FIRST RECORD OF LARVAL ENDOPHAGY IN EUILLINI (TORTRICIDAE):
A NEW SPECIES OF SETICOSTA FROM COSTA RICA

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ABSTRACT. Seticosta rubicula, new species, is described and illustrated from Costa Rica. The species is assigned provisionally to Seticosta on the basis of superficial similarities in other species in the genus (e.g., forewing length and pattern, long anal papillae in the male, and extremely elongate labial palpi in both sexes). The absence of long, strong setae from the costa of the valva in the male genitalia is the only character ruling this placement, and the species is assumed to be lost secondarily. Seticosa is assigned to Euillini on the basis of the shared possession of a uniquely derived feeding heartened in the male. Larvae of the new species are endophages feeders in the stem of Rubus spp. (Rosaceae), which represents a first reported case of gall-inducing or stem-boring in Rubus. Larvae also have been reported as borers in the fruit of Rubus. The early stages of S. rubicula, the first reported for the genus, are described and illustrated. They are unusual in the possession of several features more characteristic of other cuticular than of Rubus. The species has been recognized as a pest of quarantine significance by the Servicio de Agricultura, Costa Rica.

RESUMEN. Una nueva especie de mariposa nocturna, Seticosta rubicula, ha sido descrita e ilustrada desde Costa Rica. El ejemplar ha sido asignado provisionalmente al género Seticosta, basándose en similitudes superficiales con otras especies de este género, así como en caracteres de la genitalia. Algunas de estas similitudes son: longitud y el patrón de colores de las alas anteriores, clavos labiales extremadamente largos en ambos sexos, y presencia de un pénis de pelos en las píldoras anteriores de los machos. La ausencia de estos caracteres en la costa de la valva en los genitales del macho es la única característica que contradice esta ubicación taxonómica, y se asume que estas setas se perdieron secundariamente. El género Seticosta está asignado dentro de Euillini basándose en la presencia de un pénis de pelos distintos en las píldoras anteriores. Las larvas de esta nueva especie son formadoras de capullos en los tallos de especies de Rubus (Rosaceae). Los estudios tempranos de la Seticosta rubicula, primer registro para el género, son descritos e ilustrados. Estos son inusuales debido a la presencia de varios caracteres que son distintivos de otros géneros que no de Torticini.

Additional key words: Neotropical, systematic, Rubus spp., life history, pest species, Seticosta rubicula, taxonomy, parasitoid, Rubus new species, biological control.

Although endophagy feeding and gall-induction is not unusual in the subfamily Olethreutinae (Tortricidae), it is relatively rare in Torticini, where it is restricted primarily to the tribe Cechenini. Hence, it is fairly surprising that during investigations on gall-inducing Lepidoptera in Costa Rica, the second author discovered several species of Torticini causing galls in Rubus species (Rosaceae). One in particular, an undescribed species provisionally assigned to Seticosta, is especially unusual in its larval characteristics and other features. Larvae identical to these, and assumed to be conspecific, also have been intercepted by the U.S. Department of Agriculture’s Plant and Animal Health Inspection Service at U.S. ports-of-entry within the fruit of Rubus spp. from Guatemala. In addition, this species recently was identified as a pest of quarantine significance by the Ministerio de Agricultura, Costa Rica.

Food plants of the tribe Euillini, to which Seticosta belongs, were reviewed by Brown and Passoa (1965), who identified no previously recorded endophagus feeding species in the tribe. We take this opportunity to describe and illustrate this new species from Costa Rica, present details on the morphology of the early stages, and comment briefly on its unusual life history.

MATERIALS AND METHODS
Adults were borrowed from or examined at the following institutions: Instituto Nacional de Biodiversidad, Santo Domingo de Heredia, Costa Rica (INBio); Essig Museum of Entomology, University of California, Berkeley, California, U.S.A. (UCB); Museo de Insectos, Escuela de Biologia, Universidad de Costa Rica, San Jose (UCH); National Museum of Natural History, Smithsonian Institution, Washington, D.C., U.S.A. (USNM); and Victor Boeckh personal collection, Planaltina, Brazil (VBC). Dissection methodology follows that summarized in Brown and Powell (1961). Illustrations of genitalia are photographs of slide mounts taken with a SONY DSC-P2 digital camera and enhanced using Adobe Photoshop® and Adobe Illustrator® software. Forewing measurements were made with the aid of an ocular micrometer mounted in a Wild MZ. dissecting microscope under low power (×10-16). Terminology for wing venation and genitalic structures follows Honoka (1984), terminology for larval.
features follow Brown (1987). Abbreviations and symbols are as follows: FW = forewing; HW = hindwing; DC = discal cell; n = number of specimens examined; x = mean; ca. = circa (approximately); Est. = Estación; cf. = reared from.

