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DESCRIPTION OF THE EARLY STAGES OF *ECCOPSIS GALAPAGANA* RAZOWSKI & LANDRY (TORTRICIDAE), A DEFOLIATOR OF *PROSOPIS JULIFLORA* (SW.) DC. (FABACEAE) IN COLOMBIA

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ABSTRACT. The biology and early stages of *Eccopsis galapagana* Razowski & Landry are described and illustrated for the first time; details of the adult behavior also are provided. Under outbreak conditions the species has become a serious pest in silvopastoral systems of algarrobo tree (*Prosopis juliflora* (Sw.) DC.; Fabaceae) in Colombia. Although African members of the genus *Eccopsis* feed on a variety of different host plant families (e.g., Fabaceae, Rhizophoraceae, Sterculiaceae, Anacardiaceae, Euphorbiaceae, Flagellariaceae, and Rutaceae), New World species of *Eccopsis* are recorded only from Fabaceae.

Additional key words: asymmetrical genitalia, Olethreutinae, parasitoids, pest species, silvopastoral systems.

Prosopis juliflora (Sw.) DC. (Fabaceae), commonly known as mesquite or algarrobo tree, is a widely distributed and highly adaptable shrub of xeric habitats ranging from the southwestern United States to northern South America (Venezuela, Colombia, Ecuador, and Peru) (Silva 1988; Schnee 1984). It is a multiuse species—in the field it provides shade and food for animals; the fruit is a rich source of proteins and fats (Lima 1994). In stables the fruit is used as fodder for cattle as it is approximately 39% protein and 7–8 % fat (Lima 1994). In rural areas of Venezuela and India, the wood of algarrobo and its charcoal are in high demand by the local people. In Colombia *P. juliflora* is used as a supplementary food source for bovines under intensive silvopastoral systems on the Caribbean coast, in the dry forests of the valleys of the Cauca and Magdalena rivers, and the plains areas of Cesar and Llanos Orientales (Caldas 1975; Lima 1994).

No serious pests of this species were reported until 2006 when conspicuous damage to the foliage was noticed in silvopastoral plantations of *P. juliflora* at El Cerrito, a small town of Valle del Cauca Department, Colombia (Figs. 1–2). An investigation of the foliage revealed that the damage was the result of feeding by larvae of a tortricid moth. Defoliation can reduce fruit production by 60%, which adversely affects livestock since the fruit of algarrobo is an important energy supplement for cattle during dry periods in the silvopastoral system. Adult and larval specimens were sent to the USDA Systematic Entomology Laboratory where they were identified as *Eccopsis galapagana* Razowski & Landry, described from the Galapagos Islands, Ecuador, and recently reported from Chile (Vargas 2011). The purpose of this paper is to describe and illustrate the early stages and damage caused by this species.

MATERIALS AND METHODS

Larval specimens were collected from the leaves of *Prosopis juliflora* that were in high density in a silvopastoral system at Hacienda El Hatico, El Cerrito, Valle del Cauca, 3°27'N, 76°32'W, Colombia, 1000 m above mean sea level (Fig. 3). Annual mean precipitation at the site is 750 mm, distributed in two rainy periods (March–May and October–November); average temperature is 24°C and relative humidity 75%. All of these characteristics are typical of tropical dry forest habitat *sensu* Holdridge (1978).

FIGS. 1–2. Algarrobo tree in Hacienda el Hatico, Colombia. **1.** Typical tree. **2.** Same tree after pest damage.

FIG. 3. Map showing the geographical location of the study site (on work).

FIGS. 4–5. Adults of *Eccopsis galapagana*. **4.** Adult male. **5.** Adult female.

Larvae of different stages were collected and preserved using KAAD and transferred to 70% EtOH. In order to follow the life cycle, last instar larvae were confined in mesh cages (40×50×50 cm) and provided with fresh host plant until they pupated and produced adults. Lots consisting of 10 females and 10 males were transferred to PVC cylinders (15 cm in diameter) with a fine mesh top and a humid sponge at the bottom. Sugar solution (15%) was provided *ad libitum* as an energy source. Branches of bipinnate leaves (bearing both the leaflets and the stems) of *P. juliflora* were placed inside the cylinders to stimulate copulation and oviposition. Rearing was conducted in the laboratory at 26.8°C and 78% relative humidity.

