STUDY OF THE FOOD ATTRACTIVENESS OF *LOBOPETRA DECIPIENS* (BLATTELLIDAE) BY *PINUS HALPENSIS (PINACEAE)*

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Abstract: *Insect behavior is not fully defined. Biochemical stimulations of their nervous systems are caused essentially by one or many external factors whether food, sex pheromone, alarm pheromone, gregarious pheromone, and among those insects cockroaches. Many activities in the cockroach populations are based on the use of their antennae like communications and different attractiveness (food, pheromones).*

Our study is focused on applying a series of ethological tests in an olfactometer ("Y "tube) under red light, to test the food attractiveness of one of the forest cockroaches species belonging to the Blattellidae family, which is Loboptera decipiens (L. decipiens); Larvae, males and females. Those tests were determined under laboratory conditions by preparing hexanoic extracts using the fresh and dead leaves of Pinus halpensis (P. halpensis) in three extraction times 15min, 30min, and 60min.

From the obtained results, we were able to indicate that most individuals of L. decipiens have detected the smell of food source, after a detection time that lasts and differs from one stage to another and from one dose of odor to another. These results show that the larval or adult individuals (males and females) are attracted to the hexanoic extracts of fresh leaves of P. halpensis with a percentage ranging from 80% to 100% for females, 73.33% to 86.67% for males and 73.33% to 93.33% for thve larvae. And the dead leaves attract the females from 66.67% to 73.33% and 66.67% of males and 73.33% to 80% for larvae.

Keywords: *Food attractiveness, Forest cockroach, Loboptera decipiens, Pinus halpensis.*

1. Introduction

Insects have been living on earth for about 350 million years, while humans have only been around for about 2 million. They have evolved in many directions during this time to adapt to life in almost any type of habitat and have developed many unusual, picturesque, and even amazing features (Triplehorn & Johnson, 2005). The ability to react quickly to environmental changes makes insects useful indicators of those changes, insects are major engineers and potential regulators of ecosystem conditions, and frequent competitors with human demands for ecosystem resources or vectors of human and animal diseases (Schowalter, 2016).

Cockroaches (Blattodea) have the second-highest number of species of any group of polyneopteran insects (Beccaloni & Eggleton, 2011). Forest cockroaches are the best example of forest litter insects, Often existing in the litter and especially at ground level, these insects feed on plant debris and also help decompose dead leaves (Hedjouli, 2022).

A behavior is a set of acts controlled by the nervous system in response to external factors (Kaiser, 1999). Among cockroaches, a whole range of classical behaviors in insects: food taking, dispersion, escape, and reproduction, but these last ones also coexist, quite often, with behaviors called presocial. This name covers in fact privileged relationships of the gregarious type between individuals who have a natural tendency to gather. Their communication is largely based on the use of chemical substances called pheromones, which often act at a distance (Brossut, 1996).

In this present work, we tested the food attractiveness by the hexanoic extract of the leaves (fresh and dead) *P. halpensis* in three extraction times (15min, 30min, and 60min) was studied on a poorly known forest cockroach in terms of its biology and behavior, it is *L. decipiens*.

2. Materials and Methods

2.1. Presentation of biological material

Loboptera decipiens:

L. decipiens is a small species 8 to 10 mm with a shiny black body with a yellowish or white stripe on the sides. The legs are often weaker and reddish brown. The elytra are thin and lateral, with a rounded top. The abdomen is somewhat enlarged in the middle. The subgenital plate is transverse in males and in females is often triangular (Chopard, 1943).

Pinus halpensis:

The *Pinus* is an evergreen tree, about 20 to 30 m high, often leaning and not very straight, with a clear, crushed, and irregular top. The leaves are in the form of needles 1mm thick and about 6 to 10 cm long. They are grouped by two, of greyish green color and persistent 2 to 3 years on the tree (Rameau et *al,* 2008).

2.2. Preparation of extract

In a flask containing a volume of 60 ml of hexane, 50g of fresh and/or dead leaves of *P. halpensis* are immersed and left to extract three different times 15 min, 30 min, and 60 min, the extracts are filtered on glass wool in order to eliminate all impurities.

2.3. Food attractiveness test

Based on the plan of (Halfaoui, 2009) and under laboratory conditions we tested the attractiveness of larvae and adults (males and females) of *L. decipiens* by the different hexanoic extracts of fresh and dead leaves of *P. halpensis* in an olfactometer ("Y" tube).

