



Systematics, Morphology and Biogeography

Description and life history of a new cecidogenous species of *Palaeomystella* Fletcher (Lepidoptera, Momphidae) from Brazil



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ABSTRACT

Male, female, pupa, and last-instar larva of *Palaeomystella beckeri* (Moreira and Basilio) a new species from the Atlantic forest, southern Brazil, are described and illustrated with the aid of optical and scanning electron microscopy. Larvae induce galls on apical branches of *Tibouchina trichopoda* (DC.) Baill. (Melastomataceae) within which pupation occurs. Gall description and preliminary data on life history are also provided.

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Introduction

Palaeomystella was proposed by Fletcher (1940), to replace *Palaeomystis* (Meyrick, 1931) that was preoccupied at that time by the monotypic genus *Palaeomystis* (Warren, 1894) (Geometridae). Its taxonomic position remained uncertain until the study of Becker (1999), who associated it to the momphine lineage, as a subfamily of Coleophoridae. Recently, van Nieukerken et al. (2011) and Heikkilä et al. (2013) gave family status to this lineage, the way which it is treated herein, as Momphidae. The genus remained monotypic for long time, containing only the species type (*P. chalcopeda* Meyrick) until the study of Becker and Adamski (2008), when three new species were described: *Palaeomystella tibouchinae* (Becker and Adamski), *P. oligophaga* (Becker and Adamski), and *P. henriettiphila* (Becker and Adamski). Recently, in Luz et al. (2014), the description of three additional species was added: *P. fernandesii* (Moreira and Becker), *P. rosaemariae* (Moreira and Becker), and *P. tavaresii* (Becker and Moreira). Thus, *Palaeomystella* abridged seven recognized species that are restricted in distribution to the Neotropical region (Brazilian Cerrado and Atlantic forest). The genus is closely associated with the Melastomataceae, to which the larval stage of

all species is known to be gall inducer, with the exception of *P. chalcopeda* still uncertain regarding the life-history, since this species is known only by the adult female.

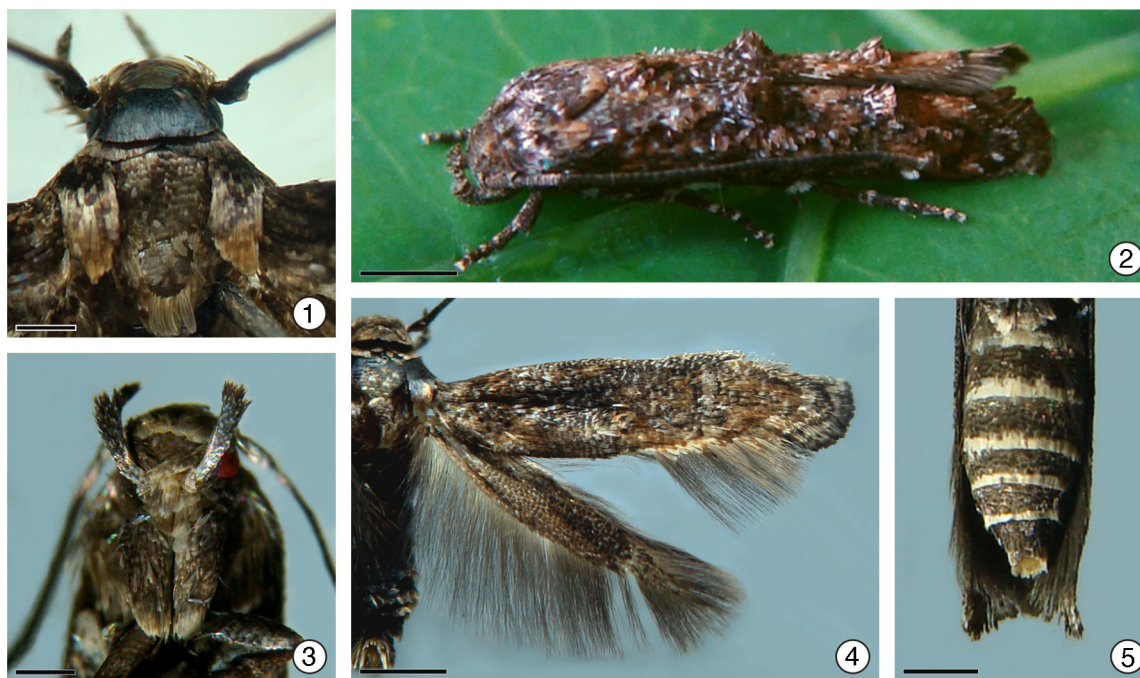
As pointed out by Luz et al. (2015), there are several species of *Palaeomystella* Fletcher waiting for description. Most are known up to now only by their gall morphotypes, which are mainly associated with *Tibouchina* Aubl. (e.g., Tavares, 1917; Houard, 1933). This is one of the most diverse genera within the Melastomataceae, especially in the Atlantic forest, where a majority of species are endemic (Goldenberg et al., 2012; Guimarães, 2014). Two of such undescribed *Palaeomystella* species were included in the molecular phylogeny study conducted by Luz et al. (2014). The aim of the present study is to describe the adults, pupa, larva and gall of one of them that is associated with *Tibouchina trichopoda* (DC.) Baill. The integumentary morphology of immatures stages for none *Palaeomystella* species is known at the ultrastructural level for the immatures stages. Thus, we also included herein a description of the larva and pupa under the scanning electron microscopy.

Material and methods

Specimens used in this study came from galls collected during March 2013 to August 2014 from a natural population of *T. trichopoda* (DC.) Baill. (Melastomataceae) existing at Coxilha das Lombas, Santo Antônio da Patrulha municipality, Rio Grande do

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Figs. 1–5. *Palaeomystella beckeri* adult: (1, 3) head and thorax, dorsal and ventral views, respectively; (2) resting female with wings folded, latero-dorsal; (4) spread right wings of pinned male, dorsal; (5) female abdomen, ventral. Scale bars = 0.2, 0.2, 1, 1 and 0.4 mm, respectively.

