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STUDY OF FEEDING AND GREGARIOUS BEHAVIOR OF TWO SPECIES OF ECTOBIIDAE; *Loboptera decipiens* AND *Loboptera ovolobata* (BLATTODEA)

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ABSTRACT

This work aims to study the feeding and gregarious behavior of the two species of forest cockroaches, *Loboptera decipiens* and *Loboptera ovolobata*, collected in the Aflou region (Laghouat; Algeria). So we tested the attractiveness of these species via the odors of the two extracts, Aleppo pine leaves or *Loboptera* species. These tests were carried out in a closed enclosure under the controlled temperature and humidity conditions of the breeding room. Time was recorded with a stopwatch.

For food tests, the results showed that both species *L. decipiens* and *L. ovolobata* were significantly attracted to the hexane extract of Aleppo pine leaves (30min). Gregarious tests show that the larvae are attracted to the smell of the hexane extract of larvae of the same species. while, adult species are attracted to the scent of the haxan extract from both adults (they cannot distinguish the scent of their species).

Keywords: *Loboptera decipiens; loboptera ovolobata*; Laghouat, feeding behavior; gregarious behavior; Aleppo pine.

INTRODUCTION

Flora and fauna of forests are very rich in species [1] and Cockroaches and ancient insects, 400 million years old, the fossil forms of which are pretty comparable to current species [2].

Cockroaches are abundant in forests, and they have of very varied forms and widely responded to across the world [3]. Cockroaches are primarily of tropical and subtropical origin, being found in various habitats, such as fallen leaves on the ground, animal dens, caves, tree trunks, ant nests, leaf litter, and sometimes in water [4].

Forest cockroaches feed on plant debris and thus participate in leaf decomposition and humus formation [5].

In cockroaches, a whole range of classic behaviors such as food intake, dispersal, flight, reproduction, but these also coexist, quite often, with so-called pro-social behaviors. This name covers privileged relationships of the gregarious type between individuals who naturally tend to come together. Their communication is primarily based on chemicals that often act at a distance, called pheromones [6].

Loboptera is a forest cockroach that is poorly understood in terms of its biology and behavior. It is mainly found in Africa, Australia, South America, and the Mediterranean region [7-9]. The genus *Loboptera* [10] is cosmopolitan and belongs to the Pseudomopinae subfamily. It lives in dead leaves, under stones, and slightly damp places [7] [11]. It is a rapidly developing and omnivorous nocturnal species, which feeds on the remains of decaying animals and plants.

Loboptera decipiens is a rapidly developing nocturnal forest cockroach, a glossy black flightless cockroach, ovoid in shape, with a whitish border around the body in adults; it measures 8 to 10 mm long [11]. An insect with hetero-metabolic development constitutes an essential link in the forest food chain [12].

It is a small species (11 to 12 mm) that closely resembles *L.* decipiens. This species is first identified by Bohn (1991). It is characterized by a shiny black body devoid of a white border, and it's short, lobiform with black elytra [13].

In this present investigation was undertaken to study its feeding behavior by the hexane extract of the leaves of the Aleppo pine and gregarious by the hexane extract of *Loboptera* for the two forest species, *Loboptera decipiens* and *Loboptera ovolobata*.

MATERIALS AND METHODS

Biological Material

The two forest species of cockroaches used in this study were collected from the forest of El-Khnegue, Aflou’s region (Laghouat; Algeria).

The study site is located 10 km northeast of the center of Aflou, in the heart of the Jebel Amour mountains [14]. In this forest, the main species is the Aleppo pine, and the secondary species are the holm oak, the *Juniper oxyhydrogen,* and the alfa. [15].

Preparation of extracts

- ✓ **For feeding behavior (extracts from Aleppo pine leaves)**

10g of cut Aleppo pine leaves was immersed in a flask containing 25 ml of organic solvent hexane and allowed to extract for two different times (15 min and 30 min). The two extracts were filtered through the wool of glass to remove all impurities.

