# Planthopper (Hemiptera: Flatidae) Parasitized by Larval Erythraeid Mite (Trombidiformes: Erythraeidae)—A Description of Two New Species From Western Madagascar

Authors: Mąkol, Joanna, Moniuszko, Hanna, Świerczewski, Dariusz, and Stroiński, Adam

Source: Journal of Insect Science, 14(194) : 1-12

Published By: Entomological Society of America

URL: https://doi.org/10.1093/jisesa/ieu056

RESEARCH

# Planthopper (Hemiptera: Flatidae) Parasitized by Larval Erythraeid Mite (Trombidiformes: Erythraeidae)—A Description of Two New Species From Western Madagascar

**Joanna Mąkol,[1,2] Hanna Moniuszko,[1] Dariusz Świerczewski,[3] and Adam Stroiński[4]**

[1]Institute of Biology, Department of Invertebrate Systematics and Ecology, Wrocław University of Environmental and Life Sciences, Kożuchowska 5b, 51-631 Wrocław, Poland
[2]Corresponding author, e-mail: joanna.makol@up.wroc.pl
[3]Department of Zoology and Animal Ecology, Jan Długosz University, Armii Krajowej 13/15, 42-201 Częstochowa, Poland
[4]Museum and Institute of Zoology, Polish Academy of Sciences, Wilcza 64, 00-697 Warsaw, Poland

**Suject Editor:** Takumasa Kondo

J. Insect Sci. 14(194): 2014; DOI: 10.1093/jisesa/ieu056

**ABSTRACT.** Descriptions of *Dambullaeus adonis* Mąkol et Moniuszko **sp. nov.** (Trombidiformes: Erythraeidae, Callidosomatinae) and *Latois nigrolineata* Świerczewski et Stroiński **sp. nov.** (Hemiptera: Fulgoromorpha, Flatidae) from Madagascar are provided. The first host record for ectoparasitic larvae of *Dambullaeus* Haitlinger, 2001 and the first evidence on host–parasite association between flatid adult and erythraeid larvae are given. Genus *Dambullaeus*, known exclusively from larvae and now comprising two species of Gondwanan distribution, is critically reappraised.

**Key Words**: host, parasite, Fulgoromorpha, Parasitengona, taxonomy

Madagascar is one of eight important global biodiversity hotspots owing to its unique biota and the high level of threat to its natural habitats (McNeely et al. 1990, Myers et al. 2000, Ganzhorn et al. 2001). It has evolved as an incredible wealth of biodiversity, with thousands of species that can be found nowhere else on earth. On the one hand, this is due to the long isolation of Madagascar from all other landmasses (Storey et al. 1995), and on the other, several alternative mechanisms have generated local endemism (Vences et al. 2009).

The knowledge of erythraeid fauna (Trombidiformes: Erythraeidae) of Madagascar is scarce and limited to single records on *Abrolophus aitapensis* (Southcott, 1948) (Abrolophinae), *Charletonia adellae* Haitlinger, 2007, *Charletonia agatae* Haitlinger, 1987, *Charletonia alarobiaensis* Haitlinger, 1987, *Charletonia arlettae* Haitlinger, 1987, *Charletonia dorotae* Haitlinger, 1987, *Charletonia edytae* Haitlinger, 1987, *Charletonia iwonae* Haitlinger, 1987, *Charletonia justynae* Haitlinger, 1987, *Charletonia kibonotensis* (Trägårdh, 1908), *Charletonia milloti* (André, 1946), *Charletonia tatianae* (Trägårdh, 1908) (Callidosomatinae), *Leptus aldonae* (Trägårdh, 1908), *Leptus madagascariensis* (André, 1941), and *Leptus maranaensis* Haitlinger, 1987 (Leptinae) (André 1941, 1946; Haitlinger 1987, 2007). Of those, *C. milloti* has been known exclusively from active postlarval forms, which are recognized as predators in parasitengone mites, whereas for other taxa, the parasitic larva constitutes the only described instar. Erythraeid larvae parasitize various arthropods. Data on hosts are scarce and, in majority of cases, restricted to unidentified representatives of hexapod orders.

The monotypic genus *Dambullaeus* Haitlinger, 2001 with *Dambullaeus piae* Haitlinger, 2001 was described from Sri Lanka based on single specimen collected from plants, and since then, no further account of the genus has been published. Here, we provide a description of a second representative of the genus, *Dambullaeus adonis* Mąkol et Moniuszko sp. nov., ectoparasitic the newly described flatid planthopper of the genus *Latois* Stål, 1866 (Hemiptera: Flatidae) from Madagascar. The present distribution pattern of *Dambullaeus* points to the history of the genus, which may date back to the sundering of Gondwana and separation of India from Madagascar.

