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The stem-gall wasp *Eurytoma* sp. (Hymenoptera: Eurytomidae): a potential biological control agent against *Psidium cattleianum*

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Abstract. The morphology of the stem gall of strawberry guava, *Psidium cattleianum*, and the life history of the causative agent, an undescribed species of *Eurytoma* (Hymenoptera: Eurytomidae), were studied in the laboratory and under field conditions. This gall wasp appears to be a highly-specific natural enemy of strawberry guava and a promising candidate for biological control. The gall is a major limiting factor of strawberry guava shoot-growth in Brazil. The wasp is known only from a small area of the first plateau, east of Curitiba, Paraná State, Brazil. It attacks both red- and yellow-fruited forms of the host plant. Within a year after the emergence of the insect, the gall dries and the distal portion of the stem dies.

Introduction

Commonly known as strawberry guava or araça, *Psidium cattleianum* Sabine (Myrtaceae) is native to south-eastern Brazil. During the last century, it was introduced to other tropical and subtropical regions where it has become an aggressive weed, particularly on oceanic islands (Ellshoff *et al.* 1995). It was deliberately introduced to Hawai`i around 1825 where it was spread very rapidly into natural areas by the common myna (*Acridotheres tristis* L.). The principal agent of dispersal today is the feral pig (*Sus scrofa* L.). Strawberry guava currently occupies forested habitat from approximately 100-1300 m elevation forming monotypic stands between 500-1000 m (Jacobi and Warshauer 1992). Smith (1985) classified it as one of the top ten most disruptive weeds in the Islands.

The search for natural enemies as biological control agents started in Brazil in the early 1980s with observations in the restinga vegetation from the states of Espírito Santo to Rio Grande do Sul. Although several insects were collected, none appeared to be specific to the target plant. The first potential agent was obtained by Hodges (1988) and, as a consequence of his studies, a co-operative research programme was initiated between the University of Hawai`i at Mânoa and the Paraná Forest Research Foundation in Curitiba to search for specific natural enemies of strawberry guava in Brazil. Hodges (1988) recommended this research should be concentrated in Paraná State, where both the yellow- and red-fruited forms of strawberry guava are found.

Materials and methods

Study sites

Collections were made from the first plateau east of Curitiba, Paraná State, Brazil. The study areas were located principally in secondary vegetation and orchards, although strawberry guava also inhabits the native *Araucaria angustifolia* (Bert.) O. Ktze. forest. The trees were small, less than 3 m tall, in the open or at the edge of scrub forest. Study sites were chosen using two criteria, the accessibility of numerous target plants and their close association (within 10 m) with the commercially exploited common guava, *Psidium guajava* L. and other myrtaceous species, particularly pitanga (*Eugenia uniflora* L.), gabiroba (*Campomanesia xanthocarpa* Berg) and *Eucalyptus* spp. The study sites were: (i) Bethânia Farm, at the edge of managed woodland, 33 km E of Curitiba; (ii) the Polytechnical Center, Curitiba, in landscaped park 10 km from the city centre; (iii) Chantecler Farm, in abandoned fields, 22 km E of Curitiba; and (iv) Manancial da Serra, in native *A. angustifolia* forest, 30 km E of Curitiba.

Sampling and observations

Stem and gall collections were made weekly for one year to study the life-history of the gall-forming insect. Subsequent samples were made every two weeks for two years. During this study 177 galls of different sizes were observed on 28 trees. At least five galls at each site were marked and followed through the complete cycle. Twelve pairs of gall-wasp adults were confined in cages (60x30x30 cm, 50x40x35 cm or 40x40x40 cm) for mating and longevity studies and fed with a blend of water, honey and dextrose. They were observed at least once an hour during daylight hours as well as for at least two hours after dark. Observations, other than behavioural studies, were made using a dissecting microscope or hand lens. Some galls were shaved or split to enable the necessary observations.

Description of the gall

Stem hypertrophy begins with oviposition. The cells around the inserted egg proliferate, plugging the external opening and enclosing the egg completely (Wikler 1995). Hatching of the larvae accelerates the process and the gall forms rapidly while the stem is still growing and before sclerification of the tissue occurs. Once the stem stops growing there is no further growth of the gall.

The natural colour of the stem and gall is initially green but, as the shoot develops, both the stem and gall darken and finally turn brown. The shape of the galls varies from a slightly widened stem to a round swelling, with many intermediary forms. The size of the galls varies from 0.6-2.1 (1.3 ±1.3) cm in length and 0.3-0.9 (0.6 ±0.4) cm width. Each gall normally contains a single cavity. In the initial phase, the galls are compact internally and the larvae are limited to the space in which the egg was laid, although they create the space necessary for development by feeding. On emergence of the adult, the wall of the galls range between 1.0-1.5 mm thick.