Specimens of larvae and adults were examined using a Wild M5A stereomicroscope and a Leitz Laborlux S compound microscope. Genitalia dissections followed the methods summarized in Brown and Powell (1991). Images of eggs, larvae, pupae, and adults were captured using a Miotic Digital Microscope DM143 camera and Miotic Images Plus 2.0 ML. All images were edited in Adobe Photoshop.

Body length of adults (i.e., from the compound eyes to the distal end of the abdomen) was measured using pinned specimens. Forewing was measured from the base of the wing to the apex. Terminology for morphological features of the genitalia follows that of Aarvik (2004) and Razowski et al. (2008); terminology for larvae and pupae follows Brown (1987) and Scoble (1995), respectively. Specimens examined are deposited in the collections of the Entomological Museum of the Universidad del Valle (Musenuv code 077), Cali, Colombia, and the National Museum of Natural History, Smithsonian Institution, Washington, D. C., USA.

RESULTS AND DISCUSSION

Systematics. The genus *Eccopsis* Zeller, 1852 is comprised of 20 described species, restricted primarily to the Old World Tropics, mostly Africa (Aarvik 2004; Brown 2005). The first New World species of the genus were recently described from Ecuador: two from the Galapagos Islands by Razowski et al. (2008), and one from the mainland by Razowski and Wojtusiak (2008). Subsequently, a species was described from Chile (Vargas 2011). This unusual geographical disjunction between Africa and South America has been reported previously for *Megalota* Diakonoff, 1966, *Cosmorrhyncha* Meyrick, 1913, *Apotoforma* Busck, 1934, and a few other genera (Brown 2009). The four

New World species differ from Old World *Eccopsis* in two features in the male genitalia: the absence of the characteristic process from the basal or subbasal portion of the valva, which is present in nearly all Old World species of *Eccopsis*; and the shape of the valve, which is much more asymmetrical in the New World species. In the Old World species the pattern of setae on the valvae are conspicuously asymmetrical, but the overall shape is only subtly different between the left and right valva. Hence, it is uncertain whether these New World species truly belong to *Eccopsis* or whether a new genus is required.

Larval food plants are recorded for a few species of African *Eccopsis*: *Acacia mearnsii* De Wild (Fabaceae) and *Aeschynomene schimperi* Hochst (Fabaceae) for *E. incultana* Walker (Ghesquière 1940; Swain & Prinsloo 1986; Krüger 1998; *Cassipourea malosana* (Baker) (Rhizophoraceae), *Theobroma cacao* L. (Sterculiaceae), and *Mangifera indica* L. (Anacardiaceae) for *E. praecedens* Walsingham (Diakonoff 1977; Aarvik 2004; USNM collection); *Drypetes natalensis* (Harv.) (Euphorbiaceae), *Flagellaria* sp. L. (Flagellariaceae), and *Vepris trichocarpa* (Engl) (Rutaceae) for *E. nebulana* Walsingham (USNM collection); and *Ricinus communis* L. (Euphorbiaceae) for *E. walhbergiana* Zeller (Aarvik 2004). Vargas (2011) recently reported *Prosopis* as a host for *E. galapagana* in Chile. Whereas fidelity to a single plant genus, or at least a single plant family, is the most common situation in most Olethreutinae, *Eccopsis* does not appear to demonstrate such host specificity, with larvae in the genus utilizing at least seven different plant families.

Eccopsis galapagana Razowski & Landry, 2008
Figs. 4–10

Description. *Adult.* Body length 4.50 + 0.46 mm; forewing length 3.48 + 0.46 mm (n = 50). Adults (Figs. 4, 5) somewhat variable in forewing pattern. Razowski et al. (2008) provides a brief comparison of *E. galapagana* with *E. floreana* Razowski & Landry. The male genitalia (Fig. 6) of *E. galapagana* can be distinguished from those of all other species of *Eccopsis* by the presence of a long curved spine from the terminal part of the sacculus of the left valva (absent in all other congeners) and the presence of a pair of thick apical setae from the uncus (usually a dense patch of setae from a distally bilobed uncus in congeners). The female genitalia (Fig. 7) are distinguished by the presence of a pair of large lobes of the sterigma.