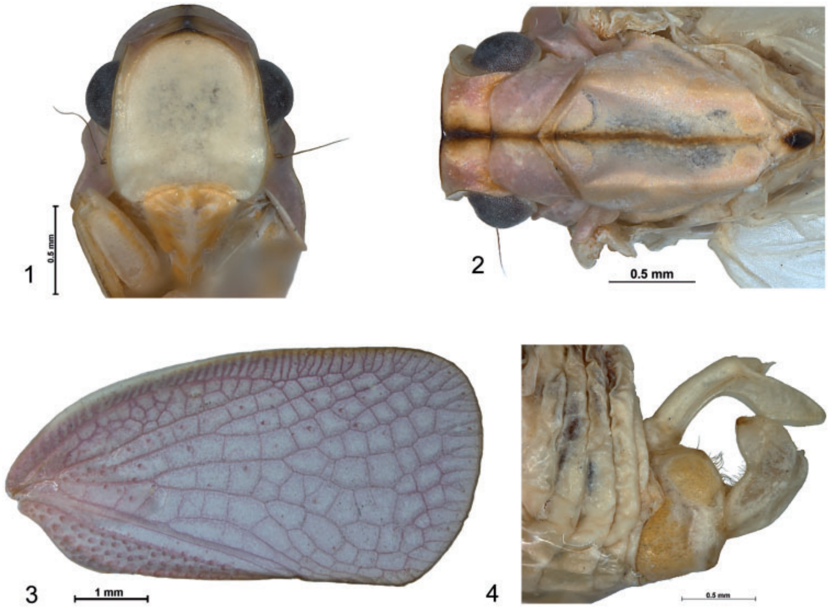
Flatidae constitute one of the largest families within planthoppers (Fulgoromorpha: Hemiptera) with 1,437 species described in 294 genera and 12 tribes distributed worldwide (Bourgoin 2013). These phytophagous insects are highly diverse in terms of their color and size (from 4.5 up to 32 mm) and are found on all continents but are especially common and abundant in the tropics (O'Brien 2002). They are divided into two subfamilies—Flatinae and Flatoidinae, which, in most cases, can be easily distinguished from each other by the shape of the body. A majority of Flatinae are flattened laterally, in contrast to Flatoidinae which hold their wings horizontally (O'Brien and Wilson 1985). Madagascan flatid fauna presently consists of 17 genera with 39 species of Flatinae and 11 genera with 37 species of Flatoidinae and has been reviewed by Świerczewski and Stroiński (2013).

The flatid planthopper genus *Latois* Stål, 1866 covers six species: *Latois antica* (Signoret, 1860), *Latois suturalis* (Signoret, 1860), *Latois bicoloripes* Karsch, 1890, *Latois frontalis* Melichar, 1901, *Latois major* Melichar, 1901 and recently discovered *Latois nigrofasciata* Świerczewski et Stroiński 2012. In this article, we describe another species *Latois nigrolineata* Świerczewski et Stroiński sp. nov., from three localities in the western part of the island.

## Materials and Methods

The studied material, originating from a few localities in western Madagascar (see: Type Material), comes from the collection of the California Academy of Sciences in San Francisco (CAS) (Dr. N. Penny, curator).

**Flatid Host Preparation.** The abdomens were cut off and boiled in 10% KOH with a few drops of chlorazol black for dying the ectodermic genital ducts based on the method introduced by Carayon (1969) and Bourgoin (1993). Dissections and cleaning of genital structures were performed in distilled water. Final observations and drawings were done in glycerin using a camera lucida attached to a light microscope. The photos of the habitus were taken using a stereoscopic microscope Leica MZ 16 with digital camera IC 3D. The photos of female genital structures were taken using a light microscope Leica DM5500B with digital camera Leica DFC49. Final images were created using




**Figs. 1–4.** *L. nigrolineata* Świerczewski et Stroiński sp. nov. (1) Frontal view. (2) Anterior part of body, dorsal view. (3) Tegmen. (4) Male, genital capsule.

HELICON 5.0 and ADOBE PHOTOSHOP software. The SEM photographs of uncoated specimens were taken in the Laboratory of Scanning Microscopy, MIZ PAS (Warsaw), using a scanning microscope HITACHI S-3400N under low vacuum conditions.

The following measurements were taken and abbreviations used in the description of hemipteran host: total length—measured (in dorsal view) from the apex of head protrusion to the apex of tegmina; A/B—width of vertex measured at the anterior margin/length of vertex measured in mid line; C/E—width of frons between eyes/length of frons in mid line; D/E—maximum width of frons/length of frons in mid line; F/B—length of pronotum in mid line/length of vertex in mid line; G/F—length of mesonotum/length of pronotum in mid line; G/B+F—length of mesonotum/cumulative length of vertex and pronotum in mid line; G/H—length of mesonotum in mid line/width of mesonotum between lateral angles; I/J—length of tegmen measured from the base to the apical margin in median portion/width of tegmen measured from the apex of clavus to the anterior margin. The nomenclature of the male genitalia follows Bourgoin (1988) and Bourgoin and Huang (1990), and for the female genitalia Bourgoin (1993). Vein nomenclature after interpretation proposed by Szwedo and Żyła (2009).