Larvae were obtained primarily during field work conducted between February 2000 and June 2001, along dirt trails near La Georgina, Villa Mills (3000–3100 m) and Estación Biológica Cerro de la Muerte (3050–3100 m) at Cerro de la Muerte, Cartago and San José provinces, Costa Rica. The vegetation of the region is referred to as Tropical Montane Cloud Forest. During the dry season, which lasts from December/January through April, rain is infrequent, although humidity remains high, and dense fog is common in the afternoons. During the wet season, which lasts from April through November/December, heavy rains are common, average annual rainfall is 5819 mm. Daily average temperature is 10.3°C, but temperatures can be as low as −3°C during the dry season (Kappelle 1996).

During field work, individuals of various species of *Rubus* were examined for galls (e.g., larval frass and swollen parts of stems). When discovered in the field, some larvae, along with their galls and additional freshly-cut stress of the food plant, were placed in plastic bags and taken to the laboratory where they were either stored in an air-conditioned room (approximately 16–18°C) at Museo de Los Insectos, Universidad de Costa Rica, in San Pedro (1150 m) or placed in a refrigerator (6°C) and removed and kept at ambient temperature (approximately 25°C) for 8 hours each day. Other active galls were reared under field conditions in plastic bags at the station, where temperatures ranged from 11–18°C during the day and 1–3°C at night.

Examples of galls, larvae, and pupae were preserved in 75% EtOH and are deposited at the USNM and UCR. Adult specimens were pinned, and pupal shells were saved in gelatin capsules pinned along with the adult moths. Parasitoids were submitted to Michael Sharkey for identification.

**SYSTEMICS**

*Seticosta rubicola* Brown & Nishida, new species

(Figs. 1–8)

Diagnosis. In forewing pattern, *S. rubicola* is extremely similar to many other species of *Seticosta*, including *S. neobstens* (Meyrick) (Clarke 1958), *S. repugnans* (Meyrick) (Clarke 1958), *S. tridentis* Razowski, and *S. tabanomachata* Razowski. These species typically have a somewhat uniform tan, brownish, or reddish ground color, divided by a light subterminal fascia paralleling the termen, and a similarly colored diagonal submarginal fascia, extending outward from the costa. Additional external features that *S. rubicola* shares with other *Seticosta* are the extremely elongate labial palpi in both sexes, the long antennal elia of the male, and the male foreleg hairpinnell (presumably lost secondarily in related genera such as *Anopetillem Powell, Strephotonurus Brown*, and *Pseudocyclura* Brown). The male of *S. rubicola* lacks the dense patch of strong setate from the costa of the valva characteristic of all other species of *Seticosta*, and it is assumed that this character is lost secondarily. The male of the new species possesses a pair of lateral processes near the distal end of the uncus giving it a triruncate appearance, which appears to define a species group within *Seticosta* that includes *S. repugnans* (Clarke 1958), *S. tridentis* (Razowski 1988), *S. semicostata* Razowski, and one or more undescribed species. This character state is less developed or absent in other species such as *S. homonacta* (Meyrick) and *S. semicostata* (Meyrick).

Description. Adult. Male (Fig. 3). Head. Frons smooth-sided, pale cream; vertex slightly rugose; pale cream, labial palps extremely elongate, all segments combined ca. 2 times horizontal diameter of compound eye, pale cream on inner surface, pale cream scales tipped with brown on outer surface; antennal elia 4.5 times width of flagellomere. Proboscis present, presumably functional. Thorax. Forewing length 6.0–11.5 mm (n = 11), ground color brick red, with diffuse area of darker scaling near middle of wing; costa with short, irregular, transverse, white and brown striae; white fascia parallel to termen, overlain with yellow-green; a second white fascia with yellow-green overlocking extending outward from costa ca. 0.2 distance from base to apex; a small block of white with yellow-green overlocking at lower half of base of FW. Aforementioned fascia and basal blotch connected by narrow line along lower edge of FW, fringe brick red. Underside gastric: Head—white, with faint, pale gray motting; Abdomen—Somewhat shiny cream white; an indistinct brownish spot near middle of A3–7. Genitalia as in Fig. 1 (photograph of UCMB slide 12614: 5 preparations examined); Uncus bearing a pair of subdistal pointed processes, giving a triruncate appearance, each moderately short, digitate, sparsely setose; gnathidial hook weakly curved, without conspicuous terminal process at junction of arms; transversa moderately long, slightly narrowed and sclerotized near middle, where it bears microtrichia; valva thick, somewhat swollen, weakly lanceolate, with rounded apex, surculus weakly developed, confined to basolateral one-third of elia, cuneus weakly developed, confined to basolateral one-third of elia, large setae in ventral half beyond scutellum and at apical region, costa with basal exclamation bearing tiny setae. Aedeagus moderately small, slightly curved, at base distally, with rounded phallobase and protruding lobe at clitoral equator; cerci absent.

