Immature Stages of *Scrobipalpula patagonica* Povolný, 1977 (Lepidoptera: Gelechiidae: Gnorimoschemini), a Gall Inquiline of *Suaeda divaricata* MOQ. (Amaranthaceae) in Argentinawith a Summary of Its Parasitoids

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IMMATURE STAGES OF *SCROBIPALPULA PATAGONICA* POVOLNÝ, 1977 (LEPIDOPTERA: GELECHIIDAE: GNORIMOSCHEMINI), A GALL INQUILINE OF *SUAEDA DIVARICATA* MOQ. (AMARANTHACEAE) IN ARGENTINA WITH A SUMMARY OF ITS PARASITOIDS

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Abstract.—Maps of the chaetotaxy and scanning electron micrographs supplement a text description of the larva and pupa of *Scrobipalpula patagonica* Povolný (Lepidoptera: Gelechiidae: Gnorimoschemini). *Scrobipalpula patagonica* is a gall inquiline of *Suaeda divaricata* Moq. (Amaranthaceae) in the "Monte" region of Argentina. The habitus of *S. patagonica* is provided along with images of the semiarid habitat of its host plant and associated gall. The parasitoids known to attack *S. patagonica* are summarized.

Key Words: chaetotaxy, fine structure, Ichneumonoidea

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Species of *Scrobipalpula* are generally gray or brown gelechiid moths, usually with a wing span less than 12 mm. Specimens are difficult to identify because of the subtle variation in coloration of the vestiture. Wing patterns are so similar among species of *Scrobipalpula* and related Gnorimoschemini that an accurate identification requires dissection of the genitalia and/or use of molecular technology. Povolný (1964) indicated that many *Scrobipalpula* differ from other Gnorimoschemini by the spatulate gnathos of the male genitalia and that this character may be a synapomorphy of the genus.

The Gnorimoschemini presently contain about 210 species among 20 genera worldwide (Huemer and Karsholt 2010). However, an estimate by Sattler (pers. com.) predicts the tribe may include more than 900 species and 40 genera worldwide. Presently, about 25% of the species within Gnorimoschemini belong to the genus *Scrobipalpula* of which more than half occur in the New World (Povolný 1991). Becker (1984) listed 19 species of *Scrobipalpula* from the

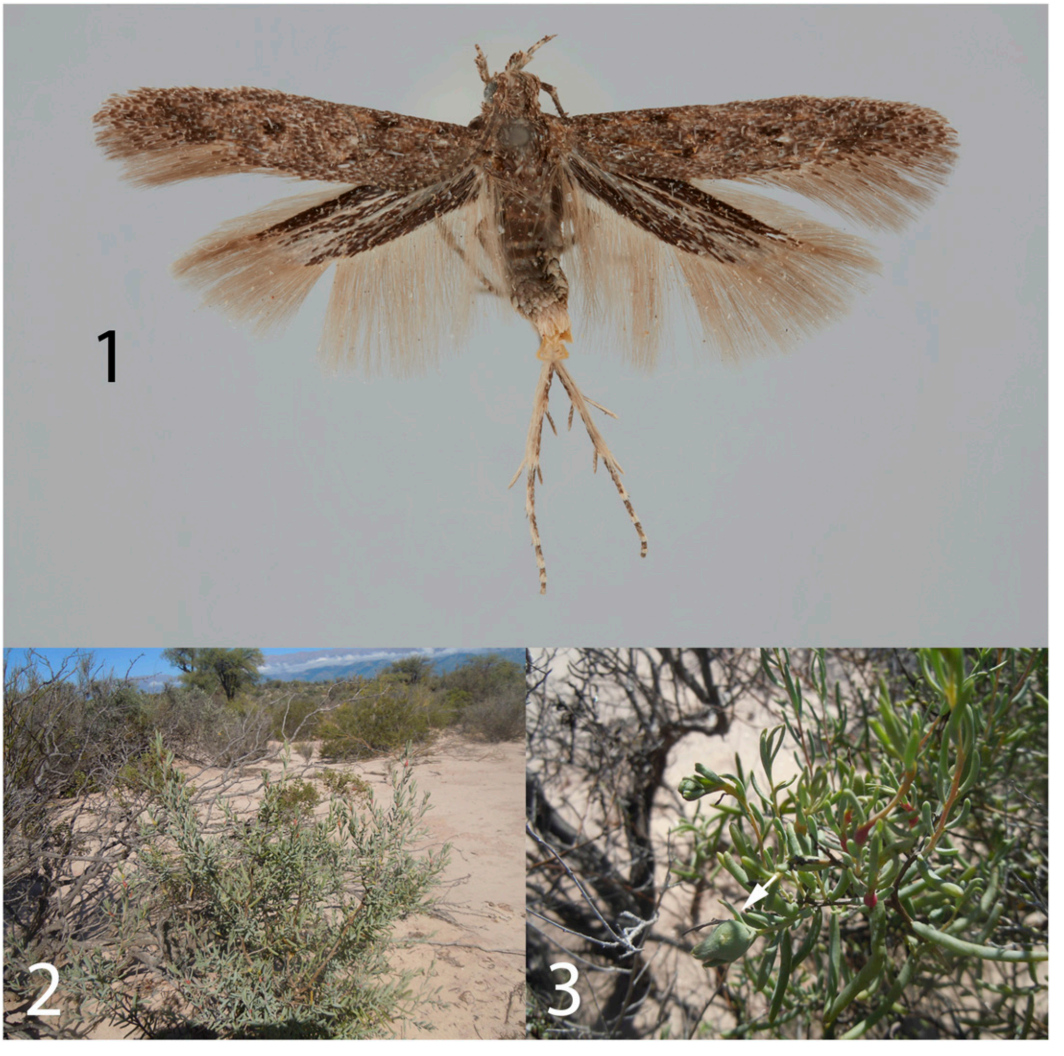
Neotropical Region, and Hodges (1983) listed 12 species from the Nearctic Region. Several species are known from the Palearctic Region, and none are known from sub-Saharan Africa, the Australian Region, or the Oriental Region, except from Nepal (Huemer and Karsholt 1998). Undoubtedly, more species remain to be described and studied.

