

Capacity of earwig *Marava arachidis* (Yersin) to access fennel plants *Foeniculum vulgare* Mill in laboratory and field

Capacidade da tesourinha *Marava arachidis* (Yersin) em acessar a planta de erva-doce *Foeniculum vulgare* Mill no laboratório e no campo

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ABSTRACT

This research was aimed at obtaining data about earwig behavior (*Marava arachidis* Y.) on fennel agroecosystems and evaluating its potential capacity to access plants in the absence of aphids under laboratory and field conditions. This study establishes a baseline to evaluate earwigs as biological controls to combat aphids that attack fennel plants. Two experiments were developed. In experiment 1, earwigs were studied under laboratory conditions, in experiment 2 under field conditions. Independent variables were sex, exposure to the essential oil of fennel for 24 or 48 hours, and whether the fennel plant was vegetative or flowering. The results indicated that earwigs will climb a fennel plant in the absence of aphids and that few statistical significant results were obtained among the independent variables examined. A difference between male and females was noted in the field experiment in animals receiving 48 h of exposure to the essential oil of fennel. The terminal height reached by males and females in the 48 h vegetative and flower condition also differed.

Key words: biological control, Dermaptera, aphids, Umbeliferae.

RESUMO

Este trabalho objetivou obter os primeiros dados a respeito da tesourinha (*Marava arachidis* Y.) em agroecossistema de erva-doce, além de avaliar sua capacidade potencial em acessar essas plantas na ausência de afídeos, em laboratório e campo, permitindo futuros trabalhos visando a seu uso no controle biológico para combater os afídeos que atacam essa cultura. Assim, dois experimentos foram realizados, sendo que no experimento 1 as tesourinhas foram estudadas em condições de laboratório e no segundo experimento em condições de campo. As variáveis independentes observadas foram: sexo, exposição a óleo essencial de erva-doce por 24 e 48 horas, em plantas no estágio vegetativo e reprodutivo. Os

resultados indicaram que as tesourinhas acessam as plantas na ausência de afídeos e que existem poucas diferenças entre as variáveis estudadas. A diferença entre os machos e as fêmeas foi observada em campo quando os insetos foram expostos por 48 horas a óleo essencial de erva-doce. A altura máxima atingida pelos machos e pelas fêmeas, quando expostos ao óleo essencial de erva-doce por 48 horas nos estágios vegetativos e de florescimento, também diferiram.

Palavras-chave: controle biológico, Dermaptera, afídeos, Umbeliferae.

INTRODUCTION

Fennel (*Foeniculum vulgare* Mill) is an important crop financially to rural farmers from the state of Paraíba (SILVEIRA et al., 2002). The crop is cultivated for various beverages such as tea and is extensively used in corn-based food, cakes and breads. In the field, the plants are primarily attacked by the aphid *Hyadaphis foeniculi*, the principal pest of fennel in Brazil (PETERSEN & ROMANO, 1999). *H. foeniculi* attacks the fennel plant usually during the flower stage, sucking the juice and damaging the plant. The females often form large colonies containing several hundred insects on the flowers and reproduce quickly during periods of high temperature.

The major method of controlling *H. foeniculi* is the use of pesticides especially methyl parathion. The use of pesticides in creating resistive strains of insects and destroying natural enemies of pest insects is well known (FOERSTER, 2002). The

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purpose of this research is to determine the capacity of earwigs to access fennel plants. This insect is active in dark environments, generally at night, and is agile. Earwigs are found in soil and on plants and can be easily identified by the presence of long tweezer-like appendages on the terminal part of the abdomen with different forms based on sex (BASTOS & TORRES, 2003).

As a necessary first step, we examine whether earwigs can climb fennel plants in the absence of aphids. If earwigs do not climb fennel plants, they will not find aphids to feed on and their use as a biological control will be limited.

This research focuses on the earwig *Marava arachidis* (Yersin). Anecdotal evidence from this laboratory suggests that this species feeds on aphids, uses the fennel plant as shelter, walks on the leaves of fennel plants, and of particular importance, feeds on fennel nectar. We believe that *M. arachidis* offers many advantages as biological controls including being easy to rear in the laboratory, the presence of artificial diets (LEMOS et al., 1998), and the ability of rearing large numbers of animals suitable for field use.

For *M. arachidis* to be an efficient predator in the control of aphid on fennel plants, it must be determined whether earwigs climb the plant and stay on the flowers. The purpose of experiment 1 was to determine whether earwigs will climb and explore the foliage of the fennel plant without the presence of soil. We wanted to determine whether fennel is attractive to earwigs independent of the nutrients contained in the soil. We were also interested in knowing whether earwigs can climb the plant because during the vegetative state the stem contains a waxy film that makes climbing difficult for some insects

The purpose of experiment 2 was a field experiment to determine whether fennel without flowers and without aphids is attractive to earwigs. This is important because it will show that fennel is attractive to earwigs alone, without the presence of nectar containing flowers and aphids.