**Erythraeid Larvae Preparation.** Larvae (for the place of origin see: Type Material under *D. adonis* Mąkol et Moniuszko sp. nov.) attached to the host specimen were stored in 70% ethanol for 5 yr, and, after pinning the host, they were kept dry for a half year in the entomological collection. During the host preparation, larvae were dyed together with the host in warm 10% KOH with a few drops of chlorazol black and, after cleaning in distilled water, transferred to glycerol. Morphological examination of larvae was carried out in LM and in SEM. The scanning electron microscope Zeiss EVO LS15 served for close-up investigation of fine structures in dehydrated and gold-coated specimens. Larvae destined for light microscopy studies were preserved in 70–75% ethanol and fixed on permanent slides in Faure's fluid (Walter and Krantz 2009). Measurements were taken under a Nikon Eclipse E600 with differential interference contrast, coupled with NIS-Elements Br software, whereas drawings (except the SEM photo-based Fig. 2) were made under a Nikon Eclipse 80i combined with camera lucida. All measurements are given in micrometers. Terminology, abbreviations, and modes of measurements follow Mąkol et al. (2012a) and Southcott (1961).

**Nomenclature.** The new taxa names published in this article have been registered in ZooBank (www.zoobank.org). The LSID is urn:lsid:zoobank.org:pub:2FF09FDB-700B-418C-818E-7FF0A873E919.

## Results

**Taxonomy.** Order: Hemiptera L., 1758
Suborder: Fulgoromorpha Evans, 1946
Superfamily: Fulgoroidea Latreille, 1807
Family: Flatidae Spinola, 1839
Subfamily: Flatinae Spinola, 1839
Genus: *Latois* Stål, 1866
Type species: *Nephesa antica* Signoret, 1860
*L. nigrolineata* Świerczewski et Stroiński **sp. nov.** (Figs. 1–33 and 50).

**Material Examined.**

*Type Material.* Holotype ♂: (MADAGASCAR: Majunga Ambovomamy Belambo, 20 km NW of Port Berger, 26 May–5 June 2007), (15° 27.07′ S, 47° 36.80′ E, CAS, coll.: R. Harin'Hala, M. Irwin, F. Parker, malaise, secondary growth on white sand, elev. 33 m, MG-33-23), (CASLOT 044483) (CAS).

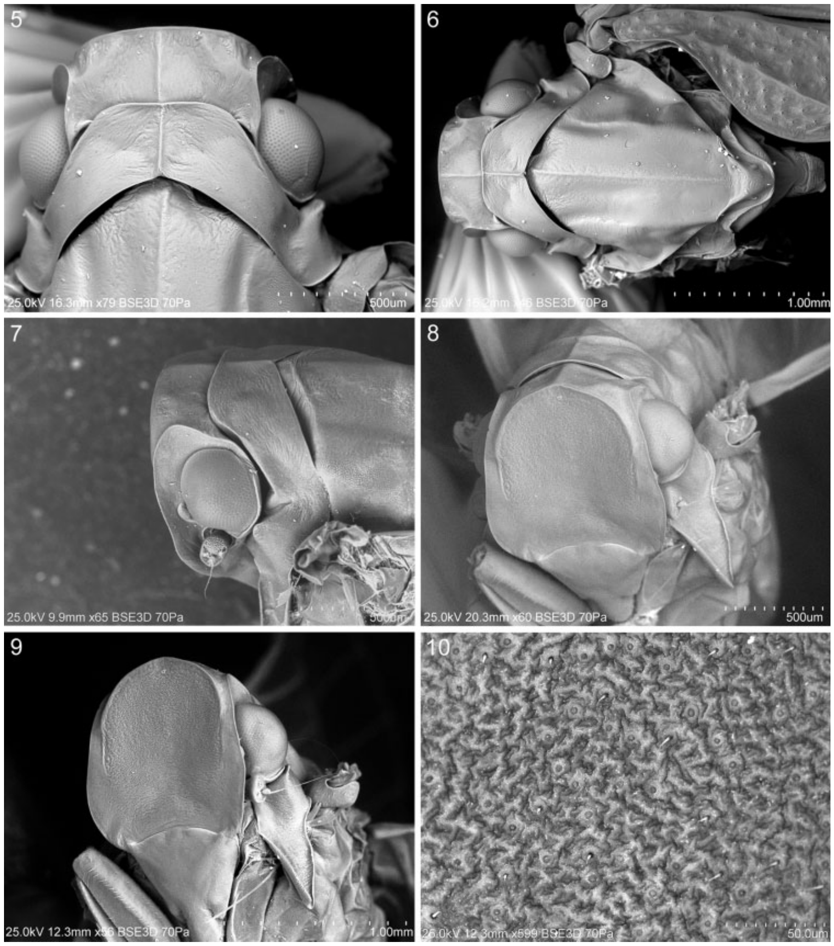
Paratypes: (MADAGASCAR: Majunga Ambovomamy Belambo, 20 km NW of Port Berger, 6–12 April 2007, 15° 27.07′ S, 47° 36.80′ E), (CAS, coll.: R. Harin'Hala, M. Irwin, F. Parker, malaise, secondary growth on white sand, elev. 33 m, MG-33-16), (CASLOT 034286)—1♀ (CAS); (MADAGASCAR: Tulear Province, Mikea Forest, NW of Manombo, elev. 30 m, 6–16 January 2002, 22° 54.22′ S, 43° 28.53′ E), (coll.: M. Irwin, R. Harin'Hala, CAS, malaise trap—in deciduous dry forest, MA-02-18A-09), (CASLOT 044695)—1♂ (CAS); (MADAGASCAR: Majunga, Prov. Besalampy District, Analangidro dry forest, 17 km W of Besalampy, 14–21 December 2007), (16° 41.49′ S 4° 31.41′ E, CAS, coll.: M. Irwin, R. Harin'Hala, malaise, dry forest on sand, elev. 200 ft, MG-41-12)–1♂ (CAS).

