshold for release of attack behavior, but is not itself a releaser of attack. The release of attack behavior requires an appropriate visual stimulus. In *V. crabro* the attack behavior is similar (Nadolski, unpubl.) and interpretations of studies results were relatively easy. Among beekeepers there is widespread belief that the outfit used to work at the apiary should be white. The results obtained fully confirm the validity of this principle,

Table 2. The effect of the look of a potential aggressor on the level of attack of *Vespa crabro* workers. n. l.– no limitations – the attack lasted until the time of removal of dummy; A*- the number of attacking of workers was too large and impossible to estimate

The form of aggressor	the number of workers	symbol	mean of the time (min.)
White dummy, head without hair	7±4	D	3±1
White dummy, head with dark hair	over 40	A*	n. l.
White dummy with animal muzzle, head without hair	about 20-40	A	9±3
White dummy with animal muzzle, head with dark hair	over 40	A*	n. l.

and points to also the green as an alternative color of such clothing.

The adaptive value of the ability to distinguish colors and to respond to them also seems to be fairly obvious. In a moderate climate zone, the social wasps are active only in spring, summer and autumn, when the white color is not present in the surroundings and, what is more, the potential predators also are not white. The green is the color of the surrounding environment and this is not the color of the aggressor as well. The situation is quite different with dark colors, in shades of brown and black, and also with vivid, bright colors. Natural selection should favor behavior that treats so colored an intruder as a potential predator.

The results of these studies have become the basis for the development by the author of a project of special protective overalls to work with social aculeate, especially hornets. This type of outfit was accepted as the standard protective clothing recommended for the Fire Department sections involved in removing the 'threats from swarms and nests of hymenopterans'.

The result of observation of the defensive behavior conditioned by the intruder looks is equally interesting. The outline of the body shape does not cause too much concern in the colony of hornets. Only the shape, which resembles animal snout and especially hairy head, causes aggression of insects. These results could not be analyzed statistically, however the overall picture of the experiment clearly points to mammals as the main enemies of wasps' societies against whom the whole strategy of defense is directed. The social behavior of Vespidae is dependent on their social structure (Carpenter, 1991; Smith et al., 2001). The social structure is higher, defensive behavior is more complex. In solitary wasps defensive behavior is directed against different types of arthropods especially other insects. In eusocial aculeate they are first of all directed against vertebrate. The studies on venom activity of aculaete also confirm this opinion. Along with the development of social behaviors, venom composition underwent changes towards producing such ingredients that would be more and more effective at defending against such an attacker. The venom of solitary wasps have properties allowing to use it primarily for paralyzing and then killing the victims serving as food for its larvae (Piek & Spanjer, 1986). Vespinae produce venoms, which by of its composition is effective in obtaining food as well as in defense (Nadolski, 2000). However, in the defense aspect, the most effective is the venom of honey bee (*Apis mellifera* L.) (O'Connor, et al., 1967). The main component of this toxin is melittin, one of the most effective detergents that causing red blood cell haemolysis and damage cells of muscles (Banks & Shipolini, 1986; Nabil et al., 1988). The *V. crabro* venom can be used not only to defend the colony and rarely to attack on other insects in order to acquire food, but it is also an effective tool to combat individuals of hornet from foreign societies (Nadolski, 2013)

In conclusion of these results, it is very important that people who are near wasp colonies should have clothes in white or green and hair obscured but when removing whole nests a man have to have a safe outfit properly constructed.

Acknowledgments

I thank two anonymous referees for helpful remarks in an early version of this manuscript.

References

Ahrné, K. (2008). Local Management and Landscape Effects on Diversity of Bees, Wasps and birds in Urban Green Areas. Doctoral Thesis, Swedish University of Agricultural Sciences.

Alabrudzińska, J., Kaliński, A., Słomczyński, R., Wawrzyniak, J., Zieliński, P. & Bańbura, J. (2003). Effects of nest characteristics on breeding success of Great Tits *Parus major*. Acta Ornithol., 38:151-154.

Banks, B. E. C. & Shipolini R. A. (1986).Chemistry and pharmacology of honey-bee venom. In Piek T. (ed.). Venoms of the *Hymenoptera*. Academic Press, London, 329-416.

Bichara Filho, C. C., Santos, G. M. M., Cruz, J.D. da, Pereira, L.C. de O. & Gobbi, N. (2006). Colony defense behavior by the social wasp *Polybia (trichothorax) sericea* (Hymenoptera, Vespidae). Sociobiology, 49: 215-220.