MATERIAL AND METHODS

Earwigs (*Marava arachidis*) reared in the Entomology Laboratory of the Universidade Federal da Paraíba were used in all experiments. They were cultured in 250mL plastic dishes containing one male and one female and given food and water "ad lib". The food consisted of an artificial diet designed especially for earwigs (LEMOS et al., 1998). One day before the experiment the food was removed and the water remained.

A translucent cylinder 30cm high with an internal diameter of 15cm and a 250ml capacity was

used. The cylinder was placed on top of a matching platform the top of which had a 0.5cm hole to permit the stem of a fennel plant. The plant had no flowers. The distance from the top of the platform to the top of the cylinder was 30cm. The bottom of the container was filled with water. Inside the cylinder was placed a 25cm long fennel plant.

A fennel plant was taken from the field and cut in such a way that only a single stem and two leaves remained. A single earwig was introduced into the bottom of the platform and the time needed climb the plant was recorded over a two hour period. At the end of the two hours, the animal was returned to the laboratory. The dependent variables were 1) the time to initiate climbing (min), 2) the terminal height (cm), and the length of time the earwig remained at the terminal height (min). Twenty earwigs were used – 10 males and 10 females.

A white plastic bottle 40cm high with an internal diameter of 30cm and a 15L capacity was used. The cylinder was placed over two different types of fennel plants. In one type the plant contained no flowers (vegetative stage) and was 50cm in height. In the second, the plant was 80cm in height, contained flowers, and was in the reproductive stage.

A 2x2x2 factorial design was used with two levels of sex (male, female), two levels of reproductive state (vegetative, flower), and two levels of exposure to the essential oil of fennel (24h, 48h). Twenty animals were used in each cell for a total of 120 animals.

Twenty-four hours prior to the experiment the earwigs were exposed to 1mL of fennel essential oil. The oil was steamed distilled in the laboratory and placed on a sheet of filter paper in their home container. Following exposure, the animals were removed from their container and placed in the field within the plastic container. The purpose of this procedure was to determine whether pre-exposure to essential oil would shorten the time necessary to begin climbing, increase the terminal height, and the length of time an earwig remained at the height. The dependent variables were the same as in experiment 1.

The statistical analysis of the dependent variables was made with an analysis of variance (ANOVA), with a significance level of 5%. If the variances among the groups were very different, we used the non-parametric Kruskal-Wallis test as recommended by GOMES (1987).

RESULTS AND DISCUSSION

In laboratory experiments five animals were dropped from the analysis because of inactivity

(2 males and 3 females). No significant differences were found in the time needed to initiate climbing. Males took a mean of 20.88min to initiate climbing (sd = 17.82) and females took a mean of 37.71 min to initiate climbing (sd = 25.32). Additional analysis revealed no significant differences in either the terminal height reached by males and females or the time spent at the terminal height. Males reach a mean height of 14.5cm (sd = 2.98) and spend a mean of 4min at that height (sd = 4.17). Females reach a mean height of 9.57cm (sd = 6.21) and spend a mean of 3.57min at that height (sd = 2.30).

In field experiments, twenty-three animals were dropped from the analysis because of inactivity (2 females from the 24h vegetative group, 3 males and 2 females from the 48h vegetative group, 3 males and 3 females from the 24h flower group, 5 males and 5 females from the 48h flower group). As in laboratory experiments, there were no major differences in regards to male and female animals. No significant differences were detected in regards to the time needed to initiate climbing or the length of time remaining at the terminal height. The only statistically significant effect was found within the group exposed to 48 hours of the essential oil of fennel. Males reached a terminal height of 3.40cm (sd = 1.5) and females reached a mean height of 17.33cm (sd = 3.33).

Comparison between 24h vegetative and 48h vegetative:

No statistically significant effects were detected among any of the three dependent variables. Earwigs exposed to fennel for 24h begin climbing with a mean of 12.00min (sd = 14.16) compared to 12.47min (sd = 9.55) in animals exposed for 48 hours. The terminal height also did not differ. Animals reached a height of 12.11 cm (sd = 10.48) when exposed for 24h compared with a height of 11.13 (sd = 9.69) for 48h of exposure. When animals reached the terminal height, the time spent at that height did not differ. Earwigs exposed for 24h spent a mean of 2.36min (sd = 2.36) compared to a mean of 2.17min (sd = 1.60) for a 48h exposure.

Comparison between 24h flower and 48h flower:

The sex difference among males and females exposed to 48h of the essential oil of fennel prohibited us from combining the males and females in our sample. Therefore we conducted separate analyses comparing males to males and females to females.