**Etymology.** The specific epithet refers to black, narrow band on dorsal surface of thorax.

**Diagnosis.** The new species differs from other members of the genus in the following characters: frons without protrusion in the upper part of head, median carina absent or as remnant.

**Description.** Total length: 0.75–0.77 cm.

Head truncate, with compound eyes (in dorsal view) about the same width as thorax (Figs. 2, 5, and 6). Vertex transverse, distinctly wider




**Figs. 5–10.** *L. nigrolineata* Świerczewski et Stroiński sp. nov. (5) Anterior part of body, dorsal view. (6) Head and thorax, dorsal view. (7) Anterior part of body, dorsolateral view. (8, 9) Anterior part of body, frontal view. (10) Frons, surface.

than long at midline, proportion A/B = 2.64–3.0; posterior part partly covered by pronotum (Figs. 5–7); lateral margins slightly arcuate and subparallel; anterior margin ridgeous and convex, medially obsolete; disc of vertex in median portion elevated, with median carina (Figs. 5–8).

Frons (Figs. 1 and 8–10), a little longer than wide, the widest below the level of compound eyes, proportion C/E = 0.90–1.00, proportion D/E = 1.00–1.08; frons without protrusion in the upper part of head; disc of frons with two well visible, arcuate and connected at base, lateral carinae, reaching the level of antennae; median carina absent or as remnant; lateral margins of frons carinate and elevated, lateral margin without incision (Figs. 1, 8, and 9); disc of frons irregularly rugose, with sensory and excretory organs (Fig. 10); central part (between lateral carinae) depressed.

Antennal segment II (pedicel) about as long as wide, wider at apex; sensory organs and sensilla located at the top of pedicel, in shallow depression and partly at upper surface (Figs. 7 and 11). Compound eyes oval with very small callus at lower posterior margin, lateral ocelli present.

Frontoclypeal suture arcuate; clypeus without carinae, median portion convex (Fig. 1). Rostrum reaching hind coxae; apical part a bit shorter than the basal one.

