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SALVATORE VICIDOMINI

BIOLOGY OF *XYLOCOPA* (*XYLOCOPA*) *VIOLACEA* (L., 1758) (HYMENOPTERA: APIDAE): FEMALE NEST-DEFENCE

Abstract - SALVATORE VICIDOMINI - Biology of *Xylocopa* (*Xylocopa*) *violacea* (L., 1758) (Hymenoptera: Apidae): female nest defence.

X. violacea was observed for 1200 h in 9 years in Southern Italy. Experiment was carried out in order to study the nest defence ethology. The females used for the experiments were the following: 60 females with nest (F); 30 females without nest (*F); 45 18h-imagine-females. The nest defence was exhibited versus following causes: conspecifics, insect intruders, man. Man evoke a particular and unique defence behaviour. The presence of experimenter do not influence the intimidatory buzzing. (F) and (*F) exhibited a buzzing behaviour with a frequency very similar. Repeated tasks do not decrease the buzzing behaviour. Temperature is not important in buzzing exhibition but influences the intensity and the behaviour duration; a exhibited cloudy phase appear more important to decrease buzzing behaviour. Buzzing is innate. Intimidatory buzzing was also observed in: *X. fenestrata*, *combusta*, *flavorufa*, *imitator*, *torrida*, *pubescens*, *sulcatipes* and in *Lestis bombylans* e *L. aeratus.* In *X. violacea* was not observed the rectal ejection of yellow liquid, observed in: *X. combusta*, *fenestrata*, *flavorufa*, *imitator*, *torrida, ciliata*, *virginica*, *Lestis bombylans*. The metasomal notum occlusion of nest entrance was frequently observed and also reported in: *X. appendiculata*, *augusti*, *auripennis*, *ciliata*, *tranquebarorum*, *virginica*, *combusta*, *flavorufa*, *imitator*, *torrida*, *pubescens*, *sulcatipes*, *Lestis bombylans*, *L. aeratus*. Results shows that acoustic stimuli are very important. Buzzing behaviours are used in intraspecific and interspecific (other insect orders) interactions; for this reason the acoustie sense appear very important in aggressive interactions. Nest-defence behaviour can be considered as a part of the shelter-defence strategy. Two new behaviours are described.

Key words: *Xylocopa violacea* - Apidae - Nest-defence - New behaviours - Southern Italy.

Riassunto - SALVATORE VICIDOMINI - Biologia di *Xylocopa* (*Xylocopa*) *violacea* (L., 1758) (Hymenoptera: Apidae): difesa del nido da parte della femmina.

X. violacea è stata osservata per complessive 1200 ore in 9 anni in Italia meridionale. Sono stati eseguiti esperimenti per studiare il comportamento di difesa del nido. Sono state usate 60 femmine in nidificazione e 30 senza nido; 45 femmine aventi al massimo 18 ore di vita allo stadio di immagine. Le cause che inducono una femmina nidificante a esibire comportamenti di minaccia sono: conspecifici che cercano di entrare nel nido, insetti intrusi nella canna, l'uomo. Nei confronti dell'uomo esiste un comportamento unico. Il buzzing intimidatorio non è influenzato dalla presenza dello sperimentatore in (F). Le (F) e le (*F) hanno una frequenza di risposta (Buzz) allo stimolo molto simile. Prove ripetute non modificano la frequenza con la quale una femmina risponde ad un eventuale stimolo. La temperatura influenza l'intensità e la durata del buzzing ma non è importante nell'evocare o meno la risposta. Un prolungato periodo di nuvolosità è più importante nel causare una diminuzione del (Buzz). Il buzzing è innato e presente sin dall'inizio nelle femmine. Il buzzing intimidatorio è stato osservato anche in *X. fenestrata*, *combusta*, *flavorufa*, *imitator*, *torrida*, *pubescens*, *sulcatipes* ed inoltre in *Lestis bombylans* e *L. aeratus.* In *X. violacea* non è stato mai osservato il comportamento di espulsione a gran velocità di liquido giallo dalla regione rettale riportato invece per *X. combusta*, *fenestrata*, *flavorufa*, *imitator*, *torrida, ciliata*, *virginica*, *Lestis bombylans*. Invece il blocco dell'ingresso col dorso metasomale riportato per *X. appendiculata*, *augusti*, *auripennis*, *ciliata*, *tranquebarorum*, *virginica*, *combusta*, *flavorufa*, *imitator*, *torrida*, *pubescens*, *sulcatipes*, *Lestis bombylans*, *L. aeratus* è stato frequentemente osservato. Si evince che gli stimoli acustici sono molto importanti in questa specie. I ronzii vengono usati non solo in tutte le manifestazioni di difesa contro conspecifici, ma anche contro insetti di altri ordini. Il senso acustico sembra essere molto importante per le interazioni aggressive. Il comportamento di difesa del nido può essere considerato un'estensione del comportamento di difesa del sito rifugio. Vengono descritti due nuovi comportamenti difensivi, uno contro l'uomo ed uno contro maschi conspecifici.