Sul State (RS), Brazil. They were either dissected or reared from galls either with feeding larvae or pupae inside that were maintained in small plastic vials under controlled abiotic conditions (14 h light/10 h dark; $25 \pm 2^\circ\text{C}$) at the Laboratório de Morfologia e Comportamento de Insetos, Departamento de Zoologia, Universidade Federal do Rio Grande do Sul (UFRGS), Porto Alegre city, RS.

Adults were preserved pinned and dried. The immatures were fixed in Dietrich's fluid and preserved in 75% ethanol. For descriptions of the gross morphology, the specimens were cleared in a 10% potassium hydroxide (KOH) solution and slide-mounted in either glycerin jelly or Canada balsam. Observations were performed with the aid of a Leica® M125 stereomicroscope. Measurements were performed with the aid of an ocular micrometer (precision = 0.01 mm).

Structures selected to be drawn were previously photographed with a Sony® Cyber-shot DSC-H10 digital camera mounted on the stereomicroscope. High resolution, light microscopy micrographs were obtained by using a Nikon® DS-U3 digital camera mounted on a Nikon® AZ100 M microscope, with the aid of the imaging software NIS-Elements. Vectorized line drawings were made with the softwares CorelDraw® and Photo-Paint® X6, using the corresponding digitalized images as a guide. At least five specimens were used for the descriptions of each life stage.

For scanning electron microscope analyses, additional specimens were dehydrated in a Bal-tec® CPD030 critical-point dryer, mounted with double-sided tape on metal stubs, and coated with gold in a Bal-tec® SCD050 sputter coater. They were examined and photographed in a JEOL® JSM5800 scanning electron microscope at the Centro de Microscopia Eletrônica (CME) of UFRGS.

Abbreviations of the Brazilian institutions from which specimens were examined are: DZUP, Collection Padre Jesus S. Moure, Departamento de Zoologia da Universidade Federal do Paraná, Curitiba, Paraná State (PR); LMCI, Laboratório de Morfologia e Comportamento de Insetos da Universidade Federal do Rio Grande do Sul, Porto Alegre, RS; MCNZ, Museu de Ciências Naturais, Fundação Zoobotânica do Rio Grande do Sul, Porto Alegre, RS; MCTP, Museu

de Ciências e Tecnologia da Pontifícia Universidade Católica do Rio Grande do Sul, Porto Alegre, RS.

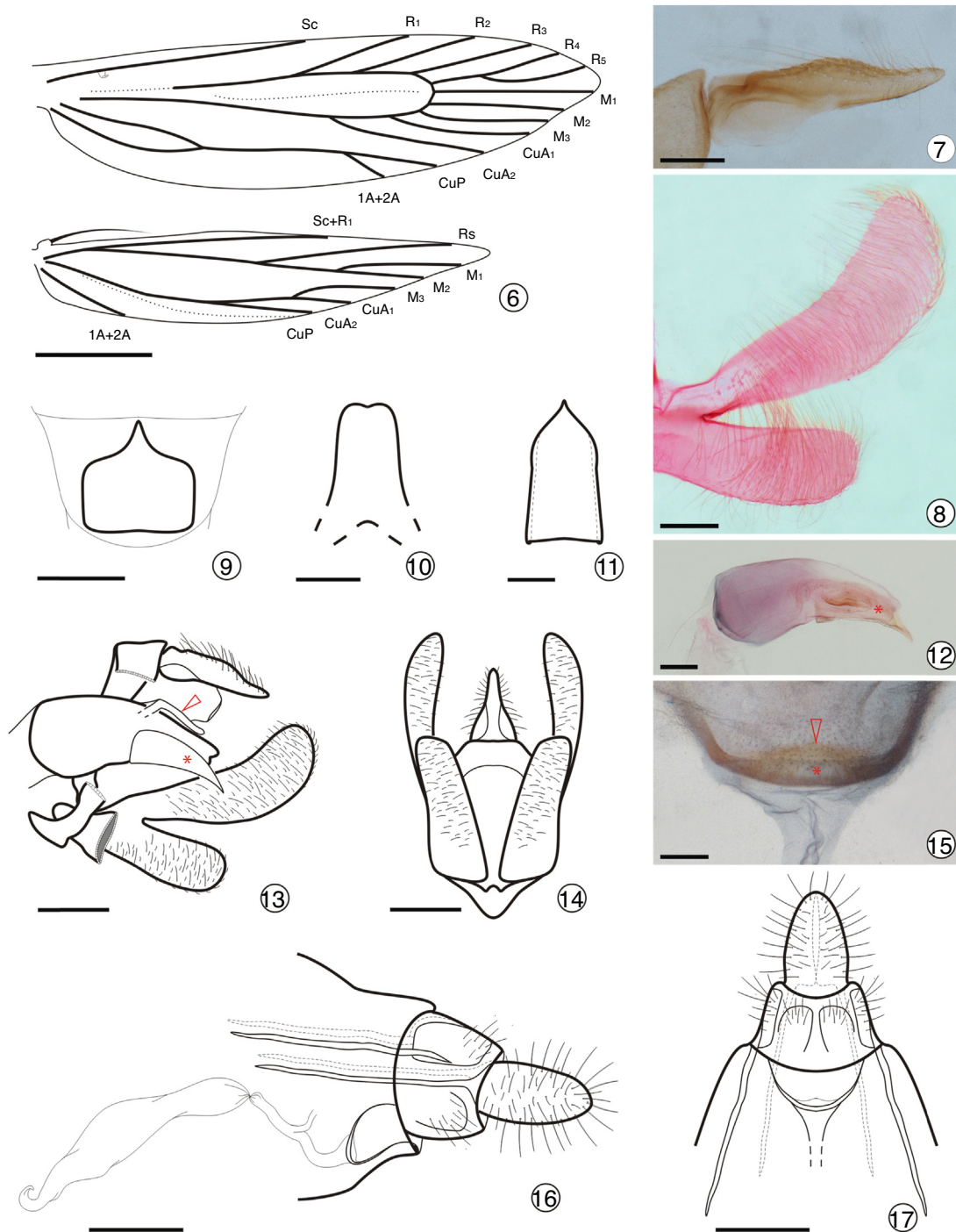
Nomenclature follows Stehr (1987) for the larva, Patočka and Turčani (2005) for the pupa, and Becker and Adamski (2008) for the adults.