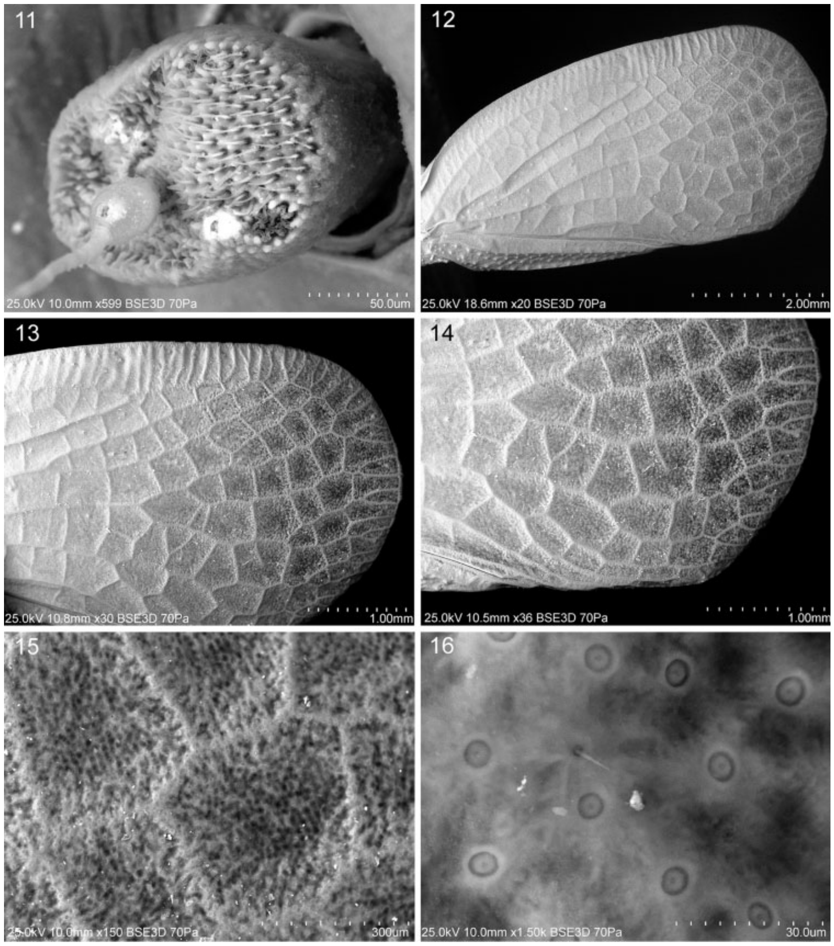
Thorax. Pronotum (Figs 2 and 5–8) a bit shorter than vertex (proportion F/B = 0.80–0.91); anterior margin (in lateral view) at the same level as posterior margin; anterior margin (in dorsal view) almost straight, partly covering posterior margin of vertex, posterior margin deeply incised; disc of pronotum with median carina and lateral pits; lateral parts of disc with strong and sharp postocular eminences.

Mesonotum (Figs. 2 and 6) deltoid, proportion G/F = 6.40–8.13, G/B + F = 3.05–3.61, G/H = 1.15–1.18; in lateral view at the same level as posterior margin of pronotum; lateral angles placed before $^{1}/_{2}$ of the length of mesonotum at midline; disc of mesonotum with three, separated at base and parallel carinae, reaching the posterior margin.

Tegmen (Figs. 3 and 12–16) subrectangular, membranous, flat, surface smooth, and proportion I/J = 1.81–1.95; costal margin—basal part to 1/3 weakly arcuate, posterior part almost straight; costal angle bluntly rounded; apical margin strongly arcuate; sutural angle rounded; postclaval sutural margin straight; costal area narrower than costal cell at midline, widening apicad, with dense and numerous transverse veinlets, ending at the level of end of clavus; costal cell tapering apicad, with sparse net of veinlets; basal cell more twice as long as wide.

Longitudinal stem Sc+R arises as extremely short common stem from basal cell; Sc+RA weakly basally elevated, distal part of RP extremely weakly visible. M leaving basal cell with a long stalk but shorter than CuA stalk. First fork of Sc+RA near the end of costal area; first fork of RP before end of costal area. Location of $M_{1+2}$ fork after RP fork; $M_{3+4}$ fork before $M_{1+2}$. CuA diverging after the level of M fork. Sc ending with 1 terminal, RA with 7–9, RP with 6–8, $M_{1+2}$ with 11–16, $M_{3+4}$ with 11–15 terminals, and CuA with 5–7 terminals ending at postclaval margin. Claval veins not elevated, connected a little before end of clavus; transverse veinlets absent.

Irregular net of numerous transverse veinlets starting from basal part of tegmen; nodal line absent; apical line weakly distinguishable; tubercles present mainly on costal area, between basal parts of Sc+RA and M veins and on clavus. Sensory and secretory structures on the whole surface of tegmen (Figs. 15 and 16).



**Figs. 11–16.** *L. nigrolineata* Świerczewski et Stroiński sp. nov. (11) Antenna. (12–14) Tegmen. (15) Tegmen surface. (16) Tegmen sensory structures.

Femora shorter than tibiae; fore and middle tibiae rectangular in cross section with carinate margins; hind tibia arcuate with two lateral spines after midlength, row of seven apical teeth in formula two (longer) + five (shorter); basitarsomere as long as cumulative length of second and hind tarsomeres, with arcuate line of seven apical teeth, lateral teeth larger than internal ones.

Male. Anal tube (in lateral view, Figs. 4 and 17) elongated and distinctly curved at midline; basal part about the same width as apical part; and anus placed a bit after half of length. Anal tube (in dorsal view, Fig. 18) in a shape of baseball bat; basal part distinctly separated and rounded, apical part tapered, shallowly incised medially; and anus placed a bit after half of length.

Pygofer (in lateral view, Figs. 4 and 17) higher than wide; dorsal part narrower than ventral, posterior margin arcuate. Posterodorsal angle widely rounded, without process.

