PROC. ENTOMOL. SOC. WASH.
124(2), 2022, pp. 316–324

INSECTS ASSOCIATED WITH SEVERE DEFOLIATION OF SALMWOOD (*CORDIA ALLIODORA* (RUIZ AND PAV.) CHAM.) (BORAGINACEAE) IN COLOMBIA

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Abstract.—Salmwood (*Cordia alliodora* (Ruiz and Pav.) Oken) (Boraginaceae) is used as a shade plant for cacao and coffee agroforestry systems in Colombia. In 2016 these trees were severely defoliated by insects on a farm in northeastern Colombia. One hemipteran and one lepidopteran were found to be associated with the damage, and one hymenopteran was found to parasitize the hemipteran. The hemipteran was *Edessa panamensis* Fernandes von Doesburg and Greve (Pentatomidae), a new record for Colombia and the first record of this species as a parasitoid host. A parasitoid wasp, *Neorileya albipes* Girault (Eurytomidae), emerged from *E. panamensis* eggs, and is recorded for the first time from Colombia. The lepidopteran feeding on salmwood was *Paridnea squamicosta* (Walker) (Pyralidae). The larva takes refuge from natural enemies in domatia on salmwood branches and emerges to feed on leaves. The larval leaf consumption was estimated to be 134.1 cm^2 with a larval duration of 15.64 days; the pupal stage was 20.44 days. We also report for the first time another host for this larva, the moncoro tree (*Cordia gerascanthus* L.), which was affected to a lesser degree. Photographs of insect adults, larvae, eggs, and morphological structures are provided.

Resumen.—El nogal cafetero *Cordia alliodora* (Ruiz y Pav.) Oken (Boraginaceae) es usado como una planta de sombrío en sistemas agroforestales en Colombia, en 2016 estos arboles fueron severamente defoliados por insectos en una finca al noroeste de Colombia. Un hemíptero y un lepidóptero fueron asociados con el daño,

además un himenóptero fue encontrado parasitando el hemíptero. El hemíptero fue identificado como el chinche *Edessa panamensis* Fernandes von Doesburg and Greve (Pentatomidae), un nuevo registro para Colombia. La avispa parasitoide, *Neorileya albipes* Girault (Eurytomidae), emergió de huevos de *E. panamensis* y es registrada por primera vez para Colombia. El lepidoptero que se alimenta de hojas de nogal cafetero fue identificado como *Paridnea squamicosta* (Walker) (Pyralidae). La larva se refugia de sus enemigos naturales en los domacios en las ramas de nogal, desde allí sale a consumir hojas. En la fase de larva el consumo de hojas fue estimado en 134,1 cm^2 con una duración de 15,64 dias, la duración de la etapa de pupa fue 20,44. También se reporta por primera vez otro hospedero para esta larva, el arbol de moncoro (*Cordia gerascanthus* L.), el cual es afectado en menor grado. Se presentan fotografías de insectos adultos, larva, huevo y estructura morfológicas.

Key Words: larval behavior, insect ecology, feeding damage

DOI: 10.4289/0013-8797.124.2.316

The white laurel, Spanish elm, cypre, or salmwood (*Cordia alliodora* (Ruiz and Pav.) Oken) (Boraginaceae) is a tree native to tropical America that is extensively used as a shade plant in cacao and coffee agroforestry systems in Colombia (Rojas-Gutiérrez 2008, Ospina et al. 2010). In 2016 severe defoliation of salmwood trees, and in some cases total defoliation of single trees, was caused by insects at the Yarigüíes Farm in northeastern Colombia that is dedicated to promotion and research in the cacao sector (Compañía Nacional de Chocolates 2021). The defoliation had a significant economic impact because it delayed growth of salmwood trees, and temporarily eliminated shade for the umbrophilous cacao, which can eventually affect its growth and productivity.

Although there are studies about associated entomofauna on salmwood trees in the Colombian coffee region, especially of the lace bug, *Dictyla monotropidea* (Stål) (Tingidae) (Ospina et al. 2010, Martínez et al. 2012), the diversity of insects associated with salmwood is poorly known. After the dry season in 2016, salmwood trees were surveyed to determine the identity of the insects associated with the damage, and to document the biology of defoliating larvae, their life cycle, foliar consumption, and possible alternative hosts.