Parole chiave: *Xylocopa violacea* - Apidae - Difesa del nido - Nuovi comportamenti - Italia meridionale.

INTRODUCTION

The species of the genus *Xylocopa* Latreille 1804, are referred to as carpenter bees, all of them having the same nesting behaviour (HURD & MOURE, 1963; IWATA, 1972; WATMOUGH, 1974): they usually nest in deadwood, excavating tunnels in several directions to form branched nests. Some species also nest in the internodes of canes or bamboo (HURD & MOURE, 1960; JANVIER, 1977).

Xylocopa (*Xylocopa*) *violacea* (L., 1758) is the most widespread and best-known species of this genus in Europe; it is distributed in the middle-western Palaearctic region. In Italy it is present throughout the peninsula, from sea level to over 1350 meters (Le Foehe: Abruzzo). It is also found in Sardinia and Sicily (as far as 1890 m on Mt.Etna), as well as on some minor islands, as Capraia and Isola del Giglio. In the study area, the reproductive period starts in late January-early February, and the mating period lasts until late April; until June females search for suitable nesting substrates: these are canes, poles, trunks (VICIDOMINI, 1995a, b, 1996, in press).

Nest morphology and kind of substrate are no doubt the aspects of reproductive biology most extensively studied in the *Xylocopa* species (e.g.: HURD & MOURE, 1963; SAKAGAMI & LAROCA, 1971; GERLING *et alii*, 1989). Mating systems (female-searching behaviour, the sensory organs implied in the recognition of the other sex, sexual ethology) have also been studied (e.g.: MARSHALL & ALCOCK, 1981; VICIDOMINI, 1996, 1997). Conversely, competition (inter- or intra-specific) for nests, demographic parameters (fecundity, birthrate, mortality, survival) and offence-defence behaviours have been poorly studied (VICIDOMINI, 1997).

The present study represents the first contribution to the knowledge of the offence-defence ethology in *X. violacea* females, and one of the few concerning the whole Xylocopini tribe. The behavioural patterns exhibited by females (nesting or not) and newly emerged individuals, when they are disturbed, are described. Similar observations have been reported by KAPIL & DALIWAL (1968), SAKAGAMI & LAROCA (1971), BONELLI (1974, 1976), ANZENBERGER (1977), GERLING *et alii*, (1983), VELTHUIS & GERLING (1983), VAN DER BLOM & VELTHUIS (1988), HOUSTON (1992).

MATERIALS AND METHODS

The observations on *X. violacea* were carried out from 1986 to 1994, for a total of 1200 hours, 800 of them in the first six months of each year. The study area is cultivated with fruit trees and vegetables and is located in the town of Nocera Superiore (Salerno: Campania: Italy. U.T.M.: 33TVF70. N 40° 44'; E 14° 41'. 60 m. a.s.l. - 4660 m^2).

Experiments were carried out to study the buzzing behaviour in defence of the nest. Buzzing is an intermittent or continuous sound given out by the female when she does not fly, and used as sound signal. For this purpose, 90 females were examined. In order to establish whether this behaviour is due only to the presence of the nest, the experiments were carried out both on nesting females (60 individuals) and on females in other periods of the year (30 individuals). The same experiments were conducted on 45 females, not older than 18 hours, at the imaginal instar, in order to establish whether the buzzing behaviour is innate, or develops immediately after birth or at a later stage during life. The experimental procedures and the individuals used are specified hereafter.

Stimuli used:

In order to simulate an intrusion by another insect into the cane occupied by the female, I introduced a drinking straw into the cane slowly as far as its bottom, then I gently stirred it for 10-30 seconds and drew it out slowly. This experiment aimed at establishing whether the female gave out the sound signal (buzzing) as a result of disturbance.