Many species of *Scrobipalpula* are associated with Asteraceae. For example, larvae of a widespread species in the United States, *Scrobipalpula artemisiella* (Kearfott), and of a Palearctic species, *S. psilella* (Herrich-Schàffer), are known to tie terminal leaves together on *Artemisia* spp. Additionally, *S. psilella* feeds on other composites including *Aster* sp., *Gnaphalium* sp., *Centaurea scabiosa* L., *Erigeron acris* L., and *Helichrysum arenarium* (L.) Moench. Similarly, in Europe *Scrobipalpula seniorum* Povolný and *S. psilella* share the host *Centaurea*, but *S. psilella* also feeds on *Achillea ageratifolia* (Sm.) Boiss. *Scrobipalpula psilella* also shares a host with another European species, *S. diffluella*. Both feed on *Aster* spp., but larvae of the latter species also feed on *Erigeron* spp. and *Homogyne alpina* L. Finally, a European species, *S. tussilaginis* (Stainton), feeds on *Petasites* spp. and *Tussilargo farfara* L.

In western North America four species of *Scrobipalpula* appear to be specialists on their host plants. Of these species, three feed on Asteraceae and include: *Scrobipalpula antiochia* Powell and Povolný on *Senecio flaccidus* var. *douglasii* (DC) B.L. Turner and T.M. Barkley; *S. gutierreziae* Powell and Povolný on *Gutierrezia californicum* (DC) Torr. and A. Gray; and *S. manierreorum* Priest, a leaf-mining species, that is associated with *Eurybia macrophylla* (L.) Cass. Finally, *Scrobipalpula potentella* (Keifer 1936) feeds on *Potentilla californica* (Cham. & Schltdl.) Greene (Rosaceae) (Keifer 1936, De Benedictis et al. 1990).

Only five species of *Scrobipalpula* are known to feed on host plants other than Asteraceae: four are found in North America and one in South America. In North America, *S. lycii* Powell and Povolný feeds on *Lycium californicum* Nutt. ex A Gray (Solanaceae), *S. polemoniella* Braun feeds on *Polemonium reptans* L. (Polemonaceae), *S. lutescella* Clarke feeds on *Castilleja lutescens* (Greenm.) Rydb. (Orobanchaceae), and *S. potentella* (Keifer) feeds on *Potentilla californica* (Cham. & Schltdl.) Greene (Rosaceae). *Scrobipalpula patagonica*, the subject of this study, is the only known gall inquiline thus far reported in the genus and the only species associated with Amaranthaceae. *Scrobipalpula patagonica* (Fig. 1) is found in semiarid areas in the "Monte" region of Argentina (Fig. 2) and has been reared from ovate galls on the terminal branches of *Suaeda divaricata* Mequin-Tandon (Amaranthaceae) (Fig. 3). Gates et al. (2017) reviewed the gall inducers associated with *S. divaricata* and their parasitoids and inquilines in Argentina, including *Scrobipalpula patagonica*.

Although the tribe Gnorimoschemini includes economically important pest species, the chaetotaxy of their immature stages has received little attention. Setal maps of only a few gnorimoschemine larvae have been illustrated in detail. The only reliable chaetotaxal maps of larval Gnorimoschemini are those of *Phthorimaea operculella* (Zeller), *Keiferia lycopersicella* (Stehr 1987), and *Scrobipalpopsis solanivora* Povolny (Povolny 2004). Several detailed illustrations of pupal Gnorimoschemini are found in Patočka and M. Turčáni (2005).