There was considerable variation in the incidence of galls (6.3 ±7.1) at the various sites, for which we have no explanation. The majority of trees (40, though only 15 trees were studied in detail) with stem galls were collected at Bethânia Farm though the highest number of galls/tree (17) was found at the Polytechnical Center. At Chantecler Farm, the average number of galls/tree was 4.0, and in the region of Manancial da Serra it was 3.37. Galls were always found on branches between 0.20 m and 1.90 m above the ground. All observed trees above 1 m tall were infested with at least one gall. The gall is formed by an undescribed species of *Eurytoma* (Hymenoptera: Eurytomidae).

Biology of *Eurytoma* sp.

The species is univoltine. The adults emerge in September and are active until February the following year. Eggs are laid from October to January and the larvae are active from January to June. Pupation occurs within the gall from June to August-September, the winter season in Brazil.

The female oviposits in developing shoots. There may be many oviposition attempts on a shoot but only one gall forms on each shoot. The whole process of oviposition takes about four minutes and was observed once in August 1994, at the Bethânia Farm study site. All attempts to induce egg laying in the laboratory failed. The eggs are 0.2 mm in length (n = 5) and are laid between 0.1-1 mm deep in the stem tissue.

According to De Santis (personal communication) eurytomids usually go through five instars. The larvae are white, initially without visible legs, and curled in a 'C' shape. Just prior to pupation, the larvae range from 1.23-5.20 mm in length. Head width of the final-instar ranges from 0.32-0.64 mm. The developmental sequence of the larvae was not observed in this species because the larvae died on exposure.

In contrast to field situations, where all undamaged galls produced adult flies, larvae always died once the galls were opened either in the field or laboratory. The mortality of developing larvae that are still within the gall on whole shoots, cut at least 20cm below the gall, and maintained in water in the laboratory is also very high. Of 60 larvae studied only 12 completed the pupal phase. It appears that late instars are better able to survive after the stem is cut.

Under laboratory conditions, the pupal phase ranged from 9-15 days. Attempts to maintain the pupae outside the gall failed. Only two adults emerged under these circumstances and they were both deformed.

To observe the emergence of adults in the laboratory, galls were collected and maintained in cages. The relative humidity was maintained at 70 ±10% to prevent the stems drying out. To open the exit holes in the gall, the adult insects excavate vigorously with the mandibles and move the frass to the back of the gall chamber with the help of the front legs. They then mine a round opening in the wall of the gall. The process takes many days and some adults die before

emergence. After emergence, in the field, the adults jump to the highest branches of the plants and mate or disperse. No other insects were found associated with the galls and only *Eurytoma* sp. emerged from the galls. The insects are vulnerable to predation by birds and other insects on emergence but no parasitoids of this species are known.

The male and female morphological characteristics conform with the descriptions for other eurytomids given by Bugbee (1936). The females are always larger than the males. The maximum longevity of the wasps in captivity was 16 days. Mating was never observed in the field. In the laboratory, eight of 12 pairs mated, always during daylight. In October/November, the time of active shoot growth, adults are frequently found in the field.

Effects of gall formation

During the year in which a gall forms, flowers are not formed distal to the gall, though vegetative growth appears to be normal. Flowers may still grow elsewhere on the plant. Gall-growth eventually obstructs the plant vascular system and stem-growth ceases above the gall. Subsequently, the leaves drop off and the shoot dies within two years after oviposition. No basipetal necrosis takes place.

Host specificity

Galls caused by *Eurytoma* sp. were never found on other species of Myrtaceae. Nor were adults ever observed on the other species of Myrtaceae, even when they were seen on *P. cattleianum* plants growing side by side. This species of *Eurytoma* appears to be extremely host specific.

Conclusions

This eurytomid gall-maker in the stems of *P. cattleianum* appears to be an important limiting factor affecting growth of strawberry guava in Brazil. Gall formation is a significant cause of damage in the field. Heavy infestations result in conspicuous pruning of the shoots and the plants are stunted. In over three years of observation in the field, galls have never been found on other species of Myrtaceae. The insect, therefore, appears to have an excellent potential as a biocontrol agent of strawberry guava. It has a strong negative effect on plant growth.

Though strawberry guava is cultivated as an ornamental plant, the pruning activity of this insect is not too unsightly. Unaffected portions of the plant continue to grow as usual. In forest situations, a biological control agent that prevents the strawberry guava trees from emerging through the forest canopy will probably reduce fruit production significantly.

Further work is needed to establish that this species is strictly monophagous. We are attempting to test it against *Metrosideros polymorpha* Gaud., the Hawaiian endemic forest dominant tree, which is also in the Myrtaceae, but we are having some difficulty getting these plants to grow in the Curitiba area.

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