Female. Foreal Thorax. Essentially as described for male, except antennal elia unmodified (inconspicuous). Forewing length 9.0–11.5 mm (n = 10; n = 8). Abdomen—Essentially as described for male. Genitalia as in Fig. 2 (photograph of UCMB slide 5156: 12 preparations examined). Parathecium smaller, apophyses anteriores and posteriores elongate, posteroteres ca. 1.3 longer than anteriore; sternites slightly variable, either fully unmodified or with posterior edge bearing a pair of weak submedian sclerotizations; ovum extremely simple, not surrounded by sclerotizations; ovarium.
burseae moderately long, frail, slender at ostium, gradually widening anteriorly, with dorso of accessory burseae originating ca. 0.1 distance from ostium to junction with corpus burseae; corpus burseae somewhat rounded-triangular, with dorso seminalis originating in posterior third of corpus; corpus burseae with dense, extremely minute spines throughout.

Larva (Figs. 4–6). Based on two fourth instars and one third instar collected 9 May 2001, two second instars collected 11 April 2000, one fifth instar collected 30 May 2001, and two fifth instars collected 20 July 2001, at Estación Ecológica Cerrada de la Muela, Mpio. San José, Costa Rica. On Zumbro rubrofuscus (Dipt., Sph.) hybrid. General: Length 12–13 mm (Fifth instar only); head black (in early instars) to orange with conspicuous black genital and sternum patches (later instars): body maroon (paler in mature larvae of each stage), with moderately large, conspicuous, darker, brownish pinacoids, prothoracic and abdominal shields brownish yellow to reddish brown, with pattern of pale brown spots, integument strongly granular; spiracles medium-sized, rounded, those on T1 and AS larger than others. Thorax: Prothoracic shield with broad, transversely region immediately anterior of line formed by ND1, ND2, and SD1, 1-group transverse on T1, with pinacoid irregularly oblong, round, situated mostly ventral of spiracle, L1 roughly equidistant from L2 and L3, 3-group on T1–5 in 2:1:1, meta- and metaturnum weakly annulate dorsally, both segments with 1st annulation bearing an extra SD1 seta (+MD1), an extra pair of 1 setae (+MSD1, MSD2), an extra 2 seta.
Figs. 4-8. Larval chaetotaxy of Setocera radiata: 4, head and thorax, lateral view; 5, first and second abdominal segments, lateral view; 6, fourth and fifth abdominal segments, lateral view; 7, seventh, eighth, ninth, and tenth abdominal segments, lateral view; 8, seventh, eighth, and ninth abdominal segments, ventral view, anterior end at top.
(≥MV1), and an extra V seta on smaller, less conspicuous papulae. Ambulacrum: DI pinaculum usually with a deep notch at ventro-anterior margin; at least at AS-3 (sometimes on more segments); extra, tiny D seta (≥MV1) and V seta (≥MV5) situated near anterior edge of segments AI–A9; SD1 located dorsal to spine on AI–7, with tiny SD2 remote, ventro-anterior, usually without pinaculum. L1 and L2 on some enlarged pinaculum on AI–8. SD1 anterior of opisthobranch on AI; 132 setae scattered on common dorsal pinaculum on AS; D2 setae always on common dorsal pinaculum on AI; DI and SD on common pinaculum on AS; L-group tritostome on A9, usually with all setae on same pinaculum; SV-group on AI, L2-7, 9; 6 (2–3) 2–3 to 2–3; V setae on A9; twice further apart on AI than on A9; and combined, with small aster, could be ophioclad ( moda-2 radial circle; 22–30 (20) 22 to fourth instar) to 25–35 (25th instar) on peduncle on A3–4, 14–21 on A3 (extremely variable, mostly instar to instar).