Materials and Methods

This study was conducted in 2016 at Yarigüíes Farm, the cacao research facility of the Compañia Nacional de Chocolates (Compañía Nacional de Chocolates 2021), located in the rural district La Lejía in the municipality of San Vicente de Chucurí, Santander Department, in northeastern Colombia. The geographical coordinates are 6° 54'30.2" N, 73° 44'08.3" W. The average temperature is 28.2°C, relative humidity is 79%, average annual rainfall is 2986 mm, and solar brightness is 2170 hours.

Fifty-two-month-old salmwood trees that provide permanent shade to cacao trees, with an average height of 8.67 m, were sampled June to September. The cultivated area for this study was 6.8 hectares, with a salmwood planting distance of 4 x 12.8 m, 195 per hectare, and

3-year-old cacao trees were 3.2 m apart in a triangular distribution for a total of 1123 trees per hectare. This study was accomplished under the framework permit 1466 of 2014 granted by the Agencia Nacional de Licencias Ambientales (ANLA) to the Colombian Corporation for Agricultural Research (AGROSAVIA). Biological material collected during this study is deposited in the Colección Taxonómica Nacional de Insectos Luís María Murillo (CTNI).

Samples of pentatomids were collected from 15 branches cut from the lower stratum of salmwood on June 16 and September 28, and taken to the AGROSAVIA entomology laboratory at La Suiza Research Center, Rionegro, Santander Department. Although other species of insects were present, one pentatomid was undoubtedly the most abundant non-Lepidopteran insect, and all stages of development were easily found. About 50 adult specimens were collected; many more dispersed when the branches fell. The pentatomids were stored in 70% ethanol. Five female and 5 male specimens were examined and identified using taxonomic keys of Fernandes et al. (2001), Torres (2004), and Almeida et al. (2018). The preliminary identification was confirmed by the pentatomid specialist José Antonio Fernandes (Federal University of Para) based on images of the male genitalia.

Pentatomid eggs were collected in the field and observed for parasitism, and after adult parasitoid wasps emerged on June 23, they were mounted on a slide with Canada balsam according to the methodology of Noyes (2003). One female and 2 males were examined and identified using the Rileyinae (Eurytomidae) revision by Gates (2008). Our preliminary identification was confirmed by the chalcidologist Michael Gates (Systematic Entomology Laboratory, ARS, USDA).

Foliar consumption by lepidopteran larvae could be observed from the ground in all strata of *C. alliodora* plants, so ladders or other means of access to the canopy were not necessary. The leaf-grasping caterpillar was found on all branches that were cut. Trees and shrubs near the cacao agroforestry systems, including cacao, were inspected to detect possible alternative hosts for the salmwood-defoliating lepidopteran larvae. The presence of just one larva was enough for the plant to be registered as affected. Larvae were taken to the laboratory and placed in rearing chambers with a supply of salmwood leaves. After adults emerged on October 18, they were pinned and dry mounted. Male and female genitalia were dissected from a sample of specimens using the following process: abdomens were placed in cold 10% potassium hydroxide (KOH) for twelve hours, genitalia were cleaned with soapy distilled water, rinsed with distilled water, transferred to 70% ethanol, and then placed in glycerin for observation under the stereomicroscope and subsequent storage. Images of the genitalia were compared with genitalia dissections at the National Museum of Natural History, Smithsonian Institution, Washington, DC (USNM), specifically USNM slides with the following numbers: 116126 from Mexico; 99948 and 99949 from Guatemala; 116120 and 116121 from Costa Rica; and 116136 from Colombia. Externally, the adults were compared to photographs taken by MAS of type specimens at the Museum National d'Histoire Naturelle (MNHP), Paris, France, and The Natural History Museum (UKNMH), London, United Kingdom, the type specimens at the USNM, and the painting of *P. demonica* (Druce) in Druce (1895). Robinson et al. (2010) was consulted for

previous records of Lepidoptera larvae feeding on *Cordia* spp.