To cause disturbance I also introduced a dead insect into the cane either before or after the female flew back from one of the many trips for pollen or nectar collection during nesting. In this case, not only I recorded the emission of buzzing but also the possible damage caused to the dead insect and the behaviour of the female after the insect was left in the cane.

Some insects were fixed on a stick, so that a kind of aggressive and persevering insect was simulated.

Females with nests (F):

a) To establish whether the buzzing was modified by repeated tests, (F) were divided into two groups of 30 specimens each: one group was treated only once during nesting, the other 2-4 times at intervals of three days.
b) The (F) treated only once were subdivided into two groups of 15 specimens: during stimulation of one group the experimenter was in front of the cane entrance, in the other it was not visible to the (F); this was aimed at establishing whether buzzing was a reaction to the sight of the experimenter.
c) The (F) treated 2-4 times were subdivided into three groups: 10 individuals were treated on sunny days, 10 on overcast days or when it had been cloudy at least for 3 hours, 10 were treated 1.5-2 hours after sunset; this was aimed at establishing whether this behaviour is temperature- or daylight-dependent.
d) Two kinds of stimuli were used for all the (F), the drinking straw and the insect, to detect possible differences in the response.
e) The reactions against the insect introduced into the cane were evaluated for all the (F): ejection or not of the insect, abandonment or not of the nest.

Females without nest (*F):

1) A total of 20 (*F) were treated once, using a straw or a dead insect.
2) Ten (*F) were treated with a straw 2-4 times every three days.
3) The reactions of the (*F) of (1) treated with insects were evaluated after the introduction of the insect, as was done for the (F) of (e).

Females which have entered the imaginal instar for max.18 hours (FI):

They were treated with a straw. Few hours before changing into imagoes, the individuals were isolated in single canes, so that they could not be influenced by brothers or sisters.

Introduction of living Forficula auricularia L. 1758 specimens, into the nest

In 5 tests a specimen of *F. auricularia* was introduced into the nest in order to evaluate the response of (F) to the intrusion of an insect which frequently occupies the canes. A metal mirror was used for the observations in the canes. All the nests and shelters studied were excavated in canes, which were derived from *Arundo donax* and were used by farmers to support plants. Those used as nests and shelters were always placed parallel to the ground, and therefore showed two holes, one of which was the entrance of the nest/shelter of the female.

RESULTS

Field Observations

Defence of the nest involves several behaviours, some of which are complex and rarely exhibited. Under natural conditions, they may be induced by the following events: females searching for nest substrate and pollen; males searching for females; presence of a man.

In cases of females in search of substrates for their nests or of female-searching males, the intruder (I) hovers in front of the nest entrance. The founder female (F) gives out some intermittent threatening buzzing sounds (which was also observed in the presence of a man) at intervals shorter than one second or much longer; moreover, there is a scale ranging from thoroughly intermittent to almost continuous buzzing. This behaviour may last even more than one minute. If, as often happens, (I) perches on the entrance of the nest, the female rushes forward and attacks, and this is sufficient to drive (I) away. If (I), e.g. the male, persists in hovering in front of the nest entrance to mate with (F), two other defensive behaviours are used. In one case, the female rushes out of her nest, and, when the male reaches her, they begin to turn around each other, at a distance of about 1-2 meters, in a double-spiral upward flight until, at a certain height, (F) attacks the male, making him fly away. This is the most common behaviour exhibited by females in such cases. The other type of defensive mechanisms was observed only 3 times in 9 years. The male is threatened by the buzzing given out by the female inside the nest; however he does not move from the entrance. Then, (F) attacks him and the male flies away, remaining however, in the proximity of the nest; (F) buzzes again, then the male enters the hole of the cane opposite to the nest entrance, and (F) gives out some intermittent buzzing sounds. If the male does not fly away, as happened in the three cases observed, the female comes out from the nest and lands on the hole of the internode occupied by the male, starting to give out a loud continuous buzz with her wings and tapping her jaws at high frequency on the external surface of the internode occupied by the male, similarly to a nesting woodpecker. After few seconds the male flies away.

If a female, flying back from pollen collection, sees a man (m) in front of, or near, the nest, she places herself in front of (m) and performs up to 15 wide side oscillations, as it were a pendulum, always remaining in front of (m); the female assumes the following flying posture: legs stretched, jaws open, antennae directed forward. Oscillations slacken, and the female comes increasingly closer to (m); then (F) turns around (m) once or more times and begins to oscillate again. At that point, if (m) has not gone away, the female either continues flying around him and oscillating, or flies away temporarily, forming a very wide circle. This oscillatory behaviour was observed on 33 occasions and only in the presence of (m); cows, dogs, cats, horses do not evoke this behaviour.

