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COMMENTARY ARTICLE

Study of feeding behavior of Lopboptera angulate (Dictyoptera; Ectobiidae)

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Our study was conducted on the feeding behaviour of the *loboptera angulata* species collected in the Chelia cedar (Aures, Algeria), where we tested with a bidirectional olfactometer the attractiveness of forty individuals (20 larvae, 20 adults) of thise species against the three hexanic extracts of fresh cedar leaves, aleppo pine and green oak. The study showed that the adults of *L, angulata* were significantly more attracted to fragrant fresh Cedar and Aleppo Pine leaves with a preference for cedar extract and they take less time to detect odour regardless of the type of extract (Aleppo Pine, Cedar or Green Oak) compared to larvae Where were not significantly attracted by any odorous extract of the leaves used and they take a much longer time to locate the odorous source from the fragrant extracts.

Keywords: *Loboptera angulata*, Feeding behavior, Cedar, Aleppo Pine, Holm oak, hexanic extract, Chelia cedar.

Introduction

Plants, insects and their ecological interactions have been key components of global terrestrial ecosystems throughout geological times. (McCoy, V.E., Gee, C. et al., 2022). Plant decomposition is an essential component of forest ecosystems (Osaki, 2022). Cockroaches are omnivorous insects that can eat anything; however, they seem to prefer carbohydrates (starch and sugar) to proteins and fats. In nature, forest cockroaches play an important role as decomposers. They contribute to the rapid recycling of organic matter by feeding on plants (Gordon, 1996). Their communication is mainly based on chemicals that often act remotely, called pheromones (Masna et al., 2021)

Loboptera angulata is a forest cockroach belonging to the genus Loboptera which lives in the dead leaves, under the stones and in the slightly humid places. (Chopard; 1943) it dominates the forests of eastern Algeria, notably the Aurès Belzma (Azoui, 2017) and Chelia (Aberkane, 2021) mountains. It is small in size, measuring 7-10 mm of glossy black colour, including squamiform lateral elytra (Chopard, 1943). It is a species little known in terms of their way of life as well as their behaviour

In our laboratory we tried to study the feeding behaviour of this forest species *Loboptera angulatta* against the three different extracts of fresh leaves of Aleppo pine (*Pinus halepensis*,), cedar (*Cedrus atlantica*) and holm oak (*Quercus ilex*) extracted by hexane (apolar organic solvents).

Materials and Methods

Collection area of *Loboptera angulata*

The species we are going to study was harvested at the level of the Chelia forest, it is a Mediterranean type forest . Located in the south-east of the city of Batna (Abdessemed, 1981) to (lat: 35°23'-35°17' N; length: 06°33'-6°45'E) (North-East des Aurès, Algeria) (Belloula and Beghami, 2018), it peaks the highest peak of the Aures at an altitude of 2328m (Abdessemed, 1981) and is characterized by the dominance of cedar (*Cedrus atlantica*).

Breeding of *L. angulata*

Individuals of the species *L. angulata* are placed in plastic boxes with mesh holes and containing honeycomb packages of eggs used as shelters. Cockroaches are fed with dog food and carrot skins and watered with cotton soaked in water that also ensures the humification of the environment. Breeding is maintained at a temperature of 23.2°C, a relative humidity of (50-55%) and a photoperiod of 12 hours.

Preparation of leaf extracts

The fresh leaves of holm oak, aleppo pine and cedar are extracted by hexane, apolar organic solvents. Five grams of fresh leaf leaves, cut into small pieces, are immersed in 40 ml of solvent for 30 minutes before being filtered on glass wool. The different extracts are stored in the freezer (-20°C) until used.

Olfactometer tests (Y-tube)

A two-way glass olfactometer (2 cm in diameter) is used (Fig. 1). The tests take place at night (period of activity of the majority of cockroaches) at a temperature of 25 to 27°C and at a humidity of 70 to 80%. A red lamp of low intensity to be able to observe the behavior of individuals.

Fig. 1. Two-way Y. 1. Starter Box Olfactometer; 2. Olfactometer; 3. Red lamp; 4. Compressor; 5. Flow meter; 6. Air inlet pipes (Habbach, 2013).