Figs. 1–3. Adult of *Scrobipalpula patagonica* and habitat of host plant. 1, Habitus of *S. patagonica* collected at light from Argentina. 2, Specimen of *Suaeda divaricata* shown in a semiarid habitat in Argentina. 3, Gall induced by *S. patagonica* (note arrow) on terminal part of branch of *S. divaricata* in Argentina.

The purpose of this research is to describe in detail the larva and pupa of *Scrobipalpula patagonica*.

Materials and Methods

Morphological observations and measurements of larvae and pupae were made using a Leitz RS dissecting microscope with a calibrated ocular micrometer. For scanning electron microscopy, samples were taken from 70% EtOH and placed in distilled H_2O for 9 successive rinses in a 3 hr period (replacing the previous rinse with fresh distilled H_2O every 20 minutes). Samples then were placed in Formula 409® cleaner for 24 hrs. After several rinses of distilled H_2O, the samples were placed in increasing concentrations of EtOH (20, 40, 60, 80, and 100%), twice every 10 minutes, per each successive change of concentration. After dehydration in liquid, specimens were further dehydrated in a CO_2 gaseous state using a Tousimis critical point dryer. Dried samples were mounted onto Al stubs using carbon paste and placed into a LEICA EM ACE600 dual sputter coater and evaporator, which placed a 2 nm layer of carbon and an 8 nm layer of AuPd at a ratio of 80/20 onto the samples. Samples were viewed with a Philips XL-30 ESEM at an accelerating voltage of 16 kV, at a spot size of 2.5, and working distances from 8.5–11.0 mm.

Genitalia were dissected as described by Clarke (1941) except mercurochrome and chlorazol black were used as stains. The Methuen Handbook of Colour (Kornerup and Wanschner 1978) was used as a color standard when needed. Voucher specimens of reared adults and immature stages are deposited in the immatures section of the Lepidoptera Collection of the United States National Museum of Natural History, Smithsonian Institution, Washington, DC (USNM).

Results

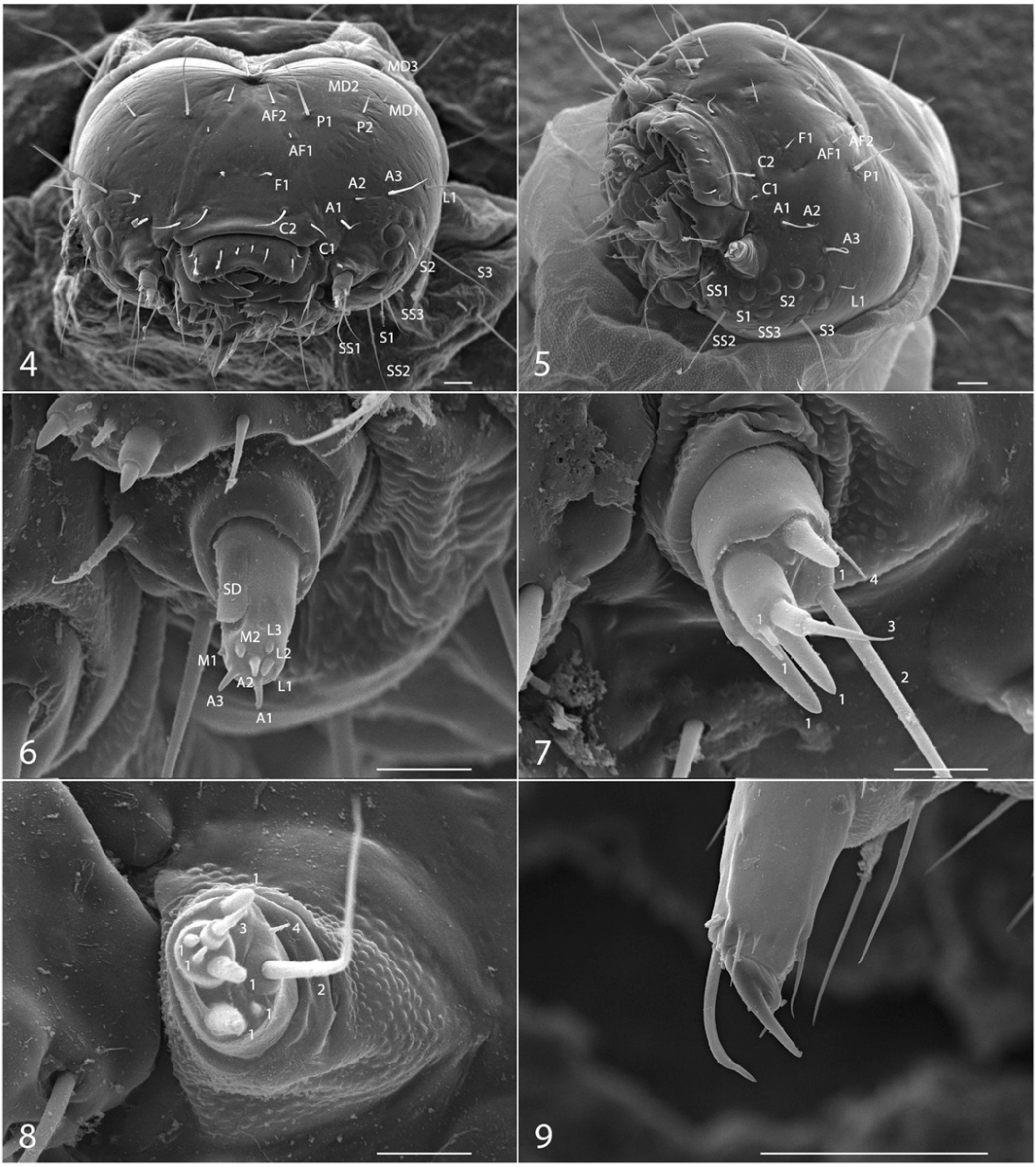
Larva.—Length 6.0–7.3 mm (n = 7). Body smooth, white or nearly so; head capsule brownish yellow; pinacula translucent, pale gray or without pigment; shield on T1 black posteriorly, gradually becoming paler anteriorly; anal plate translucent pale gray or without pigment. Spiracles on A8 about equal in size, slightly larger than spiracles on A1–A7.