Experiments

1. *(F) treated once: whether in the presence or absence of the experimenter (Tab. I)* - No significant difference was observed in the frequency of buzz after stimulation (straw/insect). Buzzing was recorded 25 times out of 30 (83.3%).

TABLE I: 30 (F) TREATED ONCE. IN 15 CASES THE EXPERIMENTER WAS VISIBLE TO THE FEMALE AND IN 15 HE WAS NOT VISIBLE. THE STIMULUS USED IS NOT SPECIFIED

Experiment	With Visible Experimenter		Without Visible Experimenter	
Behaviour	Buzz.	No. Buzz.	Buzz.	No. Buzz.
N.°	13	2	12	3
%.°	86.7	13.3	80.0	20.0

2. *(F) treated once: stimulus = straw and insect (Tab. II)* - A slight difference was observed in the response exhibited by (F) to the two stimuli: the straw seems to evoke buzzing more easily. The total percentage of buzzing was the same as that reported above, the sample being the same.

TABLE II: THE SAME 30 (F) TREATED ONCE WITH STRAWS AND INSECTS

	15 Straws		15 Hymenoptera	
Behaviour	Buzz.	No. Buzz.	Buzz.	No. Buzz.
N.°	14	1	11	4
%	93.3	6.7	73.3	26.7

3. *(F) treated 2-4 times: stimulus = straw and dead insect (Tab. III)* - A more frequent buzz was also observed in (F) treated more than once with a straw than in those stimulated with an insect; this difference is very similar to that observed in (F) treated once. The total percentage of buzzing was 81.9%, very similar to that observed for (F) treated once.

4. *(F) treated 2-4 times: on sunny days, cloudy days, or at night (Tab. III)* - On cloudy days buzzing remarkably decreased (60%). Moreover, it was weaker and lower and lasted a shorter time; the whole behaviour was observed for a shorter time. Conversely, on sunny days, the frequency of buzzing was very high, almost total. At night the response was quite higher than on cloudy days (71.0%); buzzing was much weaker and low.

TABLE III: 30 (F) TREATED 2-4 TIMES. IN 15 CASES AN INSECT WAS USED AS A STIMULUS, IN THE OTHER 15 A STRAW. WITH BOTH STIMULI, THE RESPONSE WAS EVALUATED UNDER DIFFERENT TEMPERATURE AND LIGHT CONDITIONS

Experiment	cloudy days 10 (F)		sunny days 10 (F)		at night 10 (F)		with straw		with insects	
Behaviour	Buzz	No B.	Buzz	No B.	Buzz	No B.	Buzz	No B.	Buzz	No B.
(F) N.° 1	1				1				2	
(F) N.° 2	1				1				2	
(F) N.° 3			2						2	
(F) N.° 4		1		1						2
(F) N.° 5	1				1				2	
(F) N.° 6	1	1							1	1
(F) N.° 7	1		1						2	
(F) N.° 8	1			1		1			1	2
(F) N.° 9		1	1						1	1
(F) N.° 10	1				1				2	
(F) N.° 11	1		1						2	
(F) N.° 12		1			1				1	1
(F) N.° 13	1		1						2	
(F) N.° 14				1	1				1	1
(F) N.° 15		1	1						1	1
(F) N.° 16	1		1				2			
(F) N.° 17			3				3			
(F) N.° 18	1		2			1	3	1		
(F) N.° 19	1		2		1		4			
(F) N.° 20		1	2				2	1		
(F) N.° 21			1		2	1	3	1		
(F) N.° 22			2		2		4			
(F) N.° 23		1	2				2	1		

continued

(F) N.° 24			2				2			
(F) N.° 25			1		2		3			
(F) N.° 26			3		1		4			
(F) N.° 27			1		2	1	3	1		
(F) N.° 28			2		2		4			
(F) N.° 29		1	2		1		3	1		
(F) N.° 30			3		1		4			
Total N.°	12	8	36	3	20	4	46	6	22	9
%	60.0	40.0	92.3	7.7	83.3	16.7	88.5	11.5	71.0	29.0

5. *Behaviour of (F) when insects are introduced into the nest (Tab. IV)* - Of the 21 insects introduced, 20 were ejected (95.2%); the only one that was not ejected from the cane was a dead specimen of *X. violacea* , which caused (F) to abandon the nest.