To measure foliar consumption in the laboratory, a larva was introduced to a previously washed and disinfected plastic container with a capacity of 2.5 liters, which contained a cut rectangular piece of salmwood leaf of 40 cm^2, 4 x 10 cm. Moist absorbent paper was placed at the bottom of the container to avoid dehydration and guarantee the viability of the leaf for 24 hours; the neck of each bottle was covered with mesh secured by an elastic band to prevent entry of natural enemies and promote aeration. The remaining exposed leaves were collected daily and drawn on a sheet of graph paper to estimate consumption. Twenty larvae were measured.

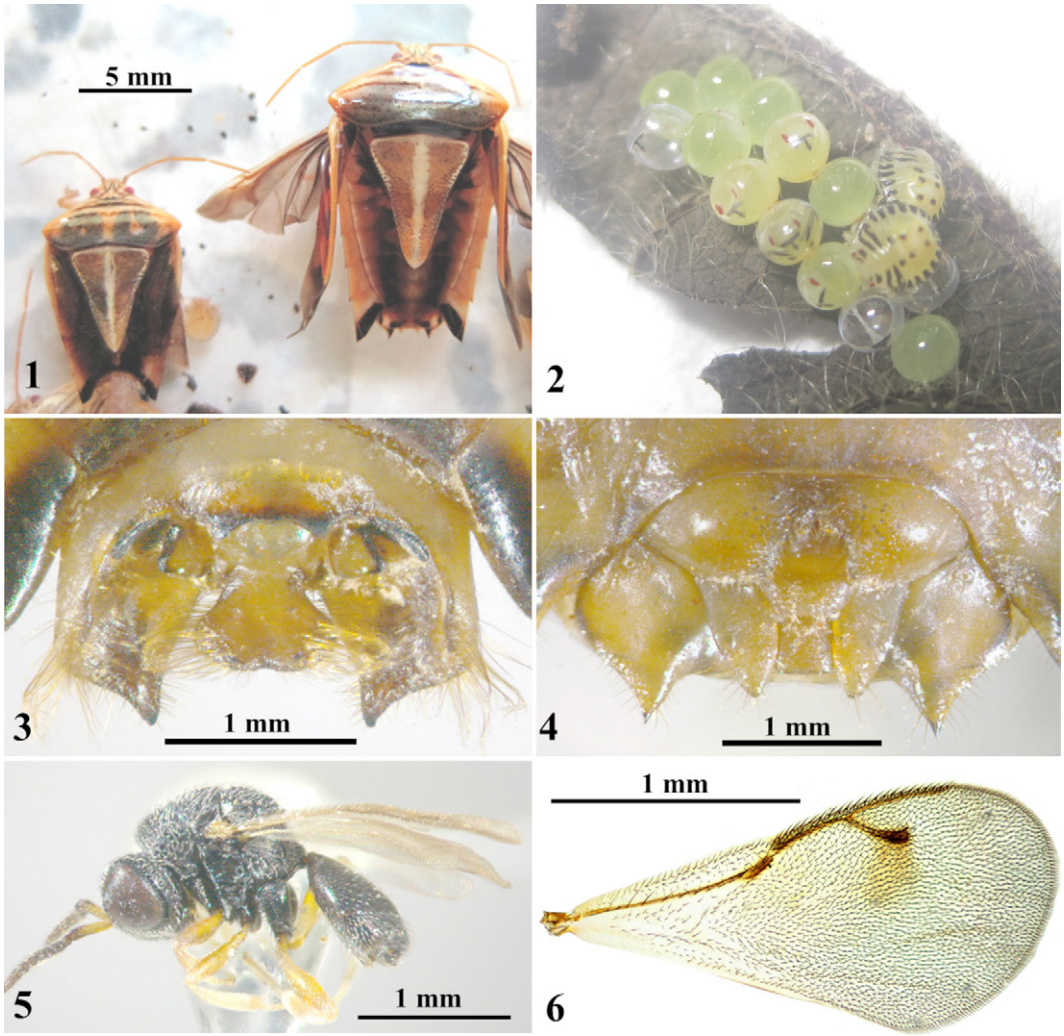
Oviposition by females in captivity was not achieved, therefore eggs were visually searched for on branches in the field. These eggs were brought to the laboratory to determine the duration of the larval and pupal stages. The larvae were placed in separate containers, fed, and checked daily. Quiescence and cessation of foliar consumption were considered as the manifestation of larval molting.