Head (Figs. 4–8, 12): Hypognathous; epicranial suture short, bissecting afrontal sclerites apically; epicranial notch broad posteriorly, gradually narrowing to a sunken apex where adfrontal sclerites converge; epicranial notch deep, forming two laterally rounded hemispheres (Figs. 4–5); integument smooth, with few shallow wrinkles; adfrontal sclerites wide apicolaterally, gradually narrowed to lateroventral margin of clypeus; AF2 distal from apex of epicranial suture, above P1 and P2; distance between AF1 and AF2 about equal to distance between AF2 and convergent point of adfrontal sclerites; distance between F1 and AF1about equal to distance between F1 and C2; C2 longer than C1; P1 about 4X P2; P2 slightly above P1 and directly anterior to three MD setae; A3 above stemma-2, and A2–A1 dorsolateral to stemma-3; S3 beneath stemma-1, S2 between and beneath stemmata 2–3, and S1 between and beneath stemmata 5–6; SS3 beneath stemma-6, SS2 mesial to S1, and SS1 directly beneath antenna; labrum with 4 pairs of setae, two subequal pairs medially and two subequal pairs along lateral margin; mandible with 6 dentitions, bearing two subequal setae adjacent to base of condyle (Fig. 12); sensilla of maxillary palpus as in Fig. 6; sensilla of antenna as in Figs. 7–8.

Thorax (Figs. 9–10): T1 with L-group trisetose, setae on an obtriangular pinaculum, anterior to spiracle; spiracle in vertical line with posterior margin of shield; L1 beneath L2 and L3, about 3.0X longer than L2, about 4.0X longer than L3; L2 about 2.0X longer than L3. SV-group pinaculum ventroposterior to L-group pinaculum; SV1 slightly longer than SV2, beneath SV2; MV2 along anterior margin between L-group pinaculum and SV-group pinaculum. V1s, slightly posterior and between coxal sclerites, about 1/4–1/5 distance between V1s on T2-T3 (not shown). Shield with SD1 about 1/4–1/3 longer than XD2 and XD1, slightly posterior to both setae; distance between XD2 and XD1 about 2X distance between XD2 and SD1; SD2 proximal to (posteromesial), and about 1/4–1/5 length of SD1; D2 about 1/4 shorter than SD1, posterior to SD1 and XD1, forming a near equilateral triangle; D1 about 1/4 shorter than D2, in straight line perpendicular with median longitudinal body axis; D1 and XD1 in straight line parallel with median longitudinal axis. T2-T3 (Fig. 10): MD1 on dorsoanterior margin; D2 about 0.3X longer than D1, on same pinaculum; SD1 about 1/3X longer than SD2, on same pinaculum; D-group pinaculum in vertical line or slightly slanted, SD-group pinaculum in straight line; MSD1-MSD2 along anterior margin between SD-group pinaculum and L-group pinaculum; L1 about 2.5X longer than L2, on same pinaculum, slightly angled anteriorly, and directly beneath or slightly anterior to SD-group pinaculum, L3 about same length as L2, dorsoposterior to L-group pinaculum, and slightly anterior to SV1; SV1 about same length as D2 and SD1. MV1 along anterior margin slightly above SV1; V1s on T2-T3 as above (not shown). Apical end of all thoracic legs with a claw, a pair of subapical setae on ventral surface, and a large, downcurved seta on dorsolateral surface.