- ✓ **For gregarious behavior (Extracts from cockroaches)**

Before extraction, first, the cockroaches (adults and larvae) were cold anaesthetized. Then, in flasks containing 1 ml of hexane, we put the individuals for five minutes afterwards. We filter the extracts through wool placed on the glass to remove all kinds of impurities. Finally, they were stored in the freezer until needed.

Food Attractiveness and Gregarious Tests in a Closed Chamber

The enclosure used for this test is made of glass (24.5 x 16.5 x 12 cm) whose base is divided in its

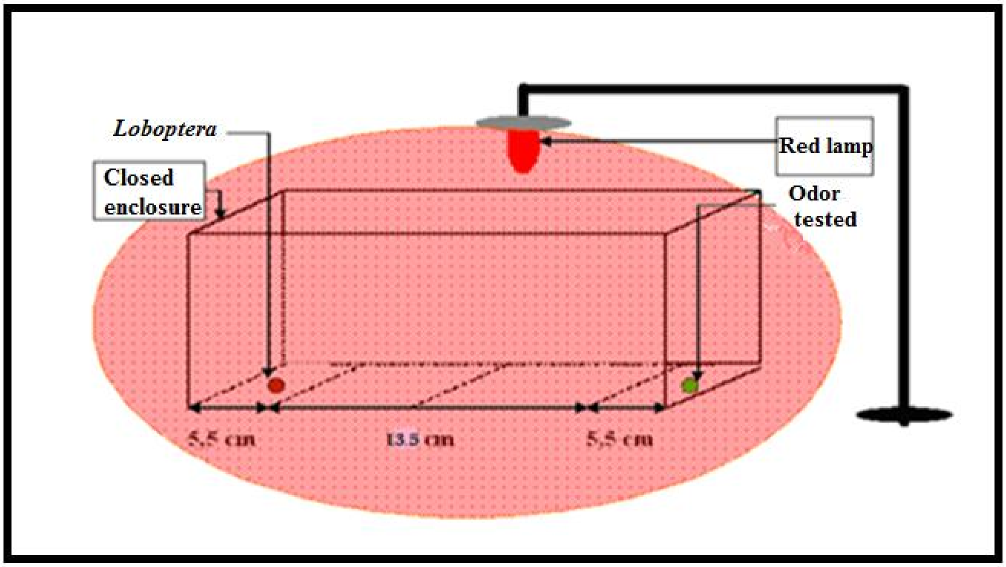

Fig. 1. The closed enclosure (Habbachi, 2013)

length into three zones: latency zone (5.5 cm), travel zone (13.5 cm), and an arrival zone (5.5 cm) [16].

We first introduce a piece of filter paper ($1cm^2$) soaked in one of the extracts previously described (Aleppo pine leaves / *Loboptera* species). The smell was allowed to diffuse after replaced the cover for 5 to 10 minutes. The individual to be tested was introduced into the enclosure at the level of the latency zone. The time between the introduction of the individual in the chamber and its exit from the area of latency (detection time) and the time taken by the individual to travel in a rectilinear motion the path to the extract odor (arrival time), the overall time (TG) is the addition of time latency and time of arrival. All scents were tested under the same conditions [16] under controlled temperature and humidity conditions in the test room as in the breeding.

Statistical Analyzes of Data

The ethological tests obtained in a closed chamber were compared using parametric tests in XLstat by comparing the variance of the K sample at the threshold of ***p =.05*** [17].

RESULTS

Study of the Food Attractiveness of *L. decipiens* and *L. ovolobata*

Detection time

Table 1 summarizes the results and the statistical analysis of the different latency times that the other species of the genus *Loboptera* taken to test the odours.

Larvae of *L. decipiens* was found more attracted to the extract of Aleppo pine leaves with hexane (30 min) (25.70s ± 8.39s), and they took more time to detect extract of the leaves of Aleppo pine with hexane (15 min) (50.80s ± 14.74s). At the significance level of α = 0.05, the statistical analysis showed a significant difference between the attraction means-tested (F = 4.40; ***p =.03*)*** (Table 1).