Taxonomy

***Palaeomystella beckeri* (Moreira and Basilio), sp. nov.**
[*Palaeomystella* sp. 1, Luz et al., 2014: 101–102] (Figs. 1–49)

Diagnosis. Although showing congeneric affinity, *Palaeomystella beckeri* has morphological features that in conjunction distinguish it from all known *Palaeomystella* species. Adults are unique by having the posterior margin of abdominal segments white-colored and forewings with CuP vein completely stalked to 1A+2A. Also, galls are of globular type, woody, with external surface lacking conspicuous ornament, induced on stem of *T. tri-chopoda* branches. Wing color pattern of *P. beckeri* resembles those of *P. oligophaga* Becker and Adamski and *P. rosaemariae* (Moreira and Becker). In addition to the above characteristics, however, it differs from both species on shape of valvular sacculus that contrary to them is distally spatulate, and by female corpus bursae lacking signum, among other characteristics. Pupae of *P. beckeri* differ from those of these species by having cremaster short and tubular, curved ventrally and bearing two pairs of latero-dorsal stout setae.

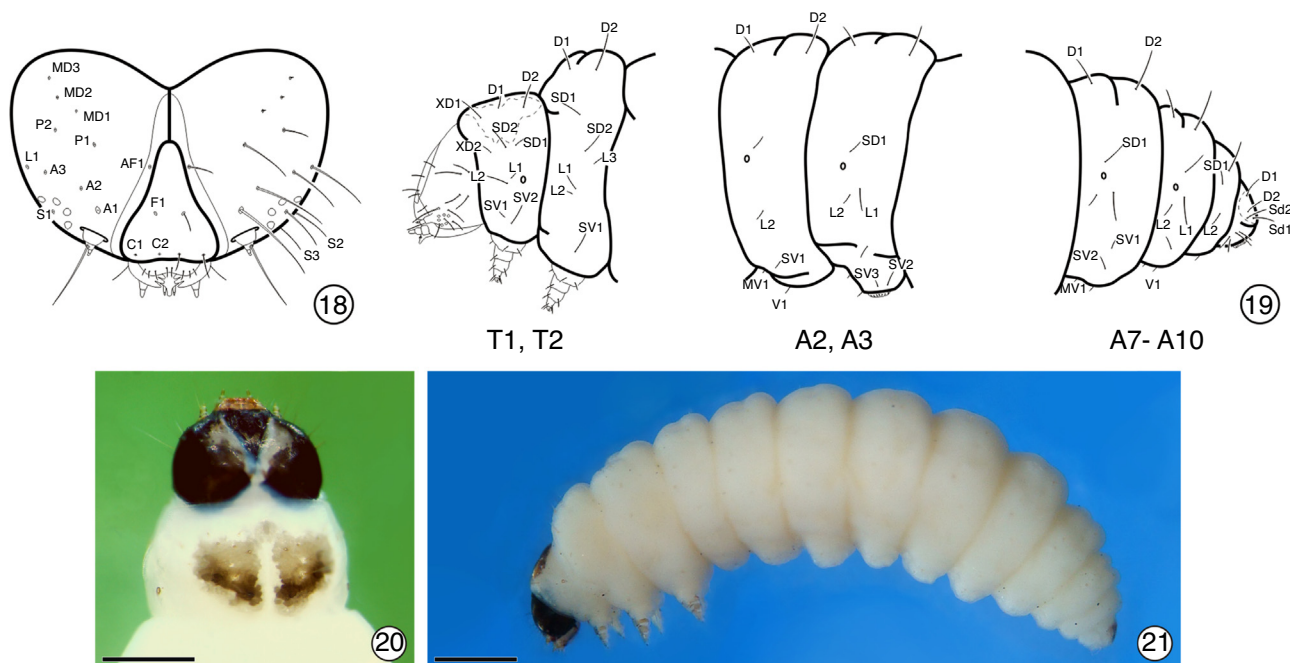
Description. *Adult* (Figs. 1–5). Sexes similar; males (wing length 5.07–5.33 mm; $n = 4$) generally smaller than females (wing length 5.72–6.24 mm; $n = 7$). Body mostly covered by dark-brown scales tipped with black, intermixed with dark-brown scales. *Head* (Figs. 1 and 3): Frons mostly dark brown; labial palpus with darkish scales tipped with pale brown laterally, and with pale-brown scales mesally; antenna darkish brown; labial palpus with basal segments angled laterally, terminal segment slightly angled upward; proboscis yellowish brown. *Thorax*: pronotum and tegula with dark brown scales tipped with black, posterior scales having more



Figs. 6–17. *Palaeomystella beckeri* adult morphology: (6) wing venation; (7) uncus, lateral view; (8) male valva, mesolateral; (9) male eighth sternum, ventral; (10) transtilla, dorsal; (11) juxta, ventral; (12) aedeagus with attached juxta (asterisk), lateral; (13) male genitalia, lateral (arrow and asterisk indicate transtilla and juxta, respectively); (14) male genitalia, ventral (transtilla, aedeagus and juxta are omitted); (15) female ostium bursae, ventral (asterisk and arrow indicate ostium bursae margin and adjacent semi-circular, melanized area of antrum, respectively); (16) female genitalia, lateral; (17) female genitalia, ventral (ductus and corpus bursae are omitted). Scale bars = 1 mm; 100, 100, 200, 100, 100, 100, 200, 200, 50, 250 and 250 μ m, respectively.