Pupa (Fig. 9). Based on two preserved in alcohol and three cotypes, two females: Typically turriculate, fusiform, 7–5 to 6.5 mm in length, 2.1 to 2.3 mm in width. Head and thorax typical for the family, as described elsewhere (e.g., Henkel 1969). Venter with 2 dorsal spicules; A2 with double row of weak dorsal spines; A3–A8 with double row of spines, strong dorsal spines; segment A9 with four large dorsal thorns. Posterior end of abdomen blood-blackened,通讯员 absent. A thorax is a pair of posterior lateral thorns. Four long hooked setae on A9, two at posterior end, two posterior lateral.


Distribution. Setocosta rubicola is known primarily from the high elevations (2000–3100 m) in the central cordillera of Cartago, including the provinces of Cartago, Heredia, Limón, and San José. The majority of the specimens are from the vicinity of Cerro de la Muerte, a high elevation cloud forest. Based on a few specimens collected above and larvae observed at U.S. ports-of-entry on Rubus sp., the species also occurs in Guatemala.

Etymology. The specific epithet is derived from the association of the larvae with Rubus.

Remarks. The larva and pupa of Setocosta rubicola are the first reported for the genus. At least three characters of the larva are more typical of Ophryotrocha than Tortricinae: (1) the occurrence of SD1 and D1 on a shared pinaculum on A9; (2) a bistose SV-group on A7 (although it was tristose on one of eight larvae examined); and (3) SD2 on a pinaculum separate from that of SD1 on A1–8. The widely separated V setae on A9 are unusual for Tortricinae as well, although this condition is present in almost all Sparganothini (MacKay 1962) and Codhydrina. Other unusual features of the larva include the extra SD, L, and V setae on the meso- and metathorax; the extra D and V setae on A1–8; the noted D2 pinaculum of A2–5, characteristic.
of the Cryptophlebia-Etreptophila group of genera (Olethreutinae, Grapholithia) (Adamski & Brown 2001), and the position of the L. pinaculum on the prothorax, i.e., mostly ventral of the spiracle. Based on previous studies on the early stages of Eulini, it appears that both the "designer" and "tritricine" conditions of SD1+D1 on A9 occur in this tribe, i.e., either on a shared (olethreutine condition) or on separate pinaculum (tritricine condition). Both states are reported to occur in Pseudeola Oenotherae and Acanthes Olneminae (Brown & Powell 2000). The pupa of Seticosta rubricola, lacking a distinct cremaster and with fewer spines in the ventral rows, is also somewhat olethreutine-like and dissimilar to that of all other Eulini reported thus far (i.e., Acanthes Olneminae, Acanthes Olneminae, Chilodon Powell, Capromena Brown & Powell, and Dolorith Powell).

**Biology**

The eggs of S. rubricola are unknown. Larvae were discovered boring in stems of Rubus ulmarius (L.) and, more frequently, Rubus ulmarius, inducing a fusiform gall (Fig. 10). The size of larvae resulting from the latter species is ca. 5–6 mm wide and ca. 12–15 mm long; the stem width at the base of the gall is ca. 3 mm. Galls often were situated near or between nodes of young parts of the stems, with one to four galls per stem. A single larva was found on each gall chamber. At the base of the gall there is an opening (5–5 mm in diameter) from which the larva ejects frass, head capsules, and other debris (Fig. 10). Apparently this opening represents the point at which the larva enters the stem (Figs. 10–12); it is usually located at the base of a leaf petiole or a shoot axis, facing upward. The opening is characterized by a patch of larval frass and debris, including head capsules and bits of the plant tissue, all of which are attached by silk. The scraps of plant tissue are made by the larva excavating the stem and by larval regurgitation. Occasionally, some larval frass is retained within the gall chamber (Fig. 15). Within the galls of early instars there usually is a silk-lined sheath, woven with frass and bits of the plant tissue.