On the other hand, in *L. ovolobata*, the results showed no significant difference between the mean latency times (F = 2.41; ***p =.21***). The individuals of *L. ovolobata* took longer time to exit the latency zone (28.72s ± 13.04s) when we use the extract of Aleppo pine leaves with hexane (15 min) (Table 1).

Table 1. Detection times of the Aleppo pine leaf extract (in seconds); n=10

	L. decipiens		*L. ovolobata*	
	15 min	**30 min**	**15 min**	**30 min**
Mean ± s	**50,80 ± 14,74**	**25,70 ± 8,39**	**28,72 ± 13,04**	**23,30 ± 8,39**
Min	3	9	3	2
Max	140	80	118	73
Var	2172,84	492,9	1699,81	704,01
F	**4.40**		**2.41**	
p	***.03****		***.21***	

Table 2. Arrival times of the Aleppo pine leaf extract (In seconds); n = 10

	L. decipiens		*L. ovolobata*	
	15 min	**30 min**	**15 min**	**30 min**
Mean ± s	**68,20 ± 17,54**	**90,50 ± 22,64**	**37,00 ± 14,41**	**17,09 ± 3,59**
Min	9	13	4	5
Max	157	236	157	45
Var	3078,84	5046,28	2076,44	128,77
F	**1.63**		**16.13**	
P	***.47***		***.001*****	

Arrival times

Table 2 summarizes the average arrival time of *L. decipiens* and *L. ovolobata* larvae. At the significance level of α = 0.05, the statistical analysis showed no significant difference between the means of attraction times tested (F = 1.63; ***p =.47***); Despite the larvae of *L. decipiens*, it taken less time to arrive by the extract of Aleppo pine leaves with hexane (15 min) (68.20s ± 17.54s), than the extract of the leaves Aleppo pine with hexane (30 min) (90.50s ± 22.64s) (Table 2).

While in *L. ovolobata*, the individuals arriving at the odorous source took an average of 37.00s ± 14.41s for the extract of Aleppo pine leaves with hexane (15 min), and an average time of 17.09s ± 3.59s for extracts of Aleppo pine leaves with hexane (30 min); and this difference is expressed by a statistical analysis which shows a very highly significant difference between the attraction means-tested (F = 16.13***; p>.001*****) (Table 2).

Study of the Gregarious Attractiveness of *L. decipiens* Larvae by Different Extracts of *Loboptera* Species

Detection times

Table 3 summarizes the statistical analysis of the different latency times that the larvae of *L. decipiens* and *L. ovolobata* taken to detect the three odors tested.

L. decipiens larvae were more attracted to the two extracts of *L. decipiens,* and *L. ovolobata* larvae (16.00s ± 8.32s) and (20.30s ± 9.98s) respectively, and they took longer time to detect extract of adults of *L. ovolobata* (37.30s ± 12.45s). Statistical analysis shows no significant difference between the attraction means-tested (F = 0.85; ***p =.44***) (Table 03).

The results also showed that the larvae of *L. ovolobata* were detected the odor of the extract of the larva *L. ovolobata* (22.10s ± 8.65s). They were also attracted to the extract of adult *L. ovolobata,* but they took a little longer (39.80s ± 11.44s), and they took longer to exit the area when we use *L. decipiens* larva extract (43.90s ± 16.38s). However, the statistical analysis does not significantly differ between the attraction means-tested (F = 1.42; ***p =.26***) (Table 3).

Arrival times

The larvae of *L. decipiens* arrived at the source of the odor with an average time of 23.50 ± 12.69s for the extract of the *L. decipiens* larvae and they took 30.20s ± 12.73s for the extract of *L. ovolobata* larvae, and they took longer for the adult of *L. ovolobata* extract (43.30s ± 13.65s) and the statistical analysis shows no significant difference between the means of attraction tested (F = 0.51; ***p =.61***) (Table 4).