The individual to be tested is placed at the end of the main branch and the filter paper soaked with the plant extract, in one of the secondary branches 5 to 10 minutes before the introduction of the insect. The beginning of the test corresponds to the introduction of the cockroach and for each individual, thanks to a stopwatch, we note the time of detection which corresponds to the moment of the introduction of the cockroach until the moment when it carries out its choice, the choice of the insect and the time it takes to reach the odorant source (the filter paper or the outside).

Fig.1. *Bidirectional olfactometer "Y" shaped tube (Masna, 2016)*
[1-Starting box ; 2- Olfactometer; 3- Red lamp; 4- Compressor; 5- Flowmeter; 6- Inlet pipes of air]

2.4. Stastical analysis of data

The results of the ethological tests obtained in an olfactometer are compared using the simulation of Monte-Carlo simulation, based on a Chi-square test with a threshold α=0.05 (Vaillant & Derrij, 1992).

3. Results

3.1.Food attractiveness in L. decipiens larvae via P. halpensis

3.1.1. The attractiveness rate

The larvae of *L. decipiens* were attracted to fresh/ or dead leaves of *P. halpensis* with percentages of 93.33% and 80% in 60min extraction respectively, 73.33% in 15min extraction, and 66.67% in 30min of extraction (Fig. 02).

The results are significant for fresh leaves of *P. halpensis* in 60min of extraction (P= 1.000) (Fig. 02).

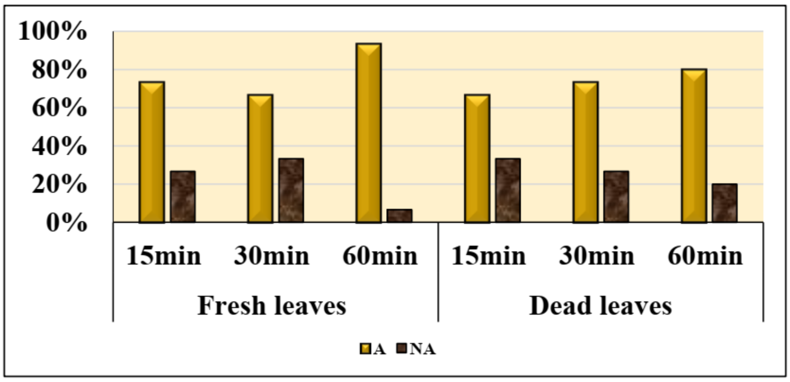

Fig.2. *Food attractiveness rates of L. decipiens larvae (A: Attracted; NA: Not attracted)*

3.1.2. Detection time

Table 1 summarizes the statistical analysis of the different latency times it takes *L. decipiens* larvae to detect the tested odor. *L. decipiens* larvae appear to be attracted to the fresh leaf extract of *P. halpensis* in hexane for 15 min (69.933±11.221).

And they take less time for the 30 min hexane extract of *P. halpensis* (48.067±9.276) and it takes (59.333±7.980) time for the 60 min hexane extract of *P. halpensis*. Statistical analysis of these detection time averages indicates significant differences (F=0.476; P = 0.625) (Tab. 1).

Knowing that for the dead leaves of *P. halpensis* and for the 15min extract, the larvae take (62.800±12.825) and more time (72.533±10.278) for the 30min hexane extract and less time (48.200±7.271) concerning the 60min hexane extract of dead leaves. Statistical analysis of these detection time averages indicates significant differences (F=0.380; P=0.686) (Tab. 1).

Table 1. *Detection time of larvae*

	Pinus halpensis				
	15min	**30min**	**60min**	**F**	***P***
Fresh	69.933±11.221	48.067±9.276	59.333±7.980	0.476	0.625
Dead	62.800±12.825	72.533±10.278	48.200±7.271	0.380	0.686
F	0.000	0.037	0.135		
P	0.999	0.848	0.716		

3.1.3. Arrival time

Table 2 presents a summary of the statistical analysis of the different latency times taken by *L. decipiens* larvae to arrive at the tested odor.

L. decipiens larvae appear to be attracted to the fresh leaf extract of *P. halpensis* in hexane for 15 min (173.067±23.132). And they take less time for the 30 min hexane extract of *P. halpensis* (125.000±19.255) and (140.333±20.331) for the 60 min hexane extract of *P. halpensis*. Statistical analysis of these detection time averages indicates significant differences (F=0.386; P = 0.682) (Tab. 2).

Knowing that for the dead leaves of *P. halpensis* and for the 15min extract, the larvae take (107.333±14.574) and more time (132.733±15.218) for the 30min hexane extract and less time (93.067±9.475) concerning the 60min hexane extract of dead leaves. Statistical analysis of these detection time means indicates significant differences (F=2.303; P = 0.112) (Tab. 2).