Carpenter, J. M. (1991). Phylogenetic relationships and the origin of social behavior in the Vespidae. In Ross, K.G. & Matthews R.W. (eds). The Social Biology of Wasps. Ithaca, NY: Cornell, University Press pp. 7–32.

Chittka, L., Beier, W., Hertel, H., Steinmann, E. & Menzel R. (1992). Opponent colour coding is a universal strategy to evaluate the photoreceptor inputs in Hymenoptera. Compar. Physiol. A, 170: 545-563.

Haeseler, V. (1982). Amaisen, Wespen und Bienen als Bewohner gepflasterter Bürgersteige, Parkplätze und Straβen (Hymenoptera: Aculeata). Drosera, 82(1): 17-32.

Jeanne, R. L. (1981). Alarm recruitment, attack behavior, and the role of the alarm pheromone in Polybia occidentalis (Hymenoptera: Vespidae). Behav. Ecol. Sociobiol., 9(2): 143-148.

Kelber, A., Jonsson, F., Wallén, R., Warrant, E., Kornfeldt, T. & Baird E. (2011). Hornets Can Fly at Night without Obvious Adaptations of Eyes and Ocelli. PLoS ONE 6(7): e21892. doi:10.1371/journal.pone.0021892

Łyszkiewicz, Z. & Nadolski, J. (2009). Principles of actions with hymenopterans. Kurier Strażacki, 111-112: 4-5. [In Polish.]

Marciniak, B., Nadolski J., Nowakowska, M., Loga, B. &

Bańbura J. (2007). Habitat and annual variation in arthropod abundance affects Blue Tit *Cyanistes caeruleus* reproduction. Acta Ornithol., 42(1):53-62.

Moritz R. F. A. & Bürgin H. (1987). Group response to alarm pheromones in social wasps and the honeybee. Ethology, 76:15-26.

Nabil, Z.,I., Hussein, A.,A., Zalat, S.,M. & Rakha M.Kh. (1998). Mechanism of action of honey bee (*Apis mellifera* L.) venom on different types of muscles. Human Experim. Toxicol., 17:185-190.

Nadolski, J. (2000). Differentiation of toxicity properties of some social Aculeata venoms (Hymenoptera, Aculeata)] Acta Universitatis Lodziensis, Folia Zool., 4: 3-24. [In Polish]

Nadolski, J. (2001). Nests of social wasps and hornets in town area of Łódź. In Indykiewicz, P., Barczak, T. & Kaczorowski G. (eds). Biodiversity and ecology of animal populations in urban environments. NICE Bydgoszcz, 89-93. [In Polish]

Nadolski, J. (2012). Structure of Nests and Colony Sizes of the European Hornet (*Vespa crabro*) and Saxon wasp (*Dolichovespula saxonica*) (Hymenoptera: Vespinae) in Urban Conditions. Sociobiology, 59 (4): 1075-1120.

Nadolski , J. (2013). The effect of LD50 of the European hornet (*Vespa crabro* Linnaeus 1761) crude venom on own species. J. Venom. An. Toxins including Trop. Dis., 19: 4.

Notman, P. R. & Beggs, J. R. (1993). Are wasps more likely to sting men than women. New Zealand Entomol., 16: 49-51.

O'Connor, R., Henderson, G., Nelson, D., Parker, R. & Peck, M. L. (1967). The venom of the honey bee (*Apis mellifera*). In Russell, F.E. & Saunders, P. R. (eds). Animal Toxins. Pergamon, Oxford: pp17-22.

Piek, T. & Spanjer, W. (1986). Chemistry and Pharmacology of solitary wasp venoms. In Piek, T. (ed.). Venoms of the Hymenoptera. Academic Press, London, pp 161-307.

Skibińska, E. (1982). Wasps (*Hymenoptera, Vespidae*) of Warsaw and Mazovia, Mem. Zool., 36: 91-102.

Smith, A.R., O'Donnell, S. & Jeanne R. L. (2001). Correlated evolution of colony defence and social structure: A comparative analysis in eusocial wasps (Hymenoptera: Vespidae). Evol. Ecol. Res., 3: 331-344.

Spiewok, S. & Schmolz, E. (2006). Changes in temperature and light alter the flight speed of hornets (*Vespa crabro* L.). Physiol. Biochem. Zool., 79(1): 188-193.

Stort, A. C. (1974). Genetic study of aggressiveness of two subspecies of *Apis mellifera* in Brazil. I some tests to measure aggressiveness. J. Appl. Res., 13: 33-38.

Veith, H. J., Koeniger, N. & Maschwitz, U. (1984). 2-Methyl-3-butene-2-ol, a major component of the alarm pheromone of the hornet *Vespa crabro*. Naturwissenschaften, 7: 328-329.