Young stage larvae (L3, L4) and adults to be tested are placed in a small cage with a mesh door downstream of the main branch of the olfactometer; filter paper (1 cm²) impregnated with extract (10 µl) is placed upstream in one of the secondary branches 5 to 10 minutes before the start of the test. The start of the test corresponds to the time of release of the cockroach. Thanks to a stopwatch, we note the "choice time" which corresponds to the moment of the introduction of the cockroach until the moment when, arriving at the intersection of the two secondary branches, it rises again in one of the branches; the choice of the insect and the time it takes to reach the odorous source (filter paper) is also noted.

Statistical tests

The results were compared using Monte-Carlo simulations, based on a Chi2 test at the p:0.05 threshold (Vaillant and Derrij, 1992). The results obtained for these tests were also the subject of a comparison of variances (Fisher's test) at the significance threshold α=0.05 using the XLStat 2009 software.

Results

Attractiveness

The olfactometric tests we conducted on *L. angulata* larvae and adults show that adults are significantly more attracted to fragrant hexanic extracts from fresh Cedar and Aleppo Pine leaves and not significant for extract from Holm oak leaves in the case of extract/air On the other hand the larvae are not significantly attracted by any odorous extract of leaves used (Table 1).

In this case the hexanic extracts of fresh leaves used are inactive for the young larvae of *L. angulata* and active for adults with the exception of Holm oak extract.

Table 1. Percentage of attractiveness of young larvae and adults by the odours of extracts of leaves of Aleppo pine, cedar, holm oak (Extract/Air) (Y-shaped olfactometer).

	Extract fresh leaves by hexane					
	Aleppo pine		**Cedar**		**Holm oak**	
	Young larva	**Adult**	**Young larva**	**Adult**	**Young larva**	**Adult**
N	11	15	12	17	9	12
NA	9	5	8	3	11	8
P	NS	0.968 S	<0.930 NS	1.000 S	NS	NS

(A: Attracted; NA: Not attracted; S: Significant; NS: Not significant).

With regard to the olfactometric tests in case of extract/ extract carried out on a number of twenty adults and twenty young larvae of *Loboptera angulata* show that the adults are all attracted by the smells of different extracts used (Aleppo pine, cedar, Holm oak), with a preference of cedar extract Regardless of the extract placed on the other side of the olfactometer whose number of adults choose cedar extract with pine are 55% and 65% with Holm Oak,While not all nymphs are attracted to fragrant extracts of leaves and for those that are attracted we always notice that there is a preference for cedar extract (Table 2).

Table 2. Percentage of attractiveness of young larvae and adults by the odours of extracts of leaves of Aleppo pine, cedar, holm oak (Extract/Extract) (Y-shaped olfactometer).

	Extrait des feuilles fraîches par hexane											
	Young larvae						**Adult**					
	Aleppo pine	**Cedar**	**Cedar**	**Holm oak**	**Aleppo pine**	**Holm oak**	**Aleppo pine**	**Cedar**	**Cedar**	**Holm oak**	**Aleppo pine**	**Holm oak**
A	35%	45%	55%	30%	50%	30%	45%	55%	65%	35%	60%	40%
Null	20%		15%		20%		0%		0%		0%	

A: Attracted; Null: Not attracted by any extracts.

By referring to the Tables 3 and 4 we notice that adults take less time to detect the smell regardless of the type of extract (Aleppo Pine, Cedar or Green Oak) compared to larvae that take a much longer time to locate the odorous source from the extracts, when individuals are tested for extract/air or extract/extract.

Table 3. Extract/air latency (minutes), by larvae and adults of *L. angulata*, odours from extracts of Aleppo cedar and holm oak pine leaves (Y-shaped olfactometer; SEM Mean).

	Holm oak	Cedar	Aleppo pine	F	P
Larvae	1.908 ± 1.415	1.447 ± 1.529	1.820 ± 0.922	1.057	0.357
Adult	1.264 ± 1.094	0.989 ± 1.105	1.480 ± 0.920	0.012	0.988

Table 4. Extract/Extract latency (minutes), by larvae and adults of *L. angulata*, of odours from extracts of Aleppo Pine, Cedar and Holm Oak leaves (Y-shaped olfactometer; SEM Mean).

	Holm oak	Cedar	Aleppo pine	F	p
Larvae	3.236 ± 3.146	1.604 ± 0.963	2.478 ± 1.376	5.773	0.006
Adult	2.818 ± 1.106	1.223 ± 0.984	2.036 ± 1.411	1.662	0.199

Compared to the time of arrival the results show that all adult controls are always faster, they take less time to get to the smell source of extracts and especially to the extract of cedar leaves when they have tested by extract/air or extract/extract while the larvae are slow they take a lot of time to get to the extract source (Tables 5 and 6).