Table 2. *Arrival time of larvae*

	Pinus halpensis				
	15min	**30min**	**60min**	**F**	***P***
Fresh	173.067±23.132	125.000±19.255	140.333±20.331	0.386	0.682
Dead	107.333±14.574	132.733±15.218	93.067±9.475	2.303	0.112
F	2.397	0.038	9.744		
P	0.133	0.848	0.004*		

(*: Significant)

3.2. Feeding attractiveness in female L. decipiens via P. halpensis

3.2.1. The attractiveness rate

From the results obtained we noticed that the females of *L. decipiens* were attracted 100% to the smell of the extract by the fresh leaves of *P. halpensis* in 60min extraction, 80% in 30min extraction, and 73.33% in 15min extraction (Fig. 3). While the dead leaves of this plant attracted females up to 73.33% in 60 min of extraction, 66.67% in 30 min and 15 min of extraction (Fig. 3).

These results are significant for fresh leaves of *P. halpensis* in 60 and 30 min extraction (P= 1.000; P= 0.978 successively) (Fig. 3).

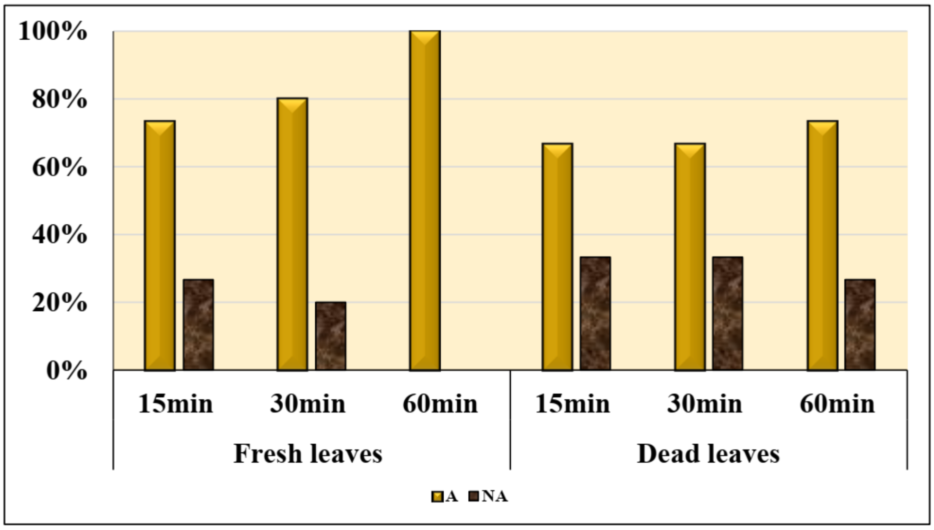

Fig. 3. *Food attractiveness rate of female L. decipiens*

3.2.2. Detection time

Table 3 shows the results of the statistical analysis of the different latency times it takes L. decipiens females to detect the tested odor.

Females of *L. decipiens* seem to be attracted by the extract of fresh leaves of *P. halpensis* in hexane for 15 min (52.667±9.368). And they take less time by the 30 min hexane extract of *P. halpensis* (35.867±7.589) and (41.333±6.606) for the 60 min hexane extract of *P. halpensis*. Statistical analysis of these detection time averages indicates significant differences (F=0.440; P=0.647) (Tab. 3). While for the dead leaves of *P. halpensis* and for the 15min extract, females take (35.600±9.003) and less time (26.800±4.197) for the 30min hexane extract and more time (47.067±6.888) concerning the 60min hexane extract of dead leaves. Statistical analysis of these detection time averages indicates significant differences (F=1.554; P=0.223) (Tab. 3).

Table 3. *Female detection time*

	Pinus halpensis				
	15min	**30min**	**60min**	**F**	***P***
Fresh	52.667±9.368	35.867±7.589	41.333±6.606	0.440	0.647
Dead	35.600±9.003	26.800±4.197	47.067±6.888	1.554	0.223
F	0.118	2.642	0.023		
P	0.734	0.115	0.881		

3.2.3. Arrival time

Table 4 will provide the results of the statistical analysis of the different latency times taken by *L. decipiens* females to arrive at the tested odor. *L. decipiens* females appear to be attracted to the fresh leaf extract of *P. halpensis* in hexane for 15 min (103.267±14.414). And they take more time by the 30 min hexane extract (107.400±24.942) and less time (87.867±11.851) for the 60 min hexane extract. Statistical analysis of these detection time means indicates significant differences (F=2.917; P = 0.065) (Tab. 4).