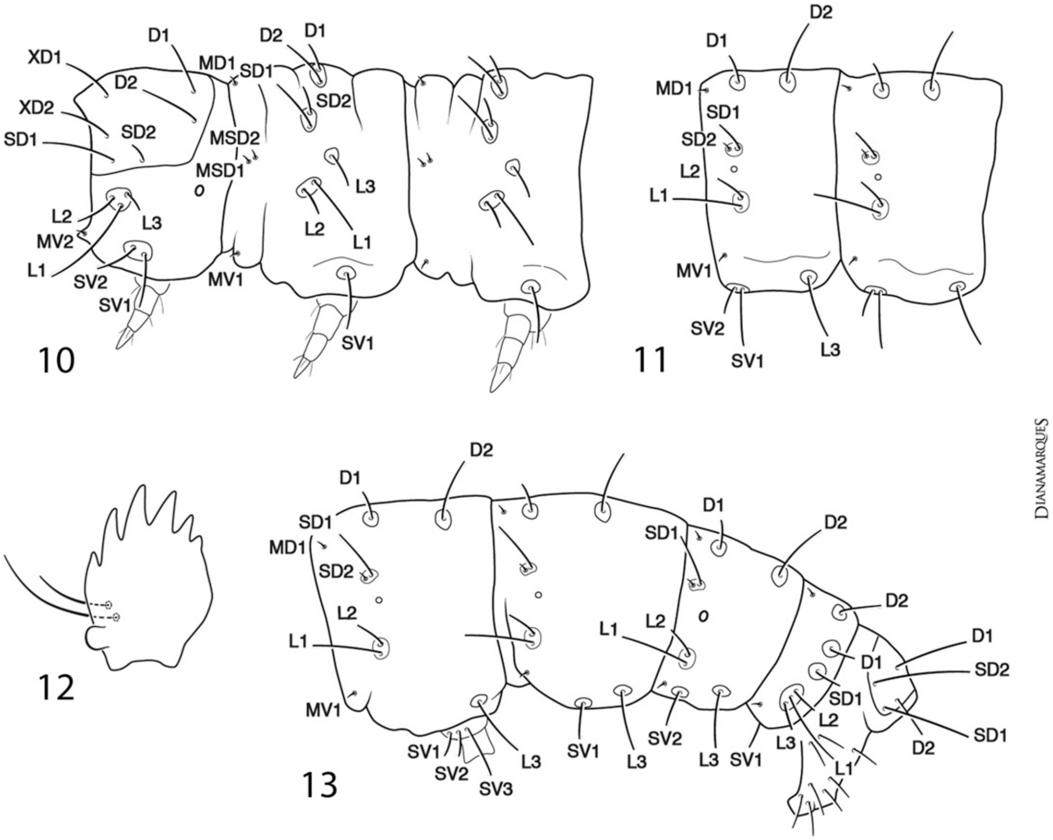
Abdomen: A1-A2 (Figs. 11, 14–15): MD1 along dorsoanterior margin; D2 about 2.0X longer than D1, on separate pinaculum posteroventral to D1; SD1 about same length as D1, posterior to spiracle on T2, slightly anterior to spiracle on T3; SD2 minute, anterior to SD1 pinaculum (Figs. 14–15); L1 about 2.5X L2, beneath L2, on same pinaculum; L-group pinaculum posteroventral to and nearly in straight line with SD1 on T1, slightly posterior to SD1 and closer to spiracle on T3; MV1 along anterior margin and slightly above L3; L3 posteroventral to L-group pinaculum and slightly posterior to D2; SV-group pinaculum bisetose, SV1 2.0X SV2; V1s about equidistant to V1s on T2-T3 (not shown). A3–A6 (Figs. 13, 16): microsetae as for A1–A2; D2 about 2.0X longer than D1; SD1 about equal in length to D2, above spiracle; L-group pinaculum beneath spiracle; L1 about 2.5X L2, L3 posteroventral to L-group pinaculum slightly posterior to D2; SV-group trisetose, SV1 about 2.0X SV2-SV3; prolegs protuberant, crochets in a circle, short and uniserial laterally, gradually lengthening, biordinal mesially; V1s as on A1–A2 (not shown). A7 (Fig. 13): as above except, L-group pinaculum slightly anterior to spiracle; SV-group unisetose, anteroventral to L3; and V1s slightly closer than on A3–A6. A8 (Fig. 13): as A7 except, SD1 slightly anterior to spiracle. A9 (Fig. 13): with all setae approximating a vertical line except, D2 slightly anterior, D2 about a third longer than D1 and SD1; D1 and SD1 about equal in lengths; L-group trisetose, on same pinaculum; L1 about 2.5X L2-L3. SV-group unisetose; V1s slightly closer than V1s on A8. A10 (Figs. 13, 17): SD1 about twice distance to SD2 than to D2; SD1 and SD2 about equal in length, and 2.0X the length of D2; D1 slightly shorter than SD1 and SD2, and slightly posterior to SD2s; V1s slightly farther apart than V1s on A9.