Table 3. Detection times (in seconds) of *L. decipiens* and *L. ovolobata* larvae by different odors of the extracts

Species	Extracts	Mean ± s	Min	Max	Var	F	*p*
L. decipiens	***L. ovolobata* Adults**	**37,30 ± 12,45**	0	118	1549,1	**0.85**	***.44***
	***L. ovolobata* Larvae**	**20,30 ± 9,98**	0	79	996,7		
	***L. decipiens* Larvae**	**16,00 ± 8,32**	0	82	692,7		
L. ovolobata	***L. ovolobata* Adults**	**39,80 ± 11,44**	0	110	1308,6	**1,42**	***.26****
	***L. ovolobata* Larvae**	**22,10 ± 8,65**	0	71	747,9		
	***L. decipiens* Larvae**	**43,90 ± 16,38**	0	150	2684,3		

Table 4. The arrival times (in seconds) of *L. decipiens* and *L. ovolobata* larvae by different odors of the extracts

Species	Extracts	Mean ± s	Min	Max	Var	F	*P*
L. decipiens	***L. ovolobata* Adults**	**43,30 ± 13,65**	0	113	1863,6	**0.51**	***.61***
	***L. ovolobata* Larvae**	**30,20 ± 12,73**	0	101	1619,3		
	***L. decipiens* Larvae**	**23,50 ± 12,69**	0	126	1610,3		
L. ovolobata	***L. ovolobata* Adults**	**39,80 ± 13,22**	0	121	1748,8	**5.49**	***.01****
	***L. ovolobata* Larvae**	**25,50 ± 8,19**	0	73	670,28		
	***L. decipiens* Larvae**	**81,50 ± 25,34**	0	210	6422,1		

Table 5. Detection time (in seconds) of *L. ovolobata* adults by different odors of the extracts

Extracts	Mean ± s	Min	Max	Var
Extract *L. ovolobata* Adult	**32,70 ± 9,94**	2	98	987,79
Extract *L. ovolobata* Larvae	**17,10 ± 11,74**	0	118	1378,32
Extract *L. decipiens* Larvae	**19,90 ± 10,70**	0	104	1145,43
F		**0,012**		
P		***.99***		

Table 6. Arrival time (in seconds) of *L. ovolobata* adults by different odors of the extracts

Extracts	Mean ± s	Min	Max	Var
Extract *L. ovolobata* Adult	**48,40 ± 14,88**	12	151	2214,04
Extract *L. ovolobata* Larvae	**23,70 ± 12,43**	0	108	1545,79
Extract *L. decipiens* Larvae	**20,30 ± 12,39**	0	126	1535,57
F		**0,42**		
P		***.66***		

The larvae of *L. ovolobata* seemed more attracted to the extract of the larvae of *L. ovolobata* (25.50s ± 8.19s), and also to the extract of *L. ovolobata* adults (39.80s ± 13.22s), but they took longer time to enter the area when using the extract of the *L. decipiens* larvae (81.50s ± 25.34s), the statistical analysis showed a significant difference between the attraction means-tested (F = 5.49; ***p =.01****) (Table 4).

Study of the Gregarious Attractiveness of Adults of *L. ovolobata* by Different Extracts of *Loboptera*

Detection times

The adults of *L. ovolobata*, taken less time to detect the smell of *L. ovolobata* larvae extract (17.10s ± 11.74s) and longer time to be attracted by the adult extract of *L. ovolobata* (32.70s ± 9.94s). At the significance level of α = 0.05, the statistical analysis showed no significant difference between the attraction means-tested (F = 0.012, ***p =.99***) (Table 5).

Arrival times

Through the statistical analysis of the data in Table 6, we noticed that the adults of *L. ovolobata* taken 20.30s ± 12.39s to arrive at the smell of the extract of the larvae of *L. decipiens*. They took also 23.70s ± 12.43s for the extract of the *L. ovolobata* larvae. They took longer time for the extract of *L. ovolobata* adult (48.40s ± 14.88s). At the threshold of significance of α = 0.05, the statistical analysis showed no significant difference between the attraction means-tested ($F = 0.42$; ***p = 0.66***) (Table 6).