TABLE IV: TYPE OF INSECT INTRODUCED AND BEHAVIOUR OF (F). (F) TREATED EITHER ONCE OR 2-4 TIMES WERE USED

Insects introduced	(F) Behaviour		
	Insect ejection	Non- ejection and abandonment of the nest	Non- ejection and permanence in the nest
Other than Hymenoptera	9	0	0
Hymenoptera	6	0	0
X. violacea	5	1	0

6. *(*F) treated once: stimulus = straw and dead insect (Tabs. V)* - The total response evoked by either stimulus in (*F) was very similar to that obtained in (F): 80.0% (6+10). A difference was instead observed between the responses to the straw (buzzing in 66.7% of the responses) and to the insect (buzzing in 90.9% of the responses).

TABLE V: SAME (*F) TREATED ONCE WITH A STRAW AND HYMENOPTERA

Behaviour	Straws		Hymenoptera	
	Buzz.	No. Buzz.	Buzz.	No. Buzz.
N.°	6	3	10	1
%	66.7	33.3	90.9	9.1

7. *Behaviour of (*F) when insects were introduced into the cane (Tab. VI)* - In this experiment, ejection was not the rule. In fact, though the threatening response was very frequent, it was not usually followed by ejection of the insect (Tab. V); however, (*F) abandoned the shelter. In two cases, she even lived together with two dead specimens of *X. violacea* for 1 hour in the same cane.

TABLE VI: BEHAVIOUR OF (*F) WHEN INSECTS WERE INTRODUCED
ONLY (*F) TREATED ONCE WERE USED

Insect Introduced	(*F) Behaviour		
	Ejection	Not ejection and abandoning	Not ejection without abandoning
Other than Hymenoptera	1	3	0
Hymenoptera	0	2	0
X. violacea	1	2	2

8. *(*F) treated 2-4 times: stimulus = straw (Tab. VII)* - The result was very similar to that obtained with (*F) and (F) treated once.

TABLE VII: (*F) TREATED 2-4 TIMES WITH A STRAW

(*F) N.°	a	b	c	d	e	f	g	h	i	j	N.°	%
Buzz.	2	2	2	1	2	2	3	3	3	3	23	82.1
No Buzz.	0	0	0	1	0	1	0	1	1	1	5	17.9

9. *(FI) treated once: stimulus = straw (Tab. VIII)* - In the immature new imagoes the response was the same as in adult female. In each case, (FI) buzzed as soon as they perceived the straw, then they opened their jaws and grasped the straw with their legs.

TABLE VIII: (FI) TREATED WITH A STRAW

Behaviour	Buzz.	No Buzz.
N.°	43	2
%	95.5	4.5

10. *Experiments with living specimens of Forficula auricularia* - As soon as a specimen of *F. auricularia* was introduced into the nest, it was immediately recognised

by (F), which showed the following behaviour: a) she rose to her legs, obstructing the bottom of the internode by her abdomen; b) with her abdomen forward, she moved with small jerky steps towards *F. auricularia*, if this advanced towards her; c) she gave out buzzing; d) if, as it always happened, *Forficula*, moved away stopping on the entrance, (F) turns with her abdomen towards *Forficula*, standing on her legs. In a single case, *Forficula* rushed towards (F), but it was immediately attacked, kept still by its fore- and mid-legs, and assailed with her jaws open, as if she intended to bite it without causing any damage. *Forficula* ran away immediately, throwing itself out of the cane.