While for the dead leaves of *P. halpensis* and for the 15min extract, females take (66.133±17.110) and less time (40.800±5.120) for the 30min hexane extract and more time (78.200±14.028) concerning the 60min hexane extract of dead leaves. Statistical analysis of these detection time means indicates significant differences (F=3.346; P = 0.045*) (Tab. 4).

Table 4. *Arrival time of females*

	Pinus halpensis				
	15min	**30min**	**60min**	**F**	***P***
Fresh	103.267±14.414	107.400±24.942	87.867±11.851	2.917	0.065
Dead	66.133±17.110	40.800±5.120	78.200±14.028	3.346	0.045*
F	0.005	12.397	0.459		
P	0.945	0.001*	0.504		

(*: Significant)

3.3. Feeding attractiveness in males of L. decipiens via P. halpensis

3.3.1. The attractiveness rate

According to the obtained results we found that the males of *L. decipiens* were attracted up to 86.67% for the odor of the extract by the fresh leaves of *P. halpensis* in 60min extraction, 73.33% in 30min extraction and 66.67% in 15min extraction (Fig. 4).

While the dead leaves of this plant attracted males up to 67.67% in 15 and 60min extraction, and 60% in 30min extraction (Fig. 4). These results are significant for fresh leaves of *P. halpensis* in 60 min of extraction (P= 0.993) (Fig. 4).

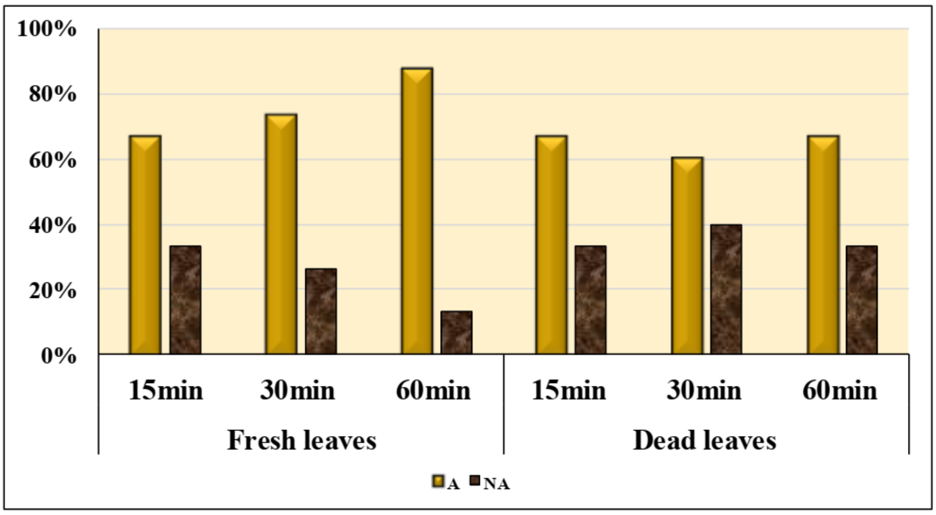

Fig. 4. *Food attractiveness rate of L. decipiens males*

3.3.2. Detection time

Table 5 resumes the statistical analysis of the different latencies taken by *L. decipiens* males to detect the tested odor.

L. decipiens males appear to be attracted to the fresh leaf extract of *P. halpensis* in hexane for 15 min (32.400±4.677). And they take more time by the 30 min hexane extract of *P. halpensis* (35,000±4,714) and (38,933±6,818) for the 60 min hexane extract of *P. halpensis*. Statistical analysis of these detection time averages indicates significant differences (F=1.079; P = 0.349) (Tab. 5).

Knowing that for the dead leaves of *P. halpensis* and for the 15min extract, males take (41.133±7.652) and more time (61.133±9.585) for the 30min hexane extract and (55.333±7.975) concerning the 60min hexane extract of dead leaves. Statistical analysis of these detection time means indicates significant differences (F=0.679; P = 0.512) (Tab. 5).

Table05. Male detection time

	Pinus halpensis				
	15min	**30min**	**60min**	**F**	***P***
Fresh	32.400±4.677	35.000±4.714	38.933±6.818	1.079	0.349
Dead	41.133±7.652	61.133±9.585	55.333±7.975	0.679	0.512
F	1.469	6.027	0.412		
P	0.236	0.021*	0.526		

(*: Significant)

3.3.3. Arrival time

Table 6 present the different latencies taken by *L. decipiens* males to arrive at the tested odor. *L. decipiens* males appear to be attracted to the fresh leaf extract of *P. halpensis* in hexane for 15 min (156,600±28,948). And they take less time for the 30 min extract of *P. halpensis* in hexane (130.467±22.339) and (143.733±29.329) for the 60 min extract of *P. halpensis* in hexane. Statistical analysis of these detection time averages indicates significant differences (F=1.544; P = 0.225) (Tab. 6).