Parasitoids: One undetermined species each of *Apanteles* and *Chelonus* have been reported as parasitoids of *S. patagonica* on *S. divaricata*, and an undetermined species of *Bracon* was reported as a possible parasitoid (Gates et al. 2017). The species of *Bracon* and *Apanteles* may be *Bracon* (*Bracon*) *suaedicola* Kieffer and Jörgensen and *Cecidobracon asphondyliae* Kieffer and Jörgensen, respectively. However, as discussed by Gates et al. (2017), the type specimens for these species are lost, and the original descriptions are insufficient for unequivocal identification. While these are the only species of Ichneumonoidea associated with *S. patagonica*, eight species of Braconidae and seven



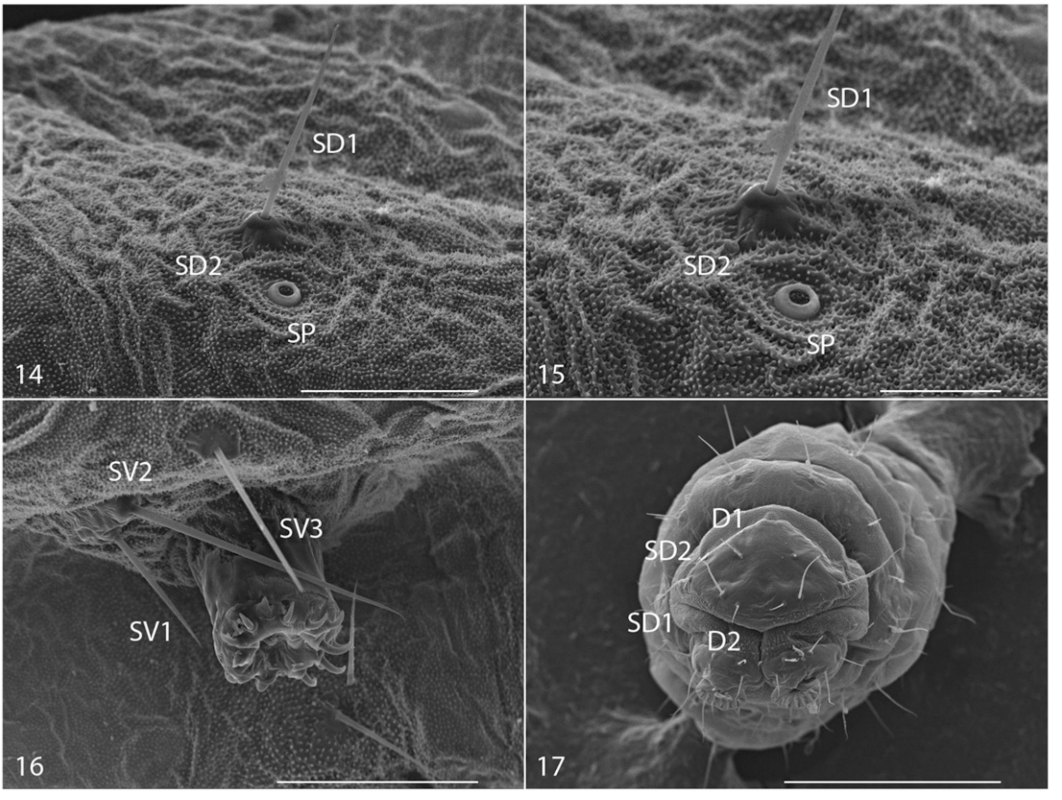
Figs. 4–9. Scanning electron micrographs of larva of *Scrobipalpula patagonica*. 4, Head, frontal view. Scale bar = 100 μm. 5, Head, ventrolateral view. Scale bar = 100 μm. 6, Apical sensilla on left maxillary palpus; A2= sensillum styloconicum; A1, A3, M1, M2, L1, L2, L3= sensilla basiconica; SD= sensillum styloconicum. Scale bar = 10 μm. 7, Apical sensilla on left antenna showing showing sensilla on basal and apical turrets (dorsofrontal view). 1= sensilla basiconica, 2= sensilla chaetica, 3= sensillum styloconicum, 4= sensillum trichodeum. Scale bar = 10 μm. 8, Sensilla on left antenna (frontal view). Scale bar = 10 μm. 9, Right leg on T2 showing large, downcurved subapical seta. Scale bar = 200 μm.