General comments on the results

The insect can be ejected in two ways: a) its head is pushed out of the nest; b) (F) surpasses the insect in the nest, then she turns towards it, and, with her jaws, drags the intruder, ejecting it. In all of the 20 cases in which (F) remained in the nest, after insect ejection she groomed her whole body accurately. Ejection always took place within 15 minutes from the introduction of the insect. When a straw or an insect is introduced, the carpenter bee is on the watch for the intruder and rises on its own legs but does not buzz. When the straw is brought near to (F), she starts buzzing, and grasps the straw with her jaws, biting it many times so as to prevent it from reaching the bottom. This behaviour is also exhibited when the experimenter tries to take the straw out of the cane. In 48 cases out of the 60 in which (F), treated once or 2-4 times, buzzed, she flew out of the cane forming a circle about 1 meter in diameter around the entrance, perching on the entrance, and then bit the straw repeatedly until it was ejected. During this attack (F) buzzed continuously. When, in experiments with (*F), the stimulus with the straw lasted longer than usual (12 cases in which the stimulus lasted 40 seconds), (*F) flew out of the cane, turning once or twice around the entrance and then flew away. The insects used as stimuli for (F) were then analysed to detect possible lacerations caused by the female. Eight insects were analysed, namely 3 lepidopterans, two specimens of *Eucera longicornis* and 3 of *X. violacea*. In three butterflies, a leg was torn off and the abdomen lacerated. In *E. longicornis*, two pairs of legs and the antennae were torn off. Three males of *X. violacea* were fixed on a stick to simulate a living specimen. The female bit it and tried to push it out of the nest in a head-to-head struggle. When the male was pushed out of the nest, antennae, tarsi, eyes and the portion of the head close to the eyes appeared to have been torn off or lacerated by (F). In several cases in which the stimulus lasted for some minutes, at a certain moment the female, whether nesting or not, turned, completely obstructing the inside of the internode with her metasomal notum. This behaviour was observed at night under normal conditions; in fact, most females always point their metasoma towards the entrance.

Discussion

Observations

A nesting female may exhibit threatening behaviours for the presence of the following intruders: 1) conspecific females searching for a nesting substrate; 2) conspecific female-searching males; 3) insects belonging to other species in the cane; 4) human beings.

In cases 1) and 2), (F) feels her nest is threatened by conspecific individuals; in fact, in the nesting period, *X. violacea* females are the major cause of nest destruction (Vicidomini, unpublished data), therefore, the defence behaviour against other females is more than justifiable. Conversely, the defence behaviour against males is probably exhibited only because (F) is no longer able to recognise the sex of the intruder or simply is no longer willing to mate; in fact, during the first half of the nesting period, males are still in search of females for mating. In case 4, the complex defence behaviour is exhibited only against human beings even in periods other than the nesting one. This and the woodpecker-like behaviour have first been described in *X. violacea.* The stage with wide oscillations closely resembles the perching of (F) on the nest entrance (Vicidomini, in press); however, in the latter case the oscillations are very narrow. It appears evident that the female tries or simulates perching in order to sting (m). I have not observed female-female interactions involving lesions, as has instead been described in *X. fimbriata*, which thus prevents many nests to be excavated on the same substrate (Janzen, 1966). In this area, the large number of (artificial) substrates suitable for nesting has never required the exhibition of this kind of interactions which might damage the two contenders seriously.

Experiments

From experiment 1 it can be deduced that in (F) threatening buzzing is not influenced by the presence of the experimenter.

In experiments 2) and 3), in (F) a straw seems to evoke buzzing more easily, since it is more mobile than a dead insect. It is not clear why in (*F) the frequency of buzzing is much higher with insects than with a straw.

In experiment 5), the dead insect was always ejected by (F), since a decaying body might spread pathogens, fungi and parasites inside the nest. For this reason, (F) always cleans up the nest accurately after ejection. Nest abandonment is always disadvantageous for the female, particularly if nest construction is at an advanced stage. Conversely, for (*F) this is the best tactic, since it allows to avoid possible damages due to parasites or pathogens introduced by the intruder, as well as physical injuries; moreover, other shelters may be easily found.

Temperature no doubt influences the intensity and duration of buzzing (experiment 4); however it does not seem important in evoking the response. It seems that buzzing is decreased more by a prolonged period of cloudy weather than by the night.

Experiment 9 shows that the buzzing behaviour is innate in females. Their failure in grasping the straw with their jaws might be related to their very young age, which would not allow them to adduct the jaws with strength, as happens with the wing movements.

When a straw or an insect is inserted into the nest, the carpenter bee rises on its legs without buzzing. This behaviour was also observed when a specimen of *F. auricularia* (experiment 10) was inserted into the cane; this may allow (F) to put the sting, which is located on apex of her metasoma, forward, thus preventing the straw or *F. auricularia* from reaching the bottom and damaging or destroying an egg or a cell.

All the experiments performed lead to the conclusion that the frequency of buzzing as a response to a stimulus (straw/insect) is very similar in (F) and (*F); moreover, repeated experiments do not appear to change the frequency of the response to a stimulus. This might be due to the fact that a female builds a single nest throughout her lifetime, and therefore she always tries to avert any danger from her only genetic investment.