DISCUSSION

Insects communicate through different modes (visual, sound, tactile, chemical, echolocation). This communication of insects and their environment is fundamental for moving, feeding, reproducing, and surviving. In contrast, chemical communication or the chemical mediator plays a determining role in the biology and behavior of insects [18].

In insects, odorous signals, sometimes much more than visual signals, play a primordial role in the life and survival of species, the relationships between the individual and his environment, and between individuals of the same species or of different species. These are often chemical signals that guide the insect to its nesting site or food sources [19].

Aggregation or gregarious behavior is a group of individuals of the same species, gathered in one place but not organized or engaged in cooperative behaviors [20]. In gregarious or social insects, the smell of the group or the nest results from the same "chemistry". Gregariousness is also used as a strategy allowing a better use or a better sharing of food resources [6]. Each individual emits an odor in the air [21].

Pheromones can be produced by glandular cells scattered throughout the integument or grouped to form exocrine glands. In the majority of cases, recognition takes place at a short distance or by contact, even if the stimulus that unites the two individuals is due to a pheromone that one of the two has perceived from the same distance, it is now accepted that the hydrocarbons cuticula's act as chemical mediators playing a determining role in the biology and behavior of insects [22].

Attractive allelochemicals play a significant role in whether the insect accepts food or not [23]. A positive response to an olfactory stimulus causes a movement directed towards the odorous source, which can be defined by its speed and direction [24]. The effectiveness of an attractant is determined by the initial concentration of the molecule at the source [25].

In our laboratories, we carried out two studies on the eating and gregarious behaviors of the two species, *L. decipiens* and *L. ovolobata*. To carry out these studies, we made different extracts of Aleppo pine.

The Aleppo Pine is a species of the genus *Pinus* (halepensis subgroup). It is an evergreen tree, about 20 to 30 m high, often leaning and not very straight, with a pale, crushed, and irregular crown [26]. Several studies have revealed vitamins, trace elements, primary and secondary metabolites endowed with interesting biological activities in the different parts of *Pinus halepensis* [27].

The study on feeding behavior shows that the individuals of the two species *L. decipiens* and *L. ovolobata* tested were significantly more attracted to the 30 min hexane extracts of the leaves of the Aleppo pine compared to the 15 min extract. And *Loboptera* larvae also give the same result. This could be explained either by a high concentration of the substances or because time led to the extraction of other substances, which attracted him more.

Our results are similar to the results of Halfaoui 2010 [28]. who reported that the different stages of *L. decipiens* are more attracted to the hexane extract from foods (fresh apple, rotten apple, vanilla cookie, etc.) and extracts from the 30 min cork oak acorns. The remote attraction of individuals by the hexane extracts of cork oak leaves us to suppose that the active molecules must be more or less apolar.

In another study counducted by Habbachi (2013). Who observed that detecting odors from eucalyptus leaf extracts also depends on the stage of development of *L. decipiens* and the condition of the leaves extracted. Thus, adults are more attracted than young larvae to extracts from fresh leaves. The distant attraction of individuals by hexane leaf extracts suggests that the active molecules must be more or less apolar.

Our gregarious behavior results show that the larvae were the most attracted to the different odors tested (*L. decipiens* and *L. ovolobata* larvae extract; *L. ovolobata* adult extract) and took less time to detect odors. This can explained by the larvae group affect, It is this group effect that causes them to detect odors in less time. This can explained by the larves group affect.

CONCLUSION

The feeding behavior of *Loboptera decipiens* and *Loboptera ovolobata* was determined in the laboratory through an ethological test in a closed chamber. Individuals detect the scent source in these two species after a detection time that differs significantly from stage to stage and from scent to scent. Volatile molecules ensure the feeding behavior with odorous properties, which guide the insect towards the odorous sources.

As well as the tests of gregarious behavior in the two species of *Loboptera* revealed that the larval stage prefered the phenomenon of regrouping and was also used as a strategy allowing a better use or a better sharing of food resources.

In view of this study, it would probably be interesting to separate this hexane extract to determine the active principle (s) responsible for these behaviors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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