Egg. Round, width 0.5–0.7 mm (mean = 0.63 mm, SD = 0.54, n = 91), length 0.5–0.7 mm (mean = 0.63 mm, SD = 0.54, n = 91). Five embryonic phases were apparent, allowing an estimate for the overall time for egg development (Fig. 8). Freshly deposited eggs are round, smooth, and translucent; by the second day they are concave, whitish, and in some individuals with two tiny dark spots that correspond to the stemmata. The stemmata are clearly evident by the third day. Mandibles are apparent by the fourth day. When fully developed, the larva ecloses by eating through the micropyle area.

6

FIG. 6. Male genitalia of *Eccopsis galapagana*

Larva. Last instar (Fig. 9) body length mean = 9.76 mm (SD = 0.98; n = 21). Head: Mandible with long ridge becoming confluent with lower tooth; distance between P1 and AF2 on head ca. 0.7 times distance between P1 and P2; a horizontal line connecting the AF2 setae on head passes closer to P2 than P1; stemmata with dark brown patch; a short, brown, patch at genal angle, extending dorsally along posterior margin of head. Thorax: Chaetotaxy typically tortricoid; prothoracic shield pale yellow with distinct brown line at posterior edge (earlier instars usually with shield entirely brown); L-pinaculum sclerotized, situated entirely anterior to spiracle; L-group trisetose on T1; SV group 2:1:1 on T1,2,3. Abdomen: All pinacula weakly sclerotized; all spiracles moderately large (larger on A8), round; SV-group on A1,2,7,8,9 with 3:3:3:2:2 setae; SD2 on A1–8 inconspicuous; SD1 pinaculum on A8 directly anterior to spiracle; D2 setae on A9 on shared dorsal pinaculum; D1 and SD1 on A9 on separate pinacula; distance between V-setae approximately the same on A7, A8, and A9; anal comb present with 6–8 tines. Abdominal prologs with 39–42 partially triordinal crochets (in previous instar 26–27 mostly biordinal crochets, with those on the outer portion of the planta slightly shorter); proleg on A10 with 22–25 biordinal crochets.

The shared D2 pinacula (dorsal saddle) on A9 and the presence of an anal comb immediately identified the larvae as Tortricidae. However, the trisetose SV-group on A7 and the separate D1 and SD2 pinacula on A9 are features more characteristic of Tortricinae than of Olethretinae, the subfamily to which the *Eccopsis* belongs. The larvae of only a few other Olethreutinae possess these typically tortricine characters (e.g., *Lobesia, Paralobesia*) (MacKay 1959).

Pupa. Obtect, fusiform, typically tortricoid, head without projection (Fig. 10). As in many tortricids, the pupa is initially green or greenish brown, becoming reddish-brown or dark brown as it matures. Labrum about half the length of proboscis. Proboscis extending just beyond prothoracic legs, approximately 1/3 of the length of the hind wing. Mesothoracic legs and antennal apices extending to about the middle of the A4. Hind wings terminating slightly before the posterior margin of the A4. Dorsum of segments A2–A8 with two rows of transverse spines; spines of anterior row conspicuously larger than those of the posterior row. Dorsum of A9 with a single row of spines near posterior margin. Genital cleft present on venter of A10; anal aperture present on A9 in males and on A8 in females. Cremaster poorly developed, with three pairs of hook-tipped setae.

Reproductive behavior. In the laboratory, adults began to emerge about 1100–1200 hrs. Newly emerged moths were relatively inactive, but by the second day, copulation was observed, usually between 0800 and 1100 hours, and lasting up to 1.5 hrs. In the field, adults were inactive during daylight, concealed in foliage or branches of the host trees. They usually became active at sundown and usually flew until sunrise.

Eggs typically were deposited individually or in pairs. When the moth population in the field was high, masses of 3–5 eggs could be found. A total of 190 eggs was collected in the field, and their locations on the leaves were recorded. Females preferred to lay eggs on the underside (80%) near the tip of the leaf rather than on the upper side.

Larval behavior. In nature, upon hatching, first instars begin to fold the upper surface of leaflets of the host. The characteristic shelters are conspicuous, facilitating identification of the location of the larvae. In some cases, larvae of *E. galapagana* are semi-gregarious, i.e., several first instars may share a leaf petiole, or second and third instars may share a pinna. Once the host leaves are folded, the larvae begin to feed on the surface of the leaf, damaging the tissue. Last instar larvae are the most voracious stage, making small holes in the leaves and, under severe infestations, totally defoliating trees (Figs. 11–16). However, they are always solitary.