No significant differences were detected between males exposed to the essential oil of fennel and given access to a flowering fennel plant for 24 or 48h. The mean time to begin climbing following 24h of exposure was 10.28min (sd = 6.45) compared to a mean

time of 8.00min (sd = 4.18). The terminal height reached after climbing began also did not differ. The mean height was 8.85cm (sd = 7.54) following 24h compared to a mean height of 3.40cm (sd = 1.52) after 48h exposure. The time spent at the terminal height was also not significantly different. Animals spent a mean of 1.57min (sd = 0.79) following 24h exposure compared to a mean of 2.00min (sd = 1.73) following 48h.

The results for the females were the same as those for the males. The time to initiate climbing had a mean of 10.83min (sd = 6.91) for 24h of exposure compared to a mean of 8.33min (sd = 5.75) for 48h of exposure. The terminal height also did not differ significantly as a function of exposure time. Animals exposed for 24 spent a mean terminal height of 11.00cm (sd = 10.00) compared to a mean terminal height of 17.33cm (sd = 3.33). When the animals reached the terminal height, those exposed for 24h spent a mean time of 1.33min (sd = 0.52) compared to a mean time of 2.17min (sd = 2.40).

Comparison between 24h vegetative and 24h flower:

Analysis revealed that there were no significant differences between any of the dependent variables. Animals exposed to the essential oil of fennel began climbing the vegetative plant with a mean of 12.00min (sd 4.16) compared to a mean of 10.54min (sd=6.39) when given access to a flowering plant. The terminal height also did not differ. The terminal height reached in the 24h vegetative group had a mean of 12.11cm (sd 10.48) and those in the 24h flower group reached a mean terminal height of 9.85cm (sd = 8.44). The time spent at the terminal height was a mean of 2.36min (sd=2.36) in the 24h vegetative group compared to a mean of 1.46min (sd = 0.66).

Comparison between 48h vegetative and 48h flower:

Separate analyses comparing males to males and females to females were conducted because of the sex differences found in a previous analysis of animals exposed to 48h of the essential oil of fennel.

Analysis revealed that the time to initiate climbing did not differ. Males exposed to the 48h vegetative condition took a mean of 11.71min (sd = 10.08) to begin climbing compared to a mean time of 8.00 (sd=4.18) in the flower condition. A statistical significant effect was found in the terminal height reached. Males in the 48h vegetative condition reached a mean height of 12.0cm (sd = 8.91) compared to a mean height of 3.40cm (sd = 1.52) in the 48h flower condition. The time spent at the terminal height did not differ. Animals in the 48h vegetative condition spend a mean of 1.64 min (sd = 0.85) at the terminal height compared

to a mean of 2.00min (sd = 1.73) in the 48h flower condition.

The time to initiate climbing did not differ in females. Females exposed to the 48h vegetative condition took a mean time of 13.12min (sd = 9.70) to initiate climbing compared to a mean of 8.33min (sd = 5.75) in the flower condition. As in the case for males, a statistical difference was found in the terminal height reached. Females in the 48h vegetative condition reached a mean height of 10.38cm (sd = 10.88) compared to a mean height of 17.33cm (sd = 3.33) in the 48h flower condition. Interestingly, the difference between males and females is in the opposite direction. Males in the 48h flower condition reached a mean height of 3.40cm (sd=1.52) compared to a mean height for females of 17.33cm (sd = 3.33) under the same condition. The time spent at the terminal height did not differ. Females in the 48h vegetative condition spent a mean time of 2.62min (sd = 2.00) compared to a mean time of 2.17min (sd = 2.40) in the 48h flower condition.

The results of our experiments clearly show that earwigs will climb fennel plants under both laboratory and field conditions. This is significant because it indicates that fennel is attractive to this predator independent of soil conditions. It should be recalled that under the laboratory condition no soil was present. In other research Dermaptera insects can access the canopy of palm trees *Attalea phalerata* Mart. which can reach seven meters in height (SANTOS et al., 2003). Like fennel plants grow between 0.5 and 2m *M. arachidis* potentially can access fennel plants until the top as we saw in other observations.

The attraction of fennel to *Marava arachidis* (Yersin) was confirmed in the field experiments. These field experiments have the added virtue of replicating the finding of the laboratory experiment where *M. arachidis* was able to climb the fennel plant during the vegetative state despite the presence of a wax film on the stem. We believe that this is an important finding because earwigs can reproduce on the fennel plant before flowers appear that attract aphids thereby reducing the destruction of the plant. The newly hatched earwigs gain experience about predation behavior, perhaps learn to search for alternative foods, and how to seek cover. All these behaviors provide earwigs with a biological advantage in growing and maintaining its populations under different environmental conditions (WANDERLEY et al., 2006a). Fennel plants appear to be an ideal environment in which young earwigs *M. arachidis* can locate near feeding sites.