Genital styles (in lateral view, Figs. 4 and 17) L-shaped; dorsal margin basally almost straight, before capitulum distinctly rising and forming fold, capitulum short and sharp; posterior margin arcuate; ventral margin weakly arcuate, apically with sharp and short process.

Phallic complex: periandrium (in lateral view, Figs. 19 and 20), excluding median ventral keel, about the same width and distinctly curved; lateral split surpassing half of length of periandrium; dorsal part longer than ventral, apically (in lateral view) with narrow incision; lower part of dorsal periandrium with spiniferous microsculpture and two well sclerotized, single processes oriented ventro-basad, lower process shorter than upper; upper part of periandrium apically well sclerotized with membranous, pleated layers (Fig. 20); ventral part of periandrium shorter than dorsal, bluntly rounded with wide keel (Fig. 19).

Aedeagus (in lateral view, Fig. 21): shaft as long as dorsal part of periandrium, weakly arcuate and apically bluntly rounded; posteroventral part near apex with well sclerotized, bulb-like appendage; ventral fold (Fig. 22) with deeply incised apex and spiniferous margins.

Female. Pregenital sternite (Fig. 25) with wide and well-sclerotized median portion; lateral parts narrower and weakly separated from median part; anterior margin almost straight, posterior margin weakly convex and covered by additional narrow and convex lobe.

Anal tube (in lateral view, Fig. 26) oval; ventral margin strongly arcuate, posterior part bluntly rounded; anus placed before midlength; anal tube extending a bit beyond the posterior margin of the gonoplac.

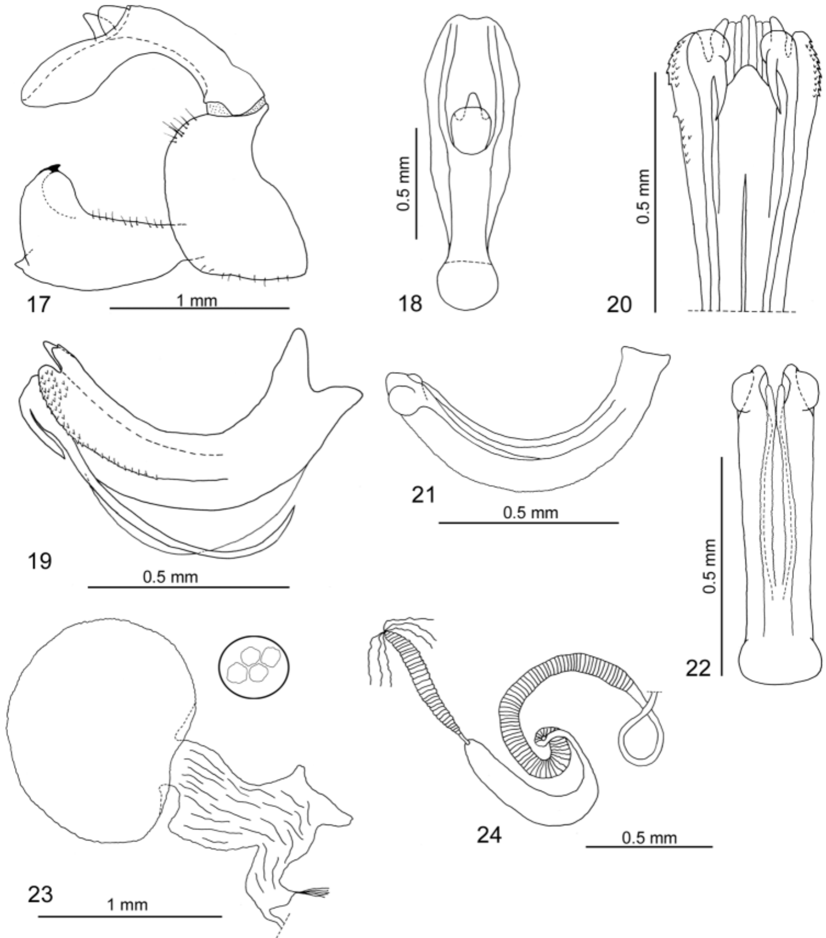
Anal tube (in dorsal view, Fig. 27) oval; anterior margin weakly concave, posterior margin in median portion with distinct incision; lateral margins arcuate; anus placed before midlength.

Gonoplac unilobate, elongately oval (Fig. 29); posterior margin in 3/4 with row of 14 well developed, elongated, dense teeth; posteroventral angle with membranous, smooth, narrow, and elongate lobe; dorsal part of ventral margin with long setae.

Gonapophysis VIII (in lateral view of the external side, Figs. 30 and 31) triangular and laterally flattened, tapering apicad with jagged ventral margin; apical part with four horizontal and one vertical denticles; endogonocoxal process huge, as long as gonapophysis, tapering apicad, membranous, with spiniferous microsculpture, and marginal hairs.