brown; legs mostly darkish brown, with distal margin of podites bearing creamy white scales. Forewing (Figs. 2, 4 and 6): lanceolate, with 13 veins; L/W index \sim 4.0; dorsally covered by dark-brown scales tipped with black, intermixed with dark-brown scales and scattered pale-brown scales; a narrow, ill-defined, blackish streak bisecting the wing longitudinally from base to tornus; a transverse faint band of pale brown scales ca. 1/3 from the wing apex; 3 raised scale tufts located posterior to cubitus, including 1 wider tuft in

anal area, 1 in line with midcell, and 1 near tornal area; tornal area with two bands of pale-brown scales tipped with black; ventrally, mostly uniformly covered with dark-brown scales; fringes dark brown. Retinaculum subcostal; discal cell closed, ca. 2/3 length of forewing, ending near 1/4 of wing distal apex; Sc ending ca. middle of anterior margin; R 5-branched; R1 ending near 2/3 of wing margin; R4 and R5 stalked ca. 1/3 distance from the cell apex; M 3-branched; CuA 2-branched; CuP stalked in most basal portion to



Figs. 18–21. *Palaeomystella beckeri* last larval instar: (18) cephalic chaetotaxy, frontal view; (19) thoracic and abdominal chaetotaxy, lateral; (20) head and prothoracic shield, dorsal; (21) body, lateral. Scale bars = 500 μ m, 1 mm, respectively.

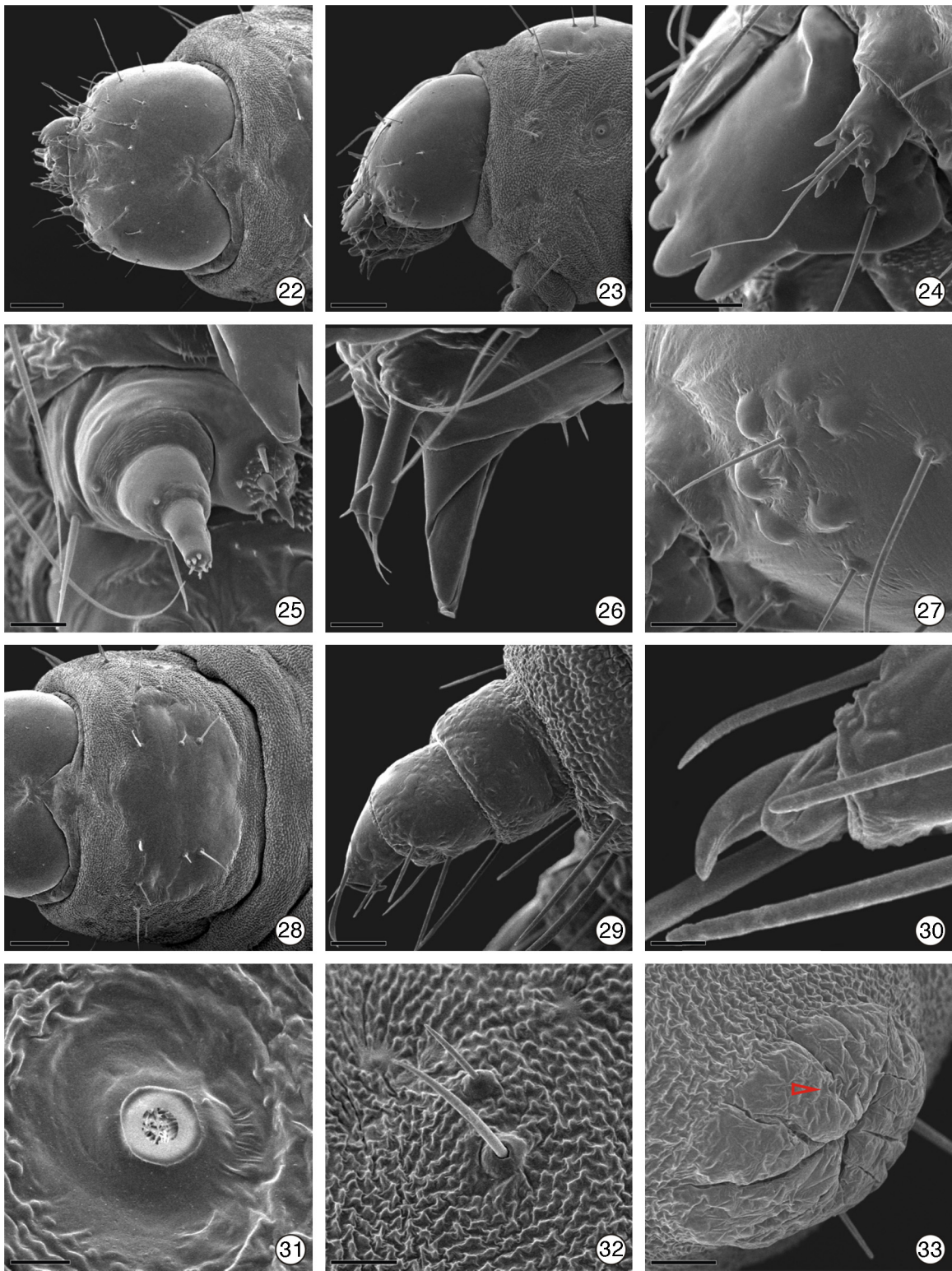
1A + 2A that is well developed, extending more than half length of posterior margin.

Hindwing (Figs. 4 and 6) strongly lanceolate, with 9 veins; L/W index \sim 5.1, \sim 0.8 forewing in length; scales dark brown on both sides; fringes dark brown; frenulum with a single acanthus in male, and with two acanthi in female, parallel to wing anterior margin; Sc + R1 ending at ca. 2/3 anterior margin; Rs ending at ca. 1/8 anterior margin; M 3-branched; CuA 2-branched, with CuA1 stalked to M3; CuP weakly sclerotized, ending at 2/3 posterior margin; 1A + 2A well developed, ending ca. 1/5 posterior margin. *Abdomen* (Fig. 5): dark, with creamy white scales on posterior margin of each segment; in sterna of males, these transverse bands are in general anteriorly expanded; eighth sternum (Fig. 9) anteriorly expanded medially into a slender, sharply pointed lobe, associated with a subretangular sternite.