Results and Discussion

The hemipteran was identified as *Edessa panamensis* Fernandes von Doesburg and Greve (Pentatomidae), a new record for Colombia. Little is known about the biology of this genus. This species had been reported only from Panama, the type locality, and a host plant association had not been previously reported. This species belongs to the *E. collaris* species group (Fernandes et al. 2001), a small group of four species, that are easily recognized by the yellow transverse bands on the pronotum and scutellum (Fig. 1) and their posture on leaves (Fig. 2). So far little is known about the biology of the group. The four species can be identified only by their genitalia (Fernandes et al. 2001) (Figs. 3, 4). Females are larger than males and, in our samples (n = 10), the measurements show slight differences from the original description (given in parentheses after our measurements). Total length = 9.9–13.6 mm (12–14 mm); pronotum width = 6.34–8.37 mm (7.5–8.4 mm); abdominal width = 5.8–7.7 mm (6.6–7.4 mm); head width = 2.06–2.4 mm (2.2 to 2.3 mm), and head length = 1.53–1.85 mm (1.4–1.5 mm).

Although we do not have sufficient evidence to show that the damage or defoliation was caused by *E. panamensis*, the presence of its nymphs and eggs confirms that it is associated with *C. alliodora* plants and most likely feeds on it. In contrast, cacao plants were inspected at a time of high populations of *E. panamensis*, and neither adults nor immatures were found on this plant.

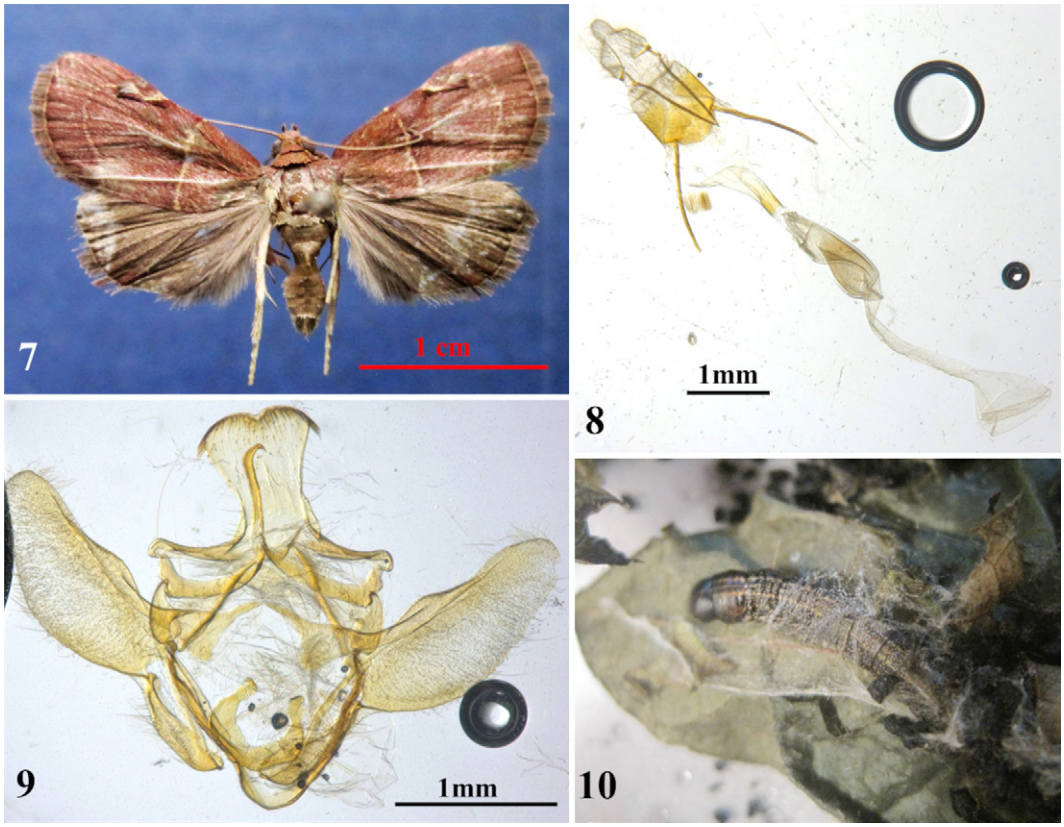
The parasitoid of *E. panamensis* eggs was identified as *Neorileya albipes* Girault (Hymenoptera: Eurytomidae). Although its distribution is Neotropical and it is known to occur in countries that border Colombia; including Panama, Venezuela, Ecuador, and Peru (Gates 2008), this is the first time it has been recorded from Colombia. Specimens we collected were slightly smaller than those reported by Gates (2008) (given in parentheses after our measurements): body length 1.97 to 2.1 mm (2.2–2.8 mm) (Fig. 5). Also, the malar space in relation to the height of the eye is less, 0.23 to 0.27 mm (0.3 to 0.4 mm). However, the length of the scape, 4.22 to 3.93 mm (3.6 to 3.9 mm), and the length/width ratio of the first funicular segment, 0.81 to 0.92 mm (0.7 to 0.8 mm), were greater. *Neorileya albipes* is easily separated from other species in the genus by the presence of an infuscation in the forewing (Gates 2008) (Fig. 6). This species also parasitizes eggs of another pentatomid,