Gonospiculum as in Figs. 32 and 33.

Bursa copulatrix (Fig. 23) with single pouch, oval, cells without sclerites. Spermatheca (Fig. 24) well developed; *ductus receptaculi* longer than *diverticulum ductus*, basal part smooth and narrow, remaining




**Figs. 17–24.** *L. nigrolineata* Świerczewski et Stroiński sp. nov. (17) Genital capsule, lateral view. (18) Anal tube, dorsal view. (19) Periandrium, lateral view. (20) Periandrium, ventral view. (21) Aedeagus, lateral view. (22) Aedeagus, ventral view. (23) Female, bursa copulatrix, lateral view. (24) Spermatheca.

part widened and ribbed; *diverticulum ductus* smooth, basal part narrower than apical part.

Coloration (Figs. 1–4). General color milky white with pinkish tinge; black or dark brown band with yellow boundaries extending from the anterior margin of vertex, through the dorsal part of head and thorax, terminating at the end of scutellum with big, black spot; lateral margins of frons, clypeus and legs yellowish; tegmina marginated with brownish-yellow band.

**Distribution.** Madagascar: Mahajanga and Toliara provinces (Fig. 50).

Order: Trombidiformes Reuter, 1909
Suborder: Prostigmata Kramer, 1877
Cohort: Parasitengona Oudemans, 1909
Superfamily: Erythraeoidea Robineau-Desvoidy, 1828
Family: Erythraeidae Robineau-Desvoidy, 1828
Subfamily: Callidosomatinae Southcott, 1957
Genus: *Dambullaeus* Haitlinger, 2001
Type species: *Dambullaeus piae* Haitlinger, 2001
*Dambullaeus* Haitlinger, 2001

**Diagnosis.** Larva. Scutum oval in outline, with straight anterior margin. Two pairs of trichobothria and three pairs of nonsensillary setae. Anterior pair of sensilla (ASens) located at c. half length of scutum, posterior sensilla (PSens)—close to the posterior margin of scutum. The second pair of nonsensillary setae (ML) distinctly elongated, more than three times longer than nonsensillary setae of first (AL) and third (PL) pair. One pair of circular eyes, placed laterally to scutum. Odontus bifid subterminally. Leg segmentation formula: 7-7-7. Coxal setation formula: 1-2-2. All tarsi terminated with double claws and claw-like empodium. Anterior claw fimbriated.

Deutonymph and adult. Not known.