Male genitalia (Figs. 7–14). Uncus narrow, subtriangular, roof-like, latero-dorsally setose (Figs. 7, 13, and 14); tegumen narrow, widened dorsally; vinculum widened ventrally; transtilla a subretangular, flat plate (Figs. 10 and 13); aedeagus tubiform, short (ca. twice as long as wide), curved ventrally, slightly wider basally (Figs. 12 and 13); vesica bearing several minute cornuti; juxta (Fig. 11) attached to distal portion of aedeagus (Figs. 12 and 13), longer than wide, with straight anterior margin and pointed distally; valva (Figs. 8, 13, and 14) covered with several long setae, divided near 1/4 from base, with flat, broad sacculus spatulate distad, and long, spatulate costa, tapered distally and gradually constricted toward base.

Female genitalia (Figs. 15–17). Papillae anales connected dorsally, setose (Figs. 16 and 17); anterior apophyses similar in size to posterior apophyses; sterigma divided into a bandlike tergum and a distally bilobed sternum, deeply emarginate medially; ostium bursae pear-shape, large, wider than long, bearing a fine, sclerotized distal margin (Figs. 15 and 17); antrum bearing a narrow, semi-circular, weakly melanized area adjacent to ostium margin (Fig. 15); ductus bursae membranous, ca. 1/2 corpus bursae in length; ductus seminalis inserted medially; corpus bursae an elongate sac, without signum (Fig. 16).

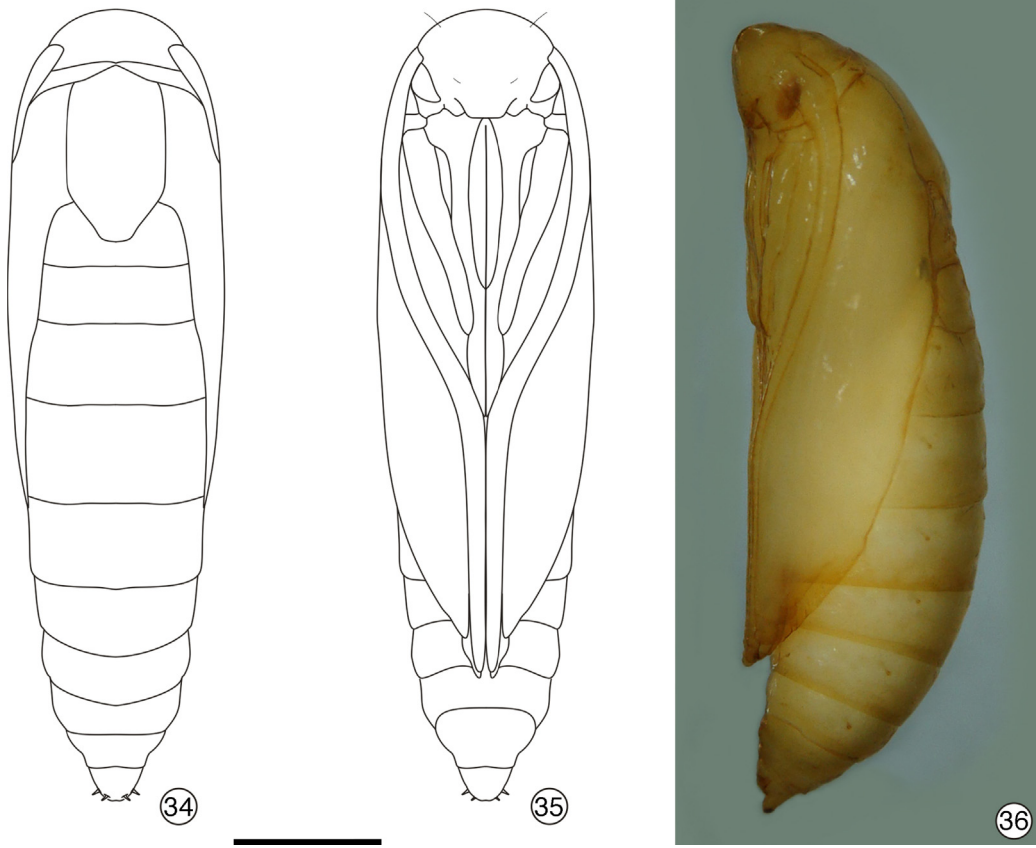
Last larval instar (Figs. 18–33). Body length = 5.2–8.06 mm ($n=4$). Cecidogenous, endophyllous, semiprognathous, and tissue-feeder. Body subcylindrical, creamy white, with setae well developed and covered with round-shaped micotrachia (Figs. 22, 23, 28, 32). *Head* (Figs. 20, 22–27): uniformly dark brown, with two paler, irregularly shaped, mid-dorsal areas associated to ecdysial line; with shallow ridges; labrum shallowly notched, bearing four pairs of setae; frons higher than wide, extending ca. 3/4 epicranial notch; six stemmata arranged in C-shape (Fig. 27). Chaetotaxy (Fig. 18): A-group trisetose; L-group unisetose; P-group bisetose; MD trisetose; C-group bisetose; F-group unisetose; AF-group unisetose; S-group trisetose. A1 and A2 about equal in length, the longest setae on head; C1, C2, S1–3, F1, AF1, A3, L1 and P1 intermediate in length; P2 shorter; MD1–3 very reduced and aligned with each other. *Antenna* (Fig. 24) two-segmented, with a long seta and five basiconic sensilla on the basal, stouter segment, and a short seta and two basiconic sensilla on the distal, smaller segment; mandibles broad with five teeth, and one seta on outer surface; maxilla prominent (Fig. 25); labium (Fig. 26) broad, with two-segmented palpus and spinneret parallel-sided; basal segment of the palpus long with a short seta on distal portion, and the distal one ca. ten times shorter, bearing a proportionally longer seta distally. *Thorax and abdomen* (Figs 19–21, 28–33): Prothoracic shield (Figs. 20 and 28) smooth, light brown with posterior region darker, and divided postero-longitudinally by indistinctly marked, unpigmented area; anal plate brown; spiracles (Fig. 31) circular, having moderately elevated peritreme; thoracic legs (Figs. 21, 29, and 30) slightly pigmented, with well-developed claws; prolegs on A3–A6 and A10 of equal size, with short planta; crochets (Fig. 33) reduced in size and in number, uniserial and uniordinal, lateral penellipse. *Thorax chaetotaxy*: T1 with D-group bisetose, both located on the dorsal shield, D1 shorter than D2; XD-group bisetose, XD2 shorter than XD1 and located laterally, outside the dorsal shield; SD bisetose, meso-laterally, close to the outside margin of the dorsal shield; L-group bisetose, L1 shorter than L2; SV-group bisetose, SV1 longer than SV2; V-group unisetose. T2 and T3 with