species of Ichneumonidae in the Neotropical Region have been reported from gelechiids currently or previously placed in *Scrobipalpula*, with most of them from *Tuta absoluta* (Meyrick) (Pacora 1978, Geraud-Pouey et al. 1997, Yu et al. 2012). Three of the braconids are species of *Bracon*; this suggests that the species



Figs. 10–13. Chaetotaxal maps and mandible of *Scrobipalpula patagonica*. 10, Thorax. 11, A1-A2. 12, Mandible. 13, A6-A10.

of *Bracon* in Gates et al. (2017) is capable of attacking *S. patagonica* but does not exclude the possibility that it might also attack the gall inducer *Asphondylia* (Diptera: Cecidomyiidae). One of the braconids, *Venanus kusikuyllurae* Rasmussen and Whitfield (Braconidae: Microgastrinae), has been reported from gelechiids on a species of Amaranthaceae (i.e., quinoa, *Chenopodium quinoa*) (Whitfield et al. 2011). Additionally, *Goniozus nigrifemur* Ashmead has been reported from *T. absoluta* (Uchoa-Fernandes and De Campos 1993); this supports the suggestion in Gates et al. (2017) that the former is a parasitoid of *S. patagonica*. *Horismenus* sp. and *Aprostocetus* sp. (Hymenoptera: Eulophidae) were also reported in (Gates et al. 2017). *Horismenus* was newly reported in (Gates et al. 2017) and the genus contains hundreds of species with Hansson (2009) treating over 400 from Costa Rica. Among known gall-associated *Horismenus*, one is known from a cecidomyiid and three from unidentified inducers, and the possibility exists that this species may be a hyperparasitoid. This specimen keyed to subkey F in Hansson (2009) but matched no species included therein. Our rearing yielded a male specimen that is clearly *Aprostocetus*, a genus that displays a wide host breadth, with many species associated with galls (LaSalle 1994). No keys to species exist for this region and combined