Figs. 1–6. Pentatomid *Edessa panamensis* and its eulophid egg parasitoid *Neorileya albipes.* Figs. 1–4. *Edessa panamensis*. 1, Dorsal view. 2, Eggs and newly hatched nymphs. 3, Male genitalia. 4, Female genitalia. Figs. 5–6. *Neorileya albipes.* 5, *L*ateral view. 6, Forewing.

Edessa meditabunda (Fabricius) (Gates 2008).

The lepidopteran was identified as *Paridnea squamicosta* (Walker) (Pyralidae: Chrysauginae) (Figs. 7–10). Walker (1867) described *P. squamicosta* from Bogota, Colombia, and its synonym, *P. demonica* (Druce, 1895), was based on a series of specimens from Mexico, Guatemala, Costa Rica, and Guyana. Specimens of *P. squamicosta* at the USNM were collected widely in the Western Hemisphere, from Mexico to northern South America. Externally, this species is similar to *P. holophaealis* Ragonot, the type species, described from Brazil, but the genitalia clearly differentiates the species. Currently, there are only five species in *Paridnea* Ragonot (Ragonot 1892, Hampson 1897, Solis et al. 1995), but there are several new, undescribed species in the Western Hemisphere.



Figs. 7–10. Lepidopteran *Paridnea squamicosta.* 7, Adult, dorsal view. 8, Female genitalia. 9, Male genitalia. 10, Larva among leaves woven together with silk.

We document for the first time the biology of *P. squamicosta* feeding on *Cordia* in Colombia, although there are host records for *Paridnea* from Panama (Van Bael et al. 2004) and Costa Rica (Janzen and Hallwachs 2009). Janzen and Hallwachs (2009) report the following host plants for *Paridnea* larvae: *Varronia* spp., *Cordia alliodora*, and *Cordia panamensis* L. (Boraginaceae), *Achyranthes indica* (L.) (Amaranthaceae), and *Piper auritum* Kunth (Piperaceae). We also report for the first time *P. squamicosta* feeding on *Cordia gerascanthus* L., locally known as moncoro, with an incidence of 8% on moncoro trees examined (n = 100).