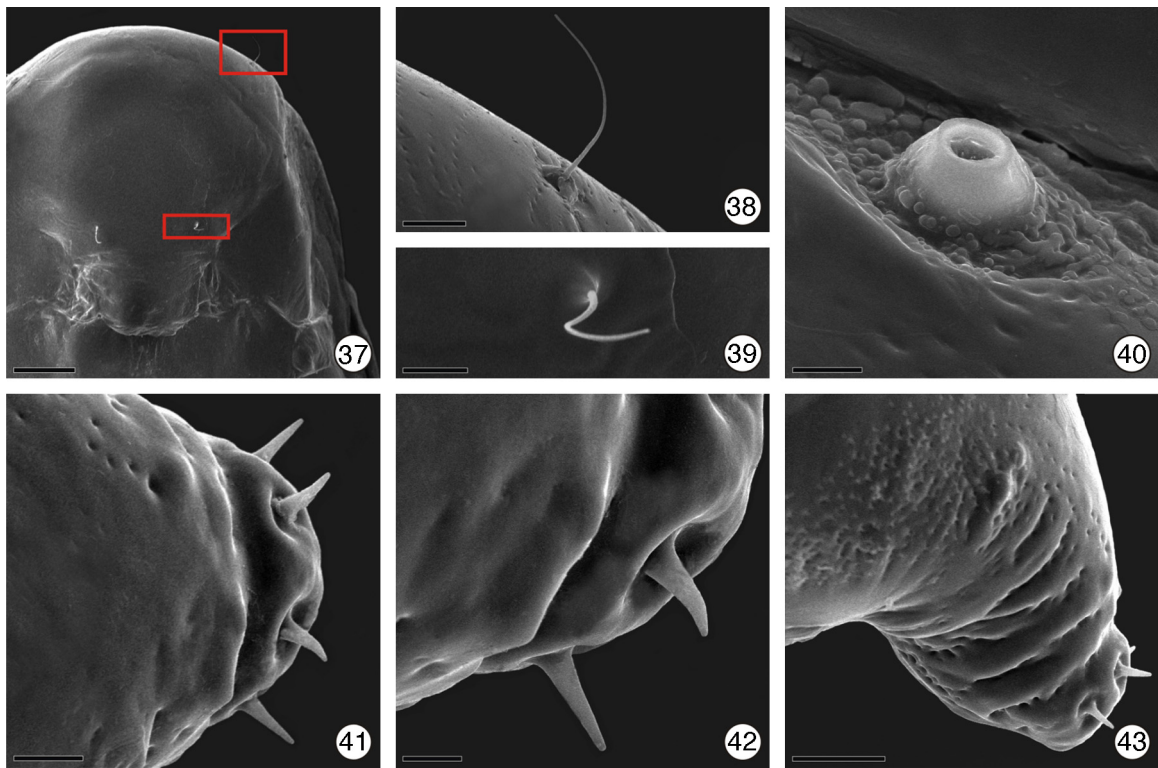
Figs. 22–33. Scanning electron micrographs of *Palaeomystella beckeri* last larval instar: (22) head, dorsal view; (23) head and prothorax, lateral; (24) labrum, mandible and antenna, lateral; (25) maxilla, lateral; (26) spinneret, lateral; (27) stemmata, lateral; (28) prothoracic shield, dorsal; (29) thoracic leg, postero-lateral; (30) tarsal claw, postero-lateral; (31) prothoracic spiracle; (32) prothoracic lateral setae; (33) pseudopodium on abdominal segment A3, antero-lateral (arrow indicates chochets). Scale bars = 200, 200, 50, 20, 20, 50, 200, 50, 10, 50, 50 and 50 μm , respectively.

D- and SD-groups bisetose, median-transversely aligned; D1, SD1 and SD2 similar in length and shorter D2; L-group trisetose, L3 posterior to L1–L2, similar in length to L2 and shorter than L1; SV unisetose; V unisetose. Abdomen chaetotaxy: D-group bisetose;