**Distribution.** Sri Lanka and Madagascar.

***D. adonis*** Mąkol et Moniuszko **sp. nov.** (Figs. 34–50).

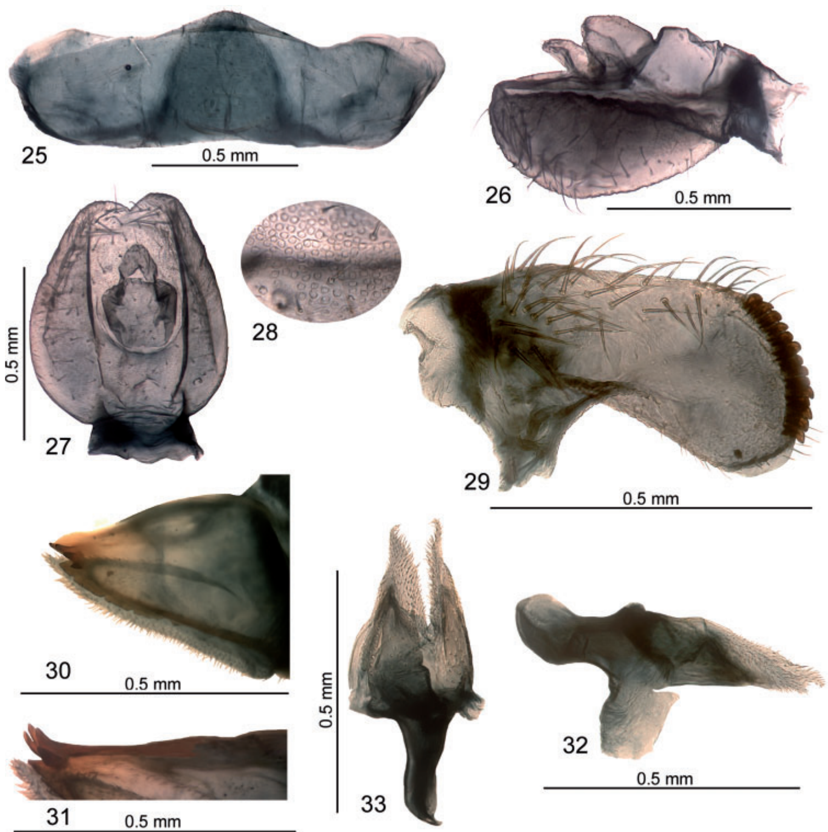
**Material Examined.**

*Type Material.* Holotype, larva: (MADAGASCAR: Majunga Ambovomamy Belambo, 20 km NW of Port Berger, 6–12 April 2007, 15° 27.07′ S, 47° 36.80′ E), (CAS coll: R. Harin'Hala, M. Irwin, F. Parker, malaise, secondary growth on white sand, elev. 33 m, MG-33-16), (CASLOT 034286), ectoparasitic on single specimen (female) of *L. nigrolineata* Świerczewski et Stroiński (CAS); paratypes, larvae: the same data as for holotype—eight specimens (CAS), four specimens (collection of the Department of Invertebrate Systematics and Ecology, Institute of Biology, Wrocław University of Environmental and Life Sciences, Wrocław, Poland).

**Etymology.** The specific epithet, *adonis*, refers to the name of the divinity in Greek mythology.

**Diagnosis.** Larva. Scutum rounded posteriorly. Setae AL, ML, and PL located in anterior half of scutum; ML more than three times longer than AL. Odontus with stout subapical splinter on lateral face.

The new species differs from *Dambullaeus piae* Haitlinger, 2001 in the shape of dorsal scutum (posterior half of scutum in the shape of semicircle in *D. adonis*; in *D. piae*, scutum narrowing posteriorly, with truncated posterior termination which encompasses the bases of PSens), L/W ratio (c. 1 in *D. adonis*, < 1—in *D. piae*).




**Figs. 25–33.** *L. nigrolineata* Świerczewski et Stroiński sp. nov., female. (25) Pregenital sternite, flattened. (26) Anal tube, lateral view. (27) Anal tube, dorsal view. (28) Anal tube, ventral surface. (29) Gonoplac, external view. (30) Gonapophysis VIII, lateral view. (31) Same, apical part. (32) Gonapophyses IX and gonospiculum bridge, lateral view. (33) Same, dorsal view.

**Description.** For morphometric data see Table 1.

Gnathosoma. Cheliceral bases stout, movable claw distinctly curved (Fig. 34). Mouth externally surrounded by flaps, which facilitate the attachment to the host, internally—with lamellar fimbriae (Figs. 35, 38 and 39). A pair of setulated, thread-like at termination adoral setae (*cs*) (c. 28) covered with minute barbs, placed dorsally in anteromedian position (Fig. 38). Club-shaped supracoxal setae (*elcp*) (c. 5) located posterolaterally, at gnathosoma base (Fig. 38). Ventral side of gnathosoma with a pair of barbed setae (*as*), shorter (c. 18) than *cs* and a pair of subcapitular setae (*bs*) (c. 55), covered with setules in proximal half of the stem (Fig. 39). Pedipalp formula (Figs. 36 and 37): 0-B-B-BBB-BBBBωζ. Odontus with stout, subapical splinter on lateral face of the claw. Palp tarsus with four normal setae covered with setules, one solenidion (ω) located in proximal position and one distal eupathidium (ζ).

Dorsal side of idiosoma. Scutum (Figs. 38 and 41) with fine, linear wisps of cuticle (character visible in SEM). Setae AL, ML, and PL placed in anterior half of scutum; PL at the widest part of the sclerite. ASens located just behind the level of PL, PSens, markedly longer than ASens, shifted to the posterior margin of scutum. Both ASens and PSens, covered with setules arising along distal half of the stem. Single eye lenses (17 μm in diameter) placed on indistinct sclerites, close to the level of posterior margin of scutum. The remaining part of idiosoma covered with folded in line cuticle. Dorsal setae (Fig. 40) covered with setules distributed along the stem; stem inserted in setal base in the shape of truncated cone. $f\mathrm{D} = 30–35$ ($N = 13$).

Ventral side of idiosoma (Fig. 39). $f\mathrm{Cx} = 1\text{-}2\text{-}2$. Supracoxal setae *elc I* present on dorsal side, in terminal part of coxae I. Setae 1b, 2b and c, 3b and c located on coxae I, II, III, respectively. Setae 1a, 2a, 3a placed between coxal plates I, II, and III. $f\mathrm{V} = 7–12$ ($N = 13$); the total number of setae in *f*D and *f*V formula (NDV) = 40–46 ($N = 13$). Ventral setae more sharpened apically than the dorsal setae.

Legs (Figs. 42–49). Leg segmentation formula: 7-7-7. For leg chaetotaxy see Table 2. Normal setae on legs setulated. Proximal solenidion (φ) on tibia I adjoined by companala (z). Famulus (ε) on tarsus I located distally to solenidion (ω). Dorsal eupathidium (ζ) on tarsus I and subterminal eupathidia (ζ) on tarsi I–III covered with barbs. Microsetae (vestigialae, κ) on genu I, tibia I, and genu II club shaped. All tarsi terminated with double claws