The field experiments under the flowering stage are equally important. Aphids are attracted to fennel more during the flowering stage. It is during this stage that nectar is produced and the plant needs greater protection to reduce, or even prevent, damage caused by aphids. Without the presence of pesticides or biological controls, aphids will multiply thereby causing more damage. Our findings lead to the predication that *M. arachidis* will also increase their numbers because they too feed on nectar and also eat aphids. Such a predication was confirmed in the case of the lady beetle (*Cycloneda sanguinea*) which increased its population by feeding on both fennel nectar and aphids (WANDERLEY et al., 2006b).

Another important finding was that the terminal height differed between males and females and between females studied under a vegetative state versus a flower state. Females reached a higher terminal height than males and females reached a higher terminal height during the flower stage than during the vegetative stage. These results are explained by the necessity of females to find more food than males because of the energy expended during the reproductive process. This observation is in accord with PRICE (1975) whereby females of predator insects provide their progenies with a good source of food and other conditions of survival.

Moreover, the females are attracted to the leaves as egg laying sites. Generally, earwigs attack during the night as much in soil as on plants (BASTOS & TORRES, 2003). Females of lady beetle *C. sanguinea* also use leaves of fennel as laying sites (ABRAMSON et al., 2006). Probably it is the time the earwigs lay eggs, and three to five minutes after the nymphs born in this specie. In two or three days after birth nymphs disperse on the plant and begin to predation aphids or to feed on flowers nectar.

Exposure to the essential oil of fennel for 24 or 48 hours has little effect on climbing behavior. This suggests that the plants release sufficient oil to attract *M. arachidis* to fennel whether the plant is in a vegetative or flower state. We would also like to note that there were a relatively large number of inactive animals. Why, this is so remains unclear at this time.

Our future research in this area will be directed towards a field test in which large numbers of *M. arachidis* are released in a green house in which fennel plants are attacked by aphids. We will measure the reproduction of *M. arachidis* on fennel plants and in the soil. We will also conduct experiments testing the predication that *M. arachidis* will increase their numbers when feeding on both nectar and aphids.

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REFERENCES

- ABRAMSON, C.I. et al. Effect of essential oil from citronella and alfazema on fennel aphids *Hyadaphis foeniculi* Passerini (Hemiptera: Aphididae) and its predator *Cycloneda sanguinea* L. (Coleoptera: Coccinellidae). **American Journal of Environmental Sciences**, New York, v.3, n.1, p.9-10, 2006.
- BASTOS, C.S.; TORRES, J.B. **Controle biológico como opção no manejo de pragas do algodoeiro**. Campina Grande: EMBRAPA, 2003. 29p. (Circular técnica, 72).
- FOERSTER, L.A. Seletividade de inseticidas a predadores e parasitóides. In: PARRA, J.R.P. et al. **Controle biológico no Brasil** – parasitóides e predadores. São Paulo: Manole, 2002. p.95-114.
- GOMES, F.P. **A estatística moderna na pesquisa agropecuária**. Piracicaba: Associação Brasileira para Pesquisa da Potassa e do Fosfato, 1987. 162p.
- LEMOS, W.P. et al. Influência da temperatura no desenvolvimento de *Euborellia annulipes* (Lucas) (Dermaptera: Anisolabididae), predador do bicudo do algodoeiro. **Anais da Sociedade Entomológica do Brasil**, Piracicaba, v.27, n.1, p.67-76, 1998.
- PRICE, P.W. **Insect ecology**. New York: John Wiley & Sons, 1975. 432p.
- PETERSEN, P.; ROMANO, J.O. **Abordagens participativas para o desenvolvimento local**. Rio de Janeiro: AS-PTA/ Actionaid-Brasil, 1999. 144p.
- SANTOS, G.B. et al. Artrópodos associados à copa de *Attalea phalerata* Mart. (Arecaceae), na região do Pantanal de Poconé, Mato Grosso, Brasil. **Revista Brasileira de Entomologia**, São Paulo, v.47, n.2, p.211-224, 2003.
- SILVEIRA, L. et al. **Agricultura familiar e agroecologia no semi-árido** – avanços a partir do Agreste da Paraíba. Rio de Janeiro: AS-PTA, 2002. 356p.
- WANDERLEY, P.A. et al. O surpreendente cuidado maternal dos dermápteros. **Ciência Hoje**. Revista eletrônica. Acesso: 02 jun. 2007. On line. Disponível em: <http://www.cienciahoje.pt/9080>, 2006a.
- WANDERLEY, P.A. et al. Erva-doce tratada com extrato de melão silvestre promove aumento na reprodução de predadores de pulgões. **Ciência Hoje**, Revista eletrônica. Acesso: 02 jun. 2007. On line. Disponível em: <http://www.cienciahoje.pt/index.php?oid=17095&op=all>, 2006b.