The analysis of the straws and the insects used shows that the behaviour exhibited in these cases consists in a phase of threat (buzzing) and a phase of attack. In fact, with their powerful jaws they are able to tear off any part of the body of an insect, like the head of another *X. violacea* female.

Comparative Defence Ethology in Xylocopini

Threatening buzzing and head-to-head fighting have also been observed in other species of the genus *Xylocopa* as well. Threatening buzzing has been reported in *X. aestuans*, (EL BOROLLOSY & ISMAIL, 1972), *X. combusta* (BONELLI, 1974, 1976), *X. fenestrata* (KAPIL & DHALIWAL, 1968), *X. flavorufa*, *X. imitator*, *X. torrida* (ANZENBERGER, 1977), *X. pubescens*, *X. sulcatipes* (GERLING *et alii*, 1983; VELTHUIS & GERLING, 1983; VAN DER BLOM & VELTHUIS, 1988) and also in *Lestis bombylans* e *L. aeratus* (HOUSTON, 1992). Head-to-head fighting has been observed in *X. pubescens* e *X. sulcatipes* as well (GERLING *et alii*, 1983). Therefore, it is likely that the two behaviour are widespread among the species of this tribe.

Obstruction of the entrance by the metasomal notum has also been observed in *X. appendiculata*, *X. augusti*, *X. auripennis*, *X. ciliata*, *X. tranquebarorum*, *X. virginica* (SAKAGAMI & LAROCA, 1971), *X. combusta* (BONELLI, 1974, 1976), *X. flavorufa*, *X. imitator*, *X. torrida* (ANZENBERGER, 1977), *X. pubescens*, *X. sulcatipes* (GERLING *et alii*, 1983), *Lestis bombylans* and *L. aeratus* (HOUSTON, 1992). It can be reasonably stated that this behaviour, too, is practically present in all the species of the Xylocopini tribe.

In *X. violacea* it was never observed fast ejection of yellow liquid from the rectal orifice, which has been reported, instead, in *X. combusta* (BONELLI, 1974, 1976), *X. fenestrata* (KAPIL & DHALIWAL, 1968), *X. flavorufa*, *X. imitator*, *X. torrida* (ANZENBERGER, 1977), *X. ciliata*, *X. virginica* (SAKAGAMI & LAROCA, 1971), *Lestis bombylans* (HOUSTON, 1992).

HOUSTON (1974), in *Xylocopa* sp. (*aruana*?), observed a (F) which drove back an (I) stretching out her forelegs from the entrance and jabbing at (I); this behaviour was not observed in any species of the Xylocopini tribe. The nest-defence behaviour exhibited by *X. violacea* females against (m) and the woodpecker-like behaviour exhibited against males have never been reported in other species of the same genus; it would be worth studying them in other *X. violacea* populations, in other species of the tribe and in related tribes (Manuelini Caratinini, Allodapini).

CONCLUSIONS

These results demonstrate that sound stimuli are very important in this species. ANZENBERGER (1977) reports that the buzzing given out by a (F) alerts all the (F) having the nest on the same substrate or plant. Not only is buzzing used as defence behaviour against conspecific individuals, but also against insects of different orders (and humans). The sense of hearing appears very important in these insects, at least in aggressive interactions, and greater attention should be attached to it in non-orthopteran insects (e.g.: KAPIL & DHALIWAL, 1968; LANE & ROTHSCHILD, 1965; FUCHS & KOENIGER, 1974; BAUER, 1976; SCHMIDT & BLUM, 1977; SMITH & LANGLEY, 1978; MASTERS, 1979, 1980; LARSEN *et alii*, 1986; VICIDOMINI & PICARIELLO, 1994). Moreover, experiments with (*F) show that the nest-defence ethology can be considered as a part of the shelter-defence ethology.

Finally, more detailed information on nest-defence ethology and other behaviours exhibited during the reproductive period in species of the genus *Xylocopa*, would allow us to attempt at a cladistic approach, as to establish possible unique characteristics (derived-ancestral condition), which, together with morphological and biochemical data, can be used to update and review the «artificial» taxonomy of the tribe, including three genera, 50 subgenera, about, divided into 800 species, subspecies and voces, about. (see: HURD & MOURE, 1963; GERLING *et alii*, 1989).

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Indirizzo dell'autore:
Salvatore Vicidomini - Università Federico II - Dipartimento di Zoologia
Via Velardi, 10 - I-84014 Nocera Inferiore (SA)