7

FIG.7. Female genitalia of *Eccopsis galapagana*

In the laboratory, when larvae prepared to molt they produced a greater quantity of silk, strongly joining the leaves. The partially eaten remains of dry leaves are used to form a cocoon. Adjacent leaves unaffected by larval feeding also were used for constructing the

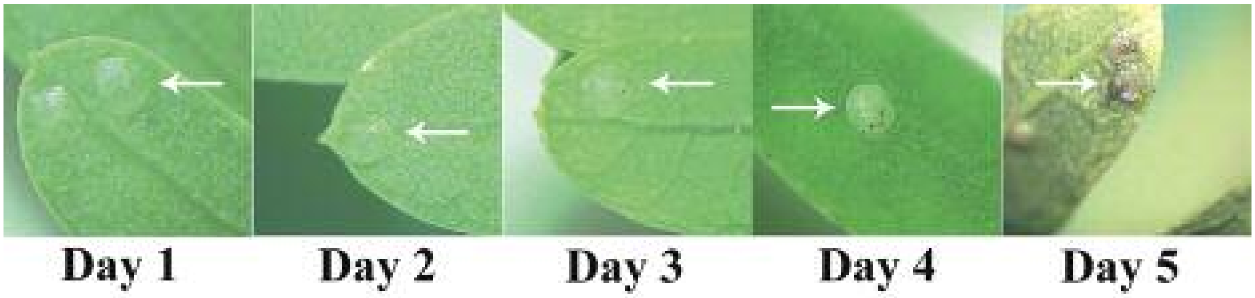


FIG. 8. Daily development of an egg of *Eccopsis galapagana.*