Salas and Valencia (1979) documented another chrysaugine that defoliated and caused a reduction in the quality of salmwood in the Carare region of Colombia. This is relatively close to our study area (65 km southwest), but we did not find this species at our study site. They stated that it was possibly *Ramphidium pselaphialis* (Ragonot) (Pyralidae: Chrysauginae), but do not include photographs, illustrations, or information regarding the origin of the identification or placement of vouchers, so we cannot confirm its identification. Voucher specimens in the USNM confirm that this species feeds on black sage (*Varronia curassavica* (Jacq.) Roem. and Schult., formerly placed in *Cordia*) (Boraginaceae) in Trinidad (2 adults each bred by F. J. Simmonds and Donald (1945)) and Guyana (1 adult bred by

H. W. B. Moore). This is a highly distinctive, chrysaugine genus with only 3 species of much larger South American moths that would be hard to confuse with *Paridnea*.

Foliar consumption of *C. alliodora* by *P. squamicosta* larvae was 134.1 cm^2 (n = 20). Additionally, the larvae of *P. squamicosta* exhibited a concealed feeding strategy by joining, mainly the most tender leaves, with threads of silk, and we observed reduced photosynthetic activity of the leaves not consumed.

Pyralidae have a wide diversity of concealed feeding strategies on leaves including folding, rolling, webbing, or tying leaves and making tunnels or tubes of silk or frass (Solis 1997, Aiello and Solis 2003). Recently, the construction of shelters by gluing or weaving leaves together by moth larvae of another genus of the Chrysauginae was reported in Piperaceae (Abarca et al. 2014).

The larvae later moved from the woven leaves, and colonized domatia located at branching points on the stems where they were also concealed and had protection from natural enemies during most of the larval period (see also Janzen and Hallwachs 2009). These domatia are usually inhabited by ants, which has been shown to have a positive effect on the plant by reducing the abundance of herbivores (Pringle and Gordon 2013). Use of domatia by lepidopteran larvae was previously reported only in trees of *Acacia* Martius (Fabaceae) (Agassiz 2011).

At the end of the larval phase, larvae exited the domatia, and the last instar wove desiccated leaves together with silk to form a shelter where it formed a cocoon and pupated. The larval phase was 15.64 days, and the pupal phase was 20.44 days under laboratory conditions (n = 29).

Salmwood is associated with a large, diverse group of insects that feed on its leaves (Madrigal 2003, Arguedas 2008). Other unidentified chrysaugine moth larvae have been reported to feed on *C. alliodora* in Costa Rica (Janzen and Hallwachs 2009) and the coffee region in Colombia (Ospina et al. 2010), with habits and damage similar to *P. squamicosta*. In Colombia, it was also observed that foliar damage was not only caused by *P. squamicosta*, but also by other insects that feed on branches and leaves, such as the lace bug *D. monotropidia*. It has been shown that *D. monotropidia* can affect up to 57% of the leaves in coffee agroforestry systems (Martínez et al. 2012). We did not measure the effects of the two hemipterans or their abundance in this study. Our discovery of a new association of the pentatomid *E. panamensis* (and its parasitoid) to salmwood in Colombia, suggests that the diversity of arthropods associated with salmwood, including phytophages and their natural enemies, is far from being sufficiently known.

Acknowledgments

The authors express their gratitude to the following taxonomists for identifications: José Antônio Marin Fernandes (Pentatomidae) and Michael Gates (Systematic Entomology Laboratory, ARS, USDA) (Eurytomidae). We thank Matthew Cock (CABI), John Lill (George Washington University), and other reviewers who provided comments that improved the manuscript.

This project originated as a thesis project of P. E. Hernández Perez and F. N. Vega at Unipaz University, Barrancabermeja, Colombia, under the direction of Professor A. Guarín. A part of this document is the result of studies on the diagnosis of insects in agroforestry systems by AGROSAVIA researchers, J. M. Montes and D. Zarate. This research was done with resources from

UNIPAZ University and the Colombian Corporation for Agricultural Research (AGROSAVIA).

This was a collaborative study and all authors contributed to the writing of the document. Specific contributions are as follows: JMMR, collection and identification of insects; PEHP and FNV, collection of field and laboratory data and insects; AG, coordination of the research; DZ, collection and identification of insects; MAS, identification of the lepidopteran. Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by USDA. USDA is an equal opportunity provider and employer.

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