Table 5. Extract/air arrival time (minutes), by larvae and adults of *L. angulata*, odours from extracts of Aleppo Pine, Cedar and Holm Oak leaves (Y-shaped olfactometer; SEM Mean).

	Holm oak	Cedar	Aleppo pine	F	p
Larvae	4.872 ± 2.044	3.094 ± 1.885	3.759 ± 1.594	0.341	0.714
Adult	1.264 ± 1.094	0.989 ± 1.105	1.480 ± 0.920	0.012	0.988

Table 6. Time of Arrival Extract/Extract (minutes), by Larvae and Adults of *L. angulata,* Odours from Extracts of Aleppo Pine, Cedar and Holm Oak Leaves (Y-shaped olfactometer; SEM Mean).

	Holm oak	Cedar	Aleppo pine	F	p
Larvae	4.689 ± 3.504	2.559 ± 1.497	3.372 ± 1.916	5.424	0.008
Adult	2.879 ± 1.135	1.432 ± 1.008	2.371 ± 1.435	1.695	1.193

Discussion

Insects have developed an extraordinarily sophisticated olfactory system to accomplish many essential behaviors, such as finding partners, looking for food, and avoiding predators (He, Peng, et al., 2021).

Plant selection by polyphagous insects consists of a behavioural sequence in response to one or more stimuli associated with a host plant or a non-host plant (Staedler, 1976).

The smell remains one of the most important signals for finding food. The smell indicates not only the direction to a food source, but also its quality and type, leading to a more efficient use of high-value foods or filling a nutritional gap, when the animal has a choice. (Zjacic, et al., 2022).

The effectiveness of an attractant is determined by the initial concentration of the molecule at the source, the manner in which it diffuses on its substrate (air, soil, liquid) and the insect's internal orientation mechanisms (Visser, 1986).

Our dietary behaviour of *Loboptera angulata* in relation to extracts of Cedar leaves, Aleppo pine and Holm oak shows that all extracts are attractive to *Loboptera angulata* individuals regardless of the phyllogenetic stage of the species (Larva or adult). this attractiveness varies according to the type of extract (Aleppo pine, cedar or holm oak) as well as the stage of development, Of which adults are most attracted to larvae in terms of number and time of smell detection and the time taken to reach the source of extract of the species this could be explained by the fact that the sensory organs of adults are more developed by in relation to larvae.

Adults are significantly more attracted to cedar extract followed by Aleppo pine extract and finally Holm oak. This could also explain that chemosensory receptors in the species *Loboptera angulata* are sensitive to molecules of semiotic substances cedar chemicals.

In the study conducted by (Habbachi, 2013) on the behaviour of *L. decipiens*, the detection of the odours of eucalyptus leaf extracts is also based on the stage of development of *L. decipiens* and the state of the extracted leaves. Thus, adults are more attracted than young larvae by fresh leaf extracts. The distant attraction of individuals by hexane leaf extracts suggests that the active molecules must be more or less apolar.

While study a conducted by (Masna et al., 2021) on the feeding behaviour of two species *L. decipiens* and *L.ovoloblata* shows that the concentration of the extracts or the time led to the extraction of other substances have an effect on the attractiveness of which the individuals of the two species tested were significantly more attracted to hexanic extracts 30 min of Aleppo Pine leaves compared to the 15 min extract and this applies to larvae and adults, another study confirmed the previous study conducted by (Halfaoui, 2010) which reports that the different stages of *L. decipiens* are more attracted by hexane food extract (fresh apple, rotten apple, vanilla biscuit, etc.) and extracts of the 30 min-oak glands-cork. The distant attraction of individuals by hexanic extracts of cork oak suggests that active molecules 4must be more or less apolar.

Conclusion

The dietary behaviour study of the blattoptere species *Loboptera angulata* shows that the adults are more obsessed with extracts of fresh cedar and aleppo pine leaves with a preference for cedar extract or they take less time to reach the source fragrant to larvae that are less attracted, This can be explained by the fact that the sensory organs of adults are more developed than those of larvae and the chemosensory receptors in the species *Loboptera angulata* are sensitive to molecules of cedar chemical semiotic substances.

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