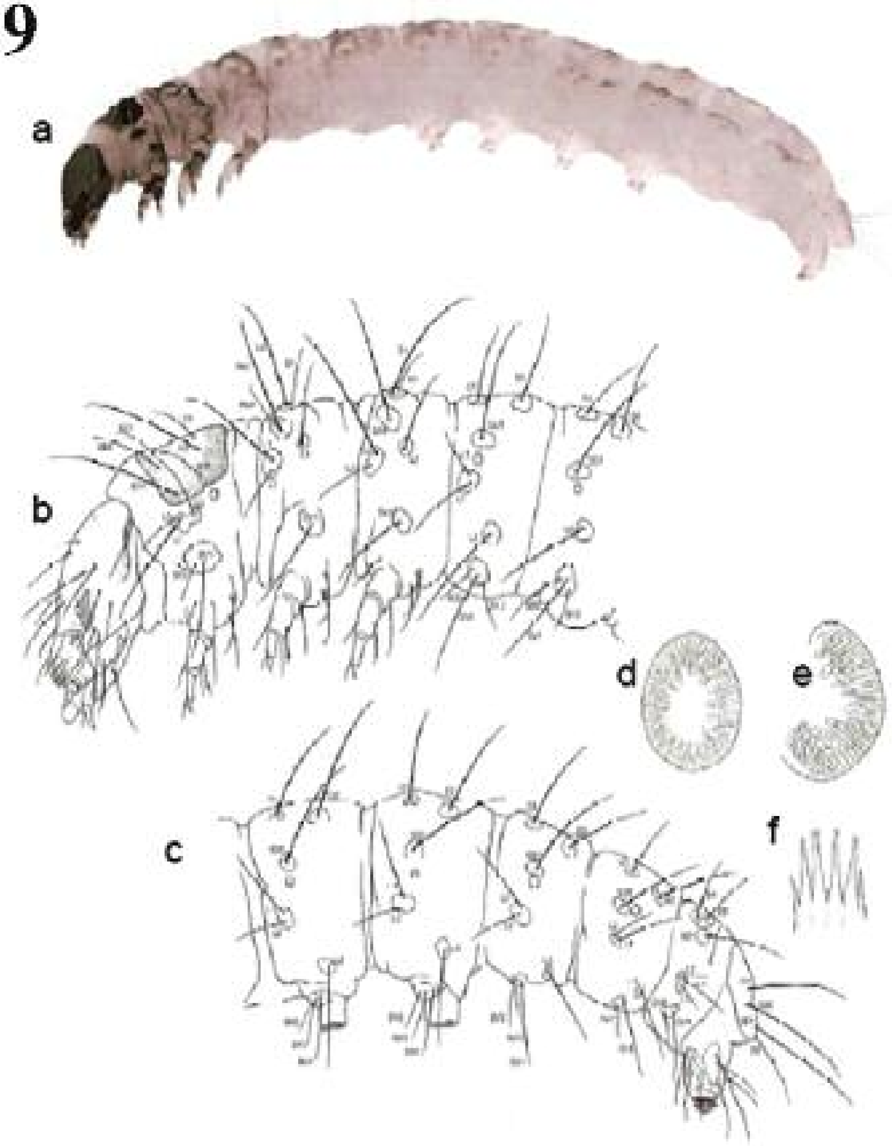


FIG. 9. Last instar larva of *Eccopsis galapagana*. **A)** Preserved larva. **B)** Chaetotaxy of head, thorax and abdominal segments 1 and 2. **C)** Chaetotaxy of abdominal segments 5–10. **D)** Arrangement of crochets on abdominal prolegs 3–6. **E)** Arrangement of crochets on abdominal proleg 10. **F)** Anal comb.

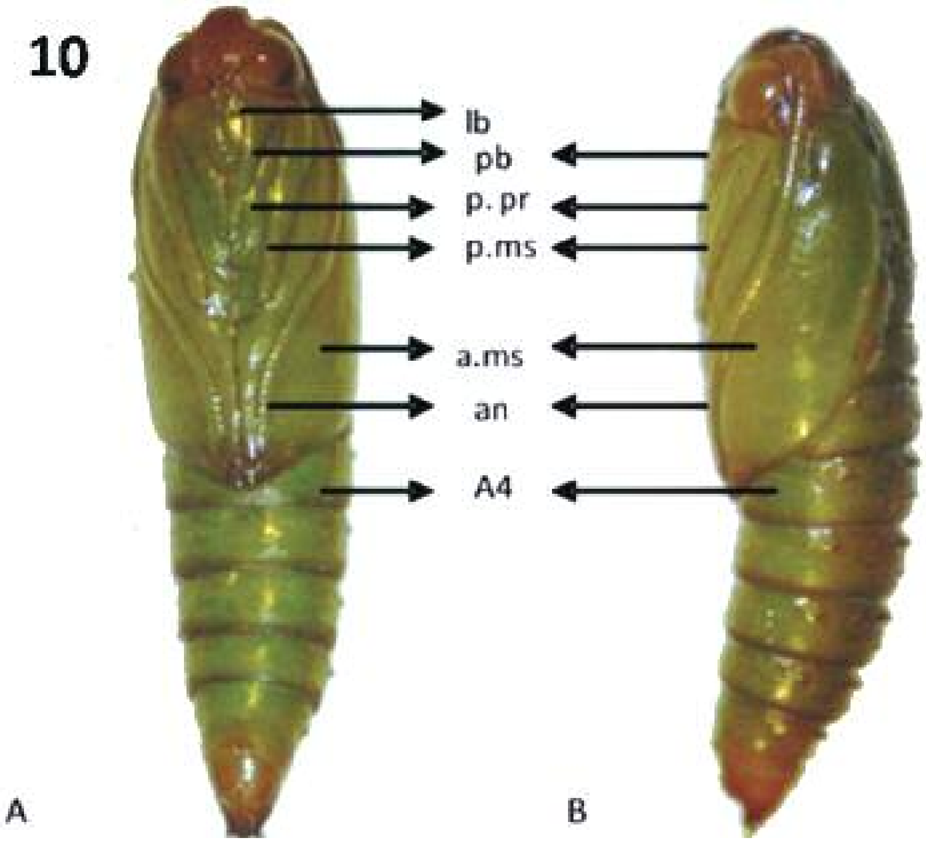
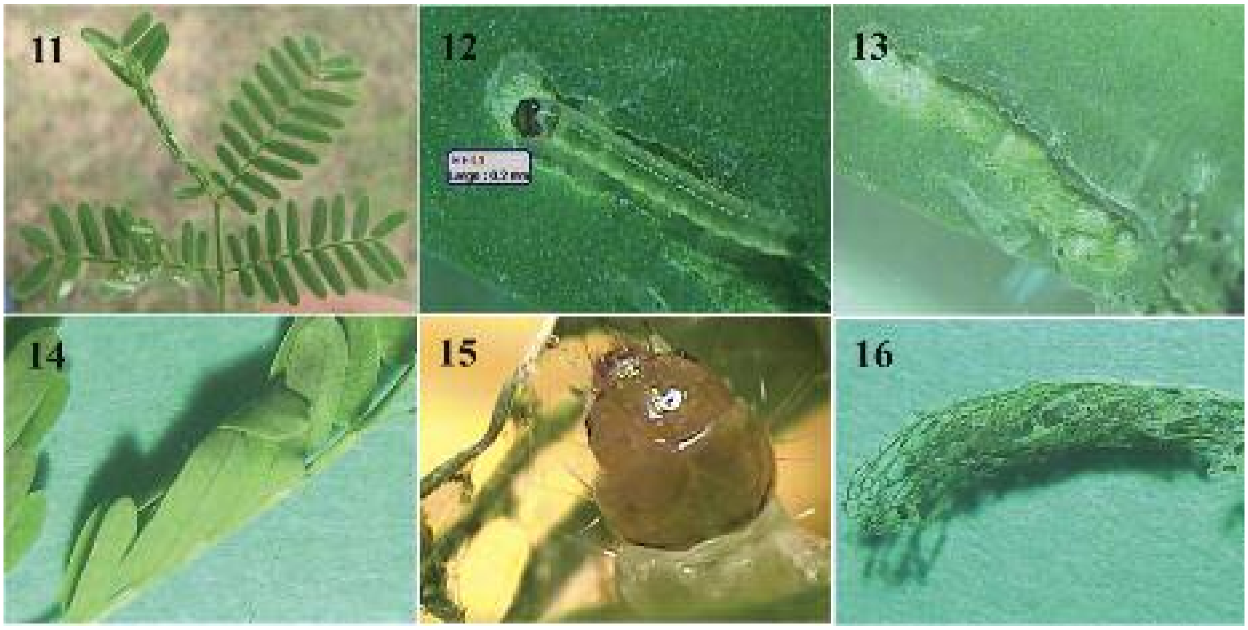