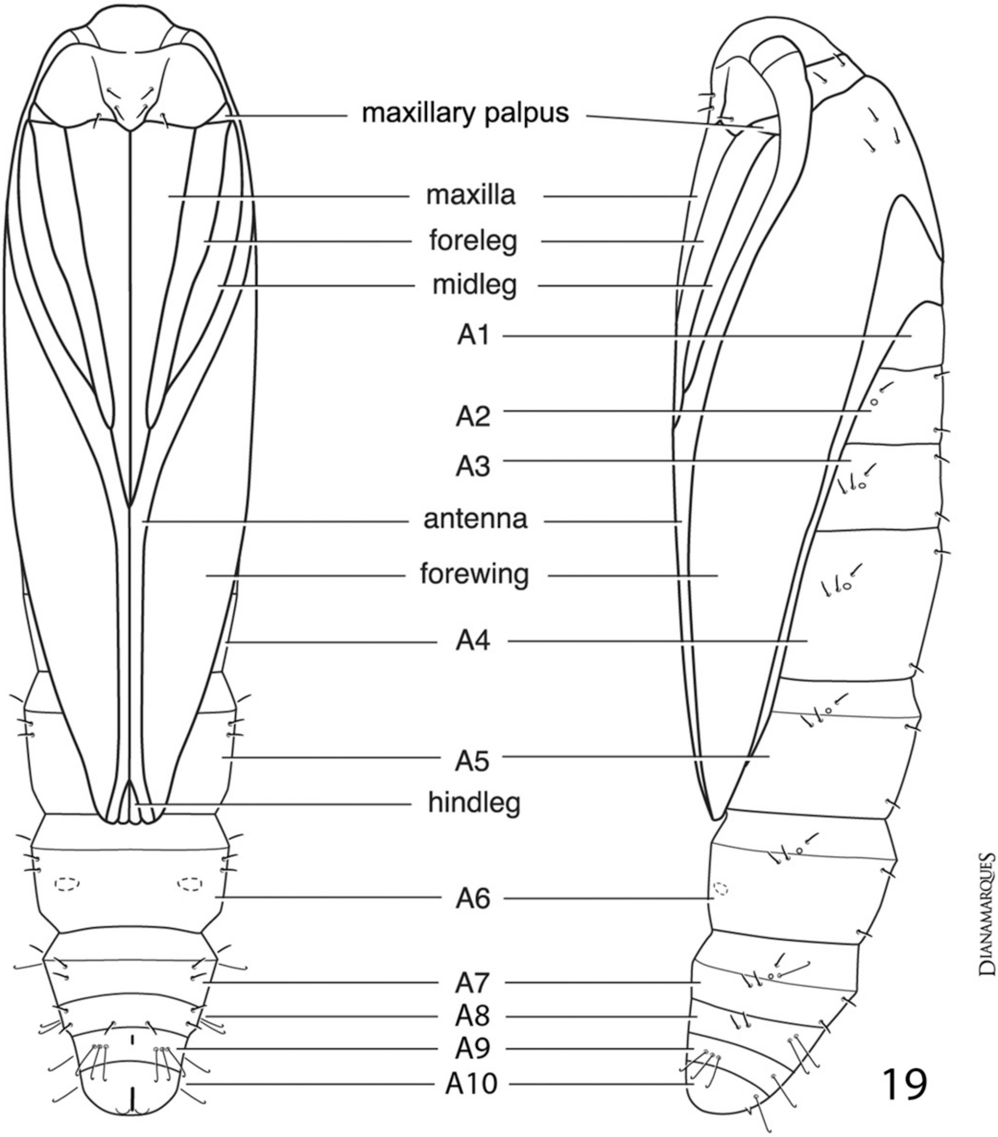


Figs. 14–17. Scanning electron micrographs of larva of *Scrobipalpula patagonica*. 14, SD1 and SD2 on A2 (left side). Scale bar = 80 µm. 15, SD1 and SD2 on A2 (left side, enlarged). Scale bar = 50 µm., SP= spiracle. 16, Left proleg on A3. Scale bar = 50 µm. 17, Anal plate. Scale bar = 100 µm.

with the loss of the Kieffer material make it impossible to identify. Given the broad host range and biology documented in *Horismenus* and *Aprostocetus* plus lack of isolated rearing, it is impossible to conclusively consider them as parasitoids of *S. patagonica*.

Remarks: Only two chaetotaxal maps of larvae of *Scrobipalpula* are available. Povolný (2004) illustrated *Tecia solanivora* (Povolný), which shows several fundamental differences between it and *Scrobipalpula*. On T1 of *T. solanivora*, Povolný illustrates a long SD2 on the shield, an L-group with three setae of equal lengths, and an SV-group with two setae of equal lengths. In *S. patagonica*, SD2 is much shorter, and the L-group and SV-group setae are all subequal. On T2-T3, Povolný illustrates all paired setae sharing a pinaculum nearly equal in lengths, an L3 near the posterior margin, and a short SV1. In *S. patagonica*, all setae sharing a pinaculum are subequal, L3 is slightly posterior to the L-group pinaculum near the middle of the segment, and an SV1 that is much longer. On a proleg-bearing abdominal segment, Povolný illustrates SD1 above the spiracle with SD2 missing, an L3 directly above the proleg, and an SV-group with three setae of equal lengths. In *S. patagonica*, SD2 is anterior to SD1, L3 is posterior to the proleg, and SV3 is longer than SV2-SV1, which are equal in length. Finally, on A9 Povolný illustrates an L-group with L2-L3 much longer than L1, whereas in *S. patagonica* the

18



19

Figs. 18–19. Sclerites and chaetotaxy of pupa of *Scrobipalpula patagonica*. 18, Ventral view. 19, Lateral view.

L-group has L1 much longer than L2-L3. Adamski et al. (2014) illustrated chaetotaxal maps for *Gnorimoschema shepherdiae* Priest. This species is a leaf-miner of *Shepherdia canadensis* (L.) Nutt. (Elaeagnaceae). And as with the illustration of *Tecia solanivora*, it too shows several fundamental differences from *Scrobipalpula patagonica.* For example, the larva of *S. patagonica* has semi-prognathus mouthparts, thoracic legs that are angled anteriorly, and body setae (especially the D-group and SD-group setae) that are shorter than in *S. shepherdiae*. These are most likely adaptational differences between two internal feeders, one a leaf-miner and the other an inquiline feeding within a gall.

In any case, these adaptations likely mask other larval features that may have potential in determining phylogenetic relationships among species and supraspecific taxa. Only more comparative examples given in the future will determine how these differences relate to species and supraspecific relationships.

Pupa (Figs. 18–19).—Length 5.2 mm (n=1). Body yellowish brown, smooth. Sclerites of antennae widely separated anteriorly, gradually convergent from beyond midlength of sclerites of foreleg, fused beyond posterior apices of sclerites of maxillae to slightly beyond posterior margin of A5, gradually divergent posteriorly, exposing distal part of sclerites of hind legs; paired nodular scars of prolegs on A6; A6-A10 fused, movable as a unit; spiracles slightly protuberant on A2–A7, not visible on A1, absent on A8; male gonopore near posterior margin of A9 (Fig. 18); A7–A10 with apically hooked setae on ventrolateral surfaces (Figs. 18–19); A10 with a short longitudinal slit demarcating anus, dorsoposterior surface with a small conical spinule; female unknown.

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