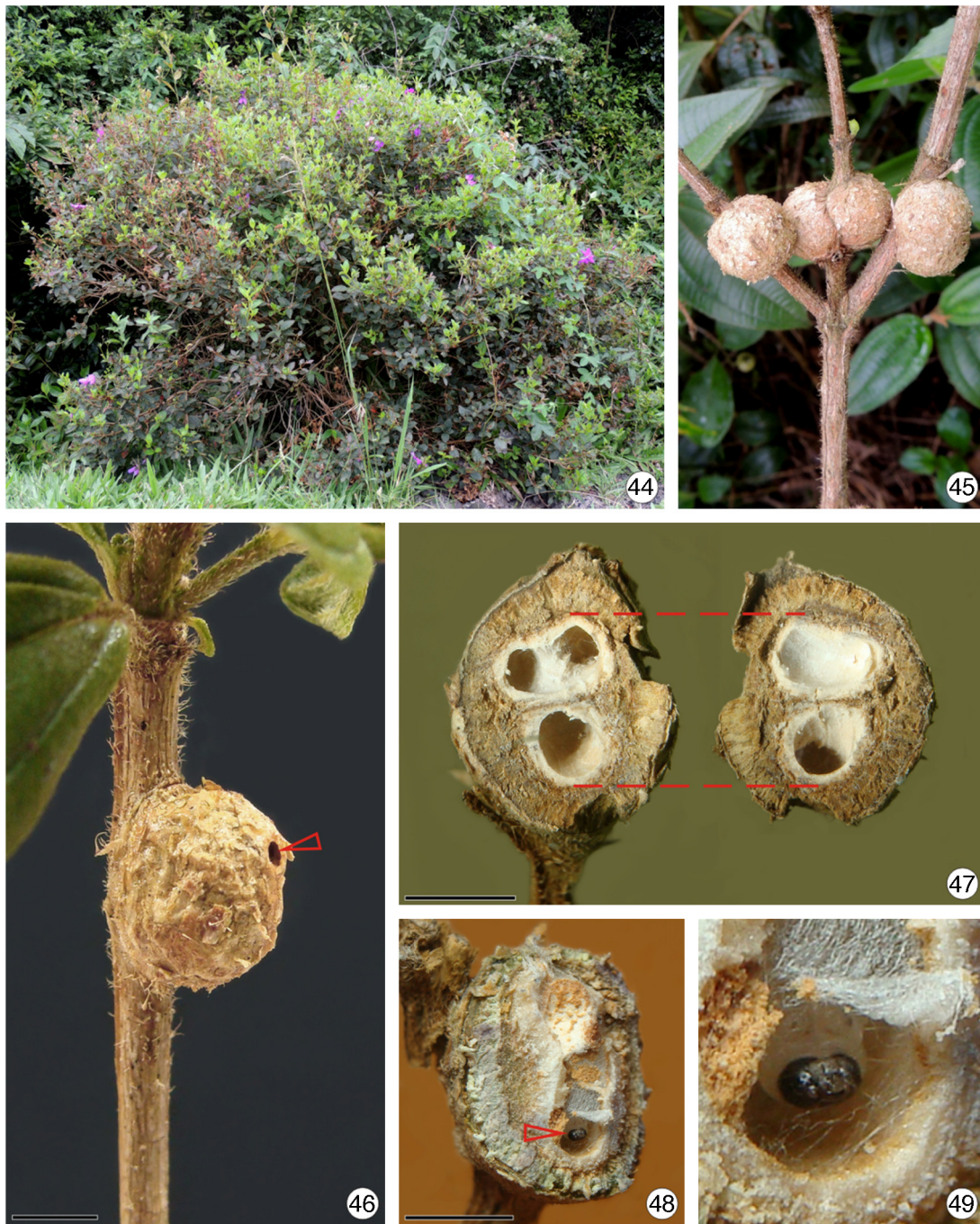
A1–A8 with D2 slightly longer than D1; A10 with D1 longer than D2; A9 without D1. SD-group unisetose in A1–A9, and bisetose in A10; A10 with SD2 slightly longer than SD1; L-group bisetose in A3–A8 and A10, L1 longer than L2; L1 absent in A1–2 and



Figs. 34–36. *Palaeomystella beckeri* pupa, in dorsal (34), ventral (35) and lateral (36) views, respectively. Scale bar = 1 mm.



Figs. 37–43. Scanning electron micrographs of *Palaeomystella beckeri* pupa: (37) head, ventral view; (38, 39) cephalic setae, on frons and clypeus, respectively (enlarged areas in A); (40) spiracle on abdominal segment A3; (41, 42) cremaster, in dorsal view (41), apical process in detail (42) and lateral view (43). Scale bars = 200, 25, 20, 20, 20, 10 and 50 μ m, respectively.



Figs. 44–49. Life history of *Palaeomystella beckeri*: (44) host-plant [*Tibouchina trichopoda* (DC.) Baill. (Melastomataceae)]; (45) galls on *T. trichopoda* branch; (46) gall in detail, showing exit orifice (pointed by arrow); (47) middle sectioned gall, showing larval chamber; (48) dissected gall, showing last-instar larva weaving cocoon; (49) detail of area pointed by arrow in (48). Scale bars = 5 mm.

A9; SV-group unisetose in A1, A2, A8 and A9, trisetose in A3–A6 and A10, bisetose in A7; SV1 and SV3 similar in length, shorter than SV2; group-V unisetose in A1–A9; group-MV unisetose em A1–A8.

Pupa (Figs. 34–43). Length = 5.46–6.63 mm ($n = 7$). Obtect, body elongate-oval in dorsal and ventral views, slightly wider in thoracic region. Integument light amber, weakly melanized, mostly smooth, with two pairs of cephalic setae, on frons (Figs. 37 and 38) and clypeus (Figs. 37 and 39); frontoclypeal suture not evident. Labrum U-shaped; labial palpi long; antennae arched anteriorly and separate, approximate and parallel posteriorly to distal margins of maxillae, surpassing apical margin of forewings; maxillae

extending distally between sclerites of mid-legs; femora of midlegs not fused distally; femora of forelegs extending beyond widest part of labial palpi. Abdominal spiracles (Fig. 40) with elevated peritreme. Cremaster (Figs. 41–43) short, tubular, ventrally curved and apically rounded, bearing two pairs of stout setae on distal margin; one latero-dorsally, another laterally.

Type material. Holotype ♂: Brazil: private farm belonging to Antonio Malta, Coxilha das Lombas, 30° 02' 13" S; 50° 36' 30" W, 17 m, Santo Antônio da Patrulha, RS, Brazil. Pinned-dry preserved adults, reared from galls induced on *T. trichopoda* (DC.) Baill. (Melastomataceae), LMCI 273, 14.VII.2014, G.R.P. Moreira and S. Bordignon, (LMCI 273-13), donated to DZUP (32.985). Paratypes: same data,

LMCI 229, 30.VII.2013, by G.R.P. Moreira, B. Santana and S. Bordignon; 1♂ (LMCI 229-14), 2♀ (LMCI 229-23 and 273-12), donated to DZUP (32.986, 32.987 and DZ 32.988, respectively); 2♂ (LMCI 229-13 and 273-11), 1♀ (LMCI 229-22), donated to MCNZ (81.907, 81.908 and 81.909, respectively); 2♂ (LMCI 229-35 and 36), 1♀ (LMCI 229-21), donated to MCTP (44869, 44870 and 44871, respectively).