FIG. 10. *Eccopsis galapagana* pupa. **A)** ventral view. **B)** dorsolateral view (4X); labrum (lb), proboscis (pb), prothoracic leg (pr. p), mesothoracic leg (ms l.), mesothoracic wing (ms w.), antenna (an), fourth abdominal segment (A4).



FIGS. 11–16. Damage caused by larvae in the leaves of the *Prosopis juliflora*. First instar larvae (top), last instar larvae (below).

TABLE 1. List of the primary Hymenoptera parasitoids attacking *E. galapagana* in a *Prosopis silvopastoral* system in Colombia.

SUPERFAMILY	FAMILY	SUBFAMILY	GENUS
ICHNEUMONOIDEA	Braconidae	Orgilinae	*Orgilus* sp.
	Ichneumonidae	Chremastinae	
CHALCIDOIDEA	Trichogrammatidae		*Trichogramma* sp.
	Chalcididae	Chalcidinae	*Conura* sp.
			Brachymeria sp.
			Brachymeria spp.
	Eurytomidae		
	Eupelmidae	Eupelminae	*Anastatus* sp.
	Eulopidae		
	Pteromalidae		

cocoon, causing additional damage to the host foliage. Immediately following the last larval molt, the larvae were pale and remained practically immobile for the entire day.

Concluding remarks. *Eccopsis galapagana* joins *Ofatulena duodecemstriata* (Walsingham), *Cydia membrosa* (Heinrich), *Rudenia leguminana* (Busck), *Cryptophlebia carpophagoides* Clarke, and *Chileulia stalactitis* (Meyrick) as documented tortricid herbivores of *Prosopis* species in the New World (e.g., Ward et al. 1977; Brown & Passoa 1998; Komai 1999).

The record of *E. galapagana* in Colombia extends northward the known geographical range of this Neotropical tortricid species previously reported from Ecuador (Razowski et al. 2008) and northern Chile (Vargas 2011). Its prior "absence" from Colombia is explained more easily by our poor knowledge of the tortricid fauna of Colombia than as a newly discovered introduction. The presence of this potential pest may serve as a warning for those managing silvopastoral systems, which are expanding in the country. The fact that the larvae were capable of damaging large amounts of vegetative cover in *Prosopis* plantations may represent a control challenge. However, if pesticides prove ineffective or inappropriate in these systems, it is likely that conventional biological control, using primarily parasitoids, would provide an alternative and convenient approach because a remarkably high proportion of *E. galapagana* larvae collected in the field were parasitized by native Ichneumonoidea and Chalcidoidea (see Table 1).

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