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Biological characteristics of *Evania appendigaster* (L.) (Hymenoptera: Evaniidae) in different densities of *Periplaneta americana* (L.) oothecae (Blattodea: Blattidae)

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Abstract

Evania appendigaster (L.) is a solitary endoparasitoid of oothecae of the American cockroach, *Periplaneta americana* (L.). In this work we report our studies on the parasitism of *P. americana* oothecae by *E. appendigaster* and the biological characteristics of this egg parasite, as it is affected by host density and mating. Cockroach oothecae were presented for individual females at different densities (one, two, three, four, five and six oothecae) during 2 days of exposition time. Reproduction was determined to be biparental and arrhenotokous. Host density did not influence sex ratio and longevity. The greatest reproductive efficiency of the females occurred in the first 14 days of their lifetime. At higher densities low parasitism rates were accompanied by a high percentage of dead oothecae. The percentage of parasitism decreases with increase in host density.

Keywords: *Periplaneta americana*; *Evania appendigaster*; Biological control; Host density

1. Introduction

The American cockroach, *Periplaneta americana* (L.), is well known as an active carrier of pathogenic organisms (Britter and Williams, 1949; Rueger and Olson, 1969), as well as for damaging stored products and being aesthetically unappealing and offensive. Its effect in creating severe allergic reaction in human habitations (Arruda and Chapman, 2001; Rosário Filho et al., 1999; Wu et al., 2000) has recently placed this species as a high priority urban pest. Currently, the most common tool for dealing with urban cockroach infestations nowadays is chemical control. However, greater efficiency could be achieved if this technique is combined with the use of predators, parasites or parasitoids, which are potentially capable of reaching the insects directly in their hiding places.

Evania appendigaster (L.) is an egg capsule (ootheca) parasite of some common cockroach species, especially *Periplaneta americana* (L.) (Stange, 1978). All immature stages of this parasitic wasp are spent inside the oothecae (Edmunds, 1955), being all the cockroach eggs consumed by the developing larva. Some authors consider it to be a good candidate for local control of cockroach populations (Cameron, 1957; Lebeck, 1991). Another evaniid wasp, *Prosevania puntacta* (Brullé), which attacks oothecae of the oriental cockroach *Blatta orientalis* L., has been studied before as a potential control agent (Thoms and Robinson, 1986, 1987). Studies with *E. appendigaster* that would be able to evaluate its potential for biological control of *P. americana* are still lacking, as emphasized by Alauzet and Malausa (1994). Among these aspects, knowledge on the adaptations of natural enemies in high, and especially in low densities of the target pests makes it possible to predict

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and avoid greater damage from applications of the biological control agents (O'Neil, 1990). Moreover, the population growth can be determined according to the number of females generated and their reproductive period (Brooijmans and van Lenteren, 1997). This is of great advantage in planning parasite release programs.

Our study describes the parasitism of *P. americana* oothecae by *E. appendigaster* and the biological characteristics of this egg parasite, as it is affected by host density and mating.

2. Materials and methods

2.1. Rearing of cockroach

A stock culture of *P. americana* was established from cockroaches collected in Rio de Janeiro, Brazil, in 1998 (22°45′51″S, 43°23′58″W). The cockroaches were reared in glass aquaria of $21 \times 21 \times 34$ cm containing PVC pipes for shelter. The cockroaches were given dog chow (Deli Dog, Purina) and tap water ad libitum, and were also provided with styrofoam pieces ($15 \times 10 \times 4$ cm) for oviposition. Oothecae laid in the styrofoam pieces were removed every 2 days, and used in the experiments and insect colony maintenance.

2.2. Rearing of parasites

A stock culture of *E. appendigaster* was established from parasites emerged from field collected oothecae in Rio de Janeiro, Brazil, in 1999. The wasps were kept in $30 \times 30 \times 30$ cm cages of wood structure and nylon frame, maintained on a 20% sucrose diet, and given oothecae on 6 cm diameter glass petri dishes.

The exposed oothecae were isolated in glass vials (10×4 cm), sealed with thin nylon frames and rubber bands, providing newly emerged parasites with no prior access to potential hosts. Both cultures were kept at 26 ± 2.2 °C, 69 ± 3% relative humidity and 14 h photophase.

2.3. Experiments

All experiments were conducted under the environmental conditions described above, and each experimental unit consisted of a 4.0 dm^3 transparent acetate box. There was an 11-cm diameter hole in the middle of the front wall of the cage, closed with a cloth sleeve to allow for introduction and removal of insects.

To determine the effect of host densities in their parasitism capacity, wasps were individualized in male/female couples in an experimental cage with 20% sucrose solution ad libitum. Every two days during the female's lifetime, 0- to 48- h-old oothecae were exposed to the wasps as hosts in the fixed parasitoid/host ratios 1/1, 1/2, 1/3, 1/4, 1/5 or 1/6 ($n = 12$). After 48 h, these oothecae were replaced with fresh ones. All oothecae used in our experiments had average size 8.49 ± 0.35 mm $\times$ 3.67 ± 0.18 mm ($n = 50$). Replaced oothecae from the cages were kept in 10×3 cm glass tubes closed with thin nylon frame until parasite/host emergence. As in preliminary studies, the development time of egg to adult of *E. appendigaster* lasted around 40 days. Non-emerged oothecae were dissected after 3–4 months of the parasitism; hence ensuring the full development of the immature stages that are in a state of arrested development.

Some couples produced only male progeny, and we tested the presence of parthenogenesis and its influence, in the same conditions, with single females in the fixed host density 1/3, to check if the biological parameters should be altered significantly.

The following parameters were measured in the different host density conditions: (i) pattern of oviposition during the female wasp's lifetime (brood size obtained per week in different host densities); (ii) mean number of parasitized hosts (number of adults emerged plus dead immature parasites found in later dissection); (iii) mean number of parasitized host per day per female (total of adult parasitized plus dead immature parasites per female's lifetime); (iv) development time of the progeny (mean time from oviposition to adult emergence); (v) adult longevity (period between adult emergence from the oothecae and death). We also quantified the following: (i) percentages of dead oothecae (number of oothecae which were either dehydrated and/or contained nymphs, immature stage of the host, that failed to complete development per number of oothecae exposed $\times$ 100); (ii) non-emerged parasites (number of oothecae containing dead immature parasites per total number of oothecae exposed $\times$ 100); and (iii) parasitism rate (the number of parasitized hosts per number of exposed hosts $\times$ 100).

Voucher specimens of the parasitic wasp are deposited in the National Museum of Natural History (Washinton, DC, USA) and in the Entomological Collection of Instituto Oswaldo Cruz, Rio de Janeiro, Brazil.

2.3.1. Data analysis

The number and percentage of parasitized oothecae were analyzed nonparametrically using one-way Dunn's test, based on Kruskal–Wallis rank sums. Parthenogenicity and longevity data were analyzed using Mann–Whitney test. All statistical tests were done using GraphPad Instat Program, Motulsky (1999), at $P < 0.05$ significance level.

3. Results and discussion

Parthenogenicity. Unmated female wasps produced only male progeny, whereas mated females produced both males and females. Thus, *E. appendigaster* is biparental and arrhenotokous. Arrhenotoky is the most common mode of reproduction in hymenopterous parasites (Jervis and Kidd, 1996). In density 1/3 (parasite/oothecae), longevity and development time of both mated and parasites parasitoids and parasitism rates of unmated and mated females were different (Table 1). Virgin females of *E. appendigaster* are less effective parasites as they produce fewer descendants