Other specimens examined. Dry preserved pinned adults, with the same collection data, LMCI 211, 12.III.2013, by G.R.P. Moreira, F.A. Luz and S. Bordignon, deposited in LMCI under the following accession numbers: 4♂ (LMCI 229-9 to 12); 9♀ (LMCI 229-15 to 18, 24, 25, 34; LMCI 273-8 and 50). Slide preparations, mounted in Canada balsam: genitalia, 10♂ (GRPM 50-72 to 74, 77, 78, 81, 82, 85 to 87), 8♀ (GRPM 50-75, 76, 79, 80, 83, 84, 88, 89); wings, 2♂ (GRPM 50-73 and 77), 2♀ (GRPM 50-75 and 76); larvae, 2 last-instars (GRPM 50-90 and 91). Adult abdomens, mounted in glycerin jelly: 2♂ (LMCI 273-48 and 49); 2♀ (LMCI 273-46 and 47). Immature stages, fixed in Kahle-Dietrich's fluid and preserved in 70% EtOH: 5 last-instar larvae (LMCI 273-19 to 22); 16 pupae (LMCI 273-14 and 15); 22 mature galls (LMCI 229-8; 273-5 and 6). In tissue collection, fixed and preserved in 100% ethanol, at -20 °C; 2 larvae (LMCI 211-4) and 10 pupae (LMCI 273-16).

Distribution. *P. beckeri* is known only from the type locality, in the low land fragments of Dense Umbrophilous Forest (=Brazilian Atlantic Forest *sensu stricto*) of the Coxilha das Lombas, Santo Antônio da Patrulha municipality, RS, Brazil.

Host plant (Fig. 44). *T. trichopoda* (DC.) Baill. (Melastomataceae) is a shrub (ca. 1 m), endemic to coastal forests of southern Brazil, ranging from Minas Gerais and Espírito Santo to Rio Grande do Sul (Guimarães, 2014). It is generally found in poorly drained, sandy soils, associated with lowland forests that are located in swampy areas (Souza, 1986).

Life history. Galls (Figs. 45–49) induced by *P. beckeri* are globular, 11–15 mm in diameter ($n=6$); they are found on the stem of apical branches; uniformly light brown, with irregular, scaly surface; woody, usually unilocular and unilarval. The larval chamber consists of a tubular gallery, which circundates the gall cortex, and that is revested by a lighter brown, tissue layer (Fig. 47), which becomes harder than cortex in mature galls. These have an exit orifice (Fig. 46) that is kept open, and through which the adult emerges. Fusion between two or among a few adjacent galls may occur, but also in this case each of them has an individualized gallery and corresponding exit orifice when mature. Pupation occurs in the deepest portion of the gallery, under a thin, flimsy layer of silk woven by the last-instar larva (Figs. 48 and 49). Pupal exuvia were always found inside of such gallery portions after adult emergence. *P. beckeri* galls are common on *T. trichopoda* plants at the type locality, and several can be found per plant. Our observations suggest that they remain attached to the host for at least 1 year after adult emergence. Under laboratory conditions, galls bearing last-instar larvae that were collected during early winter (July) had adult emergence starting in early spring (September).

Etymology. Named in honor of Dr. Vitor O. Becker, an entomologist of the Serra Bonita Reserve, Camaçan, Bahia, Brazil, for his great contribution to the development of lepidopterology in the Neotropics.

Further remarks. The female genitalia of *P. beckeri* have apophyses of similar length, different from those of the type species *P. chalcopeda* that are unequal in size (Becker, 1999). Thus, *P. chalcopeda* that has the state of Rio de Janeiro as the type locality is not co-specific to specimens studied herein, and thus remains unknown regarding the male, immature stages and galls, if any (for further discussion, see Becker and Adamski, 2008; Luz et al., 2014). The overall shape and the unique arrangement of spines on *P. beckeri* cremaster reinforces the importance of such structure in identification within *Palaeomystella*, already called to attention by

Luz et al. (2014). The woody nature of *P. beckeri* galls bearing a larval chamber consisting a tubular gallery that circundates internally the cortex and is open distally, without an operculum is for the first time described in *Palaeomystella*. Among the diagnostic characters proposed for the larval stage of Momphidae is the bisetose L group on the prothoracic segment (Stehr, 1987; Wagner et al., 2004; Heikkilä et al., 2013). This is also the case of *P. beckeri*, which regarding this character in particular shows the same chaetotaxy pattern to *P. oligophaga* (Becker and Adamski, 2008), *P. fernandesi*, *P. rosaemariae* and *P. tavaresi* (Luz et al., 2014). It differs, however, from the remaining two congeneric species from which the larva are known, *P. tibouchinae* and *P. henriettiphila*, which have lost the L2 seta on the prothorax (Becker and Adamski, 2008). *P. beckeri* differs from *P. fernandesi* and *P. rosaemariae* by having bisetose L group on abdominal segments A1–A8. Similar to larvae of *P. rosaemariae* and *P. tavaresi*, those of *P. beckeri* have trisetose SV group on abdominal segments A3–A6.

In summary, results presented in this study illustrated further the expressive interspecific variation existing within *Palaeomystella*, not only among the adults but also the immatures, and galls. As pointed by Luz et al. (2014), there is a strong genetic variability within this momphid lineage (average among species = 18%), resulting supposedly from gaps in diversity existing the analysis, associated with low collection efforts and small number of taxonomic studies on this lineage in the area. These authors also pointed out that they share adult, pupal and larval characters with *Mompha* Hübner, and that classification of *Palaeomystella* may change in the future. Thus, the corresponding revision remains pending upon the increase in the knowledge about the diversity of *Palaeomystella* and other associated lineages, if any, in the Neotropics (e.g., Miller, 2005; Hanson et al., 2014).

Conflicts of interest

The authors declare no conflicts of interest.

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