Recognizing that for the dead leaves of *P. halpensis* and for the 15min extract, males take (77.933±22.493) and more time (170.867±34.156) for the 30min hexane extract and (114.133±20.449) concerning the 60min hexane extract of dead leaves. Statistical analysis of these detection time averages indicates significant differences (F=1.635; P=0.207) (Tab. 6).

Table 6. Arrival time of males

Pinus halpensis					
	15min	**30min**	**60min**	**F**	***P***
Fresh	156.600±28.948	130.467±22.339	143.733±29.329	1.544	0.225
Dead	77.933±22.493	170.867±34.156	114.133±20.449	1.635	0.207
F	2.454	2.073	2.358		
P	0.128	0.161	0.136		

3. Discussions

Insects communicate with each other in different ways (visual, sound, tactile, chemical, and echolocation). This communication of insects with each other and with their environment is fundamental for movement, feeding, reproduction, and survival. On the other hand, chemical communication or chemical mediator plays a determining role in the biology and behavior of insects (Brossut & Sreng 1985).

In insects, olfactory signals, sometimes much more than visual signals, play a crucial role in the species' life and survival, as well as the relationships between individuals and their environments and between individuals of the same or different species. They are frequently chemical signals that direct the insect to its site of oviposition or food sources (Masson & Brossut, 1981).

Attractive allelochemicals play a major role in whether or not the insect accepts the food (Burden & Norris, 1992). In case of a positive response to an olfactory stimulus, it causes a movement towards the odorant source which can be defined by its speed and direction (Visser, 1986). The effectiveness of an attractant is determined by the initial concentration of the molecule at the source (Ouakid, 2006).

Cockroaches have developed a real chemical communication (Cornnette, 1997), the feeding behavior of cockroaches takes place in a succession of different behavioral sequences leading to the odorant source. In cockroaches, the different behavioral phases of feeding behavior begin with odor detection behavior, after detection the individual (larva or adult) moves towards the odorant source (Halfaoui, 2009). A chemical compound allows the insect to locate its food thanks to an olfactory phenomenon that attracts or repels (Dajoz, 1998).

The main features of the diet are stable within the genus: we are always dealing with omnivores consuming carbohydrates and proteins (Gordon, 1996).

The antennae of *L.decipiens* are an important sensory organ that, in addition to serving as the seat of olfaction, also provides other functions such as gustation, orientation, and touch. It is a mobile organ with many innervated bristles of various forms, the sensilla of tegumentary origin, their intrinsic organization is a function of their role and the mode of development of the insect, and these sensilla are carriers of olfactory neurons, the number of which varies between species (Bouachria, 2005).

The lack of studies on the behavior of cockroaches led us to study the behavior or the food attractiveness of *L. decipiens* with hexanoic extracts of fresh and dead leaves of *P. halpensis*. According to the results obtained we could indicate that females are more attractive than males and larvae where females are 100% attracted to fresh leaves of *P. halpensis* in 60min of extraction where the odor is stronger, moreover, males are attracted to 86.67% to the odorous source of fresh leaves of *P. halpensis* and larvae to 93.33%.

We were also able to mark that the attractiveness towards the odorous source is increased depending on the extraction time where the apolar materials are more extracted depending on the time.

My results are similar to the work of (Halfaoui, 2009) where she found that the individuals of this forest cockroach are better attracted also according to the concentration of the extract; the more the time of extraction of the cork oak acorns increases the faster the attraction of the individuals and the older individuals tested are more attractive than the young larval stages (L1, L2, L3).

The first, second instar larvae of *L. decipiens* are not significantly attracted to the different extracts of cork oak acorns with hexane and pentane while the older larvae seem to be better attracted to these odors.

Conclusion and perspective

The food attractiveness of *L. decipiens* towards *P. halpensis* was studied under laboratory conditions with an olfactometer ("Y"tube), the results allowed us to highlight that this species is always attracted by the different odors of the hexanoic extracts of fresh leaves much more than the dead ones of *P. halpensis*.

The attractiveness differs from one stage to another and it varies according to the extraction time.

In perspective, it will be interesting to make a thorough study to determine the chemical composition of the studied extract.

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