Dissection of galls on Rubus ulmarius revealed that the tissue surrounding the larval chamber is apparently parenchyma tissue. This tissue, upon which the larva feeds, is light green and consists of dome cells, resembling tissue in apical parts of the plants. In contrast, other parts of the stem were filled with white spongy tissue (Figs. 11, 13). The gall chamber was surrounded with irregular tissue (vulvalike growth) or irregularly constricted tissue. The surface of the gall chamber has a brownish tint (Fig. 15) and is loosely covered with silk. When galls of later instar larvae were cut open, the larva immediately began to seal the opening with silk, incorporating frass and debris. These galls were approximately 20 mm in length with a maximum radius of about 4 mm. In contrast, larval chambers of Seticosta rubricola on Rubus edwardsii reached a length of approximately 40 mm, although the swelling of the stem was less conspicuous than that of galls on R. ulmarius. The initiation of stem-boring can be detected by the presence of a small amount of frass near the stem apex (Fig. 12). The swelling or initiation of gall-formation can be detected less than two weeks after the initiation of boring.

When reared in plastic bags, immature larvae left the original galls and moved to the extra stems that were included in the bag. Larvae usually bored into the stems from the cut surface (Fig. 15). Three larvae completed development feeding on the stem tissue by boring (parenchyma and apparently some vascular tissues). Dense, tan silk (darker than the silk spun in the gall chamber) was present on the chamber floor. The larvae bored the stem continuously, resulting in chambers slightly greater than 4 cm in length (n = 15).

In response to probing with forceps, larvae regurgitated brown liquid. Larvae also often responded to "irritation" by moving the head and the caudal part of the abdomen up and down a few times for about two seconds.

We assume that under natural conditions pupation takes place outside of the gall chamber since pupae were found in some of the older galls. The pupae were discovered (n = 50). Under laboratory conditions, most larvae left their galls and pupated in the plastic bag without spinning cocoons (n = 7). However, one larva pupated inside the gall chamber, spinning a thin cocoon; two pupated in the split part of the stem, spinning cocoons with bits of the plant tissue (Fig. 15).

In the latter two cases, the larvae initially left the gall chamber, presumably for an appropriate pupation site (i.e., wandered around in the plastic bag), and finally returned to the gall or split part of the stem. This behavior suggests that the larvae were searching for a narrow or concealed space within which to pupate. Larval development from the beginning of the third instar to pupation took about 20 days in the refrigerator (n = 4); the pupal stage required about 35 days (n = 1).

Two specimens of a parasitoid wasp, Bracon or chrysalis Sharkey (Braconidae: Agathidinae), were reared from a larva of S. rubricola. An additional female of this parasitoid was captured while it investigated a larva on R. ulmarius.

The second author reared a single female of S. rubricola from cultivated blackberry (Rosa), Rubus pra

Ciprus L. H. Bailey, and larvae of \textit{S. rubicola} have been reported as a serious pest of this crop in Pérez Zeledón, Costa Rica (Ralph León pers. comm.). Parts of the stems where galls were present showed splitting tissues. Larvae identical to those from Costa Rica have been intercepted by APHIS at U.S. ports-of-entry on the fruit of \textit{Rubus} sp. imported from Guatemala. Hence, larvae occasionally may be responsible for damaging fruit as well as stems.

In general, gall-inducing species usually require a specialized food source (i.e., a specific part of gall tissue commonly called nutritive tissue) in order to com-
plete development (Deegre-Jailliet & Shortlehouse 1992). Based on gall structure and larval behavior, a ruibola may be a stem-borer behaving like a gall-inducer, or a gall-inducer behaving like a stem-borer. The swellings found on the stems of Rubus spp. probably are induced by the mechanical damage caused by larval feeding and/or silk deposition in the chamber. The densely spun silk in the stem chamber may indicate that larvae responded to non-regrowing stem tissue, tried to induce regrowth of the tissue, or the stem tissue did not dissolve the silk.

No species of Eudallia previously have been reported to have endophagous-feeding larvae. While some species are known to attack fruit (e.g., Prunus Clark, Chelieu Powell, Acoma Do nation Brown), larvae of these taxa are unknown (or are reported) to feed externally on the surface of the fruit. During the preparation of a systematic treatise of Asphodelaceae, Powell, a close relative of Serriola, we discovered a species in that genus that has been reared from the fruit of Strobilanthes (Strobilanthes) and a second species from a fleshy gall on Inga longipes (Fabeaceae). In addition, the closely related genus Apolyphora Ansell is reported to be fed on the seeds of pine cones (Pogge 1989, Brown & Paisna 1998). These limited data suggest the possibility that this shaft within Rubus may be adopted to internal or endophagous feeding, a unique adaptation within the Torricellinae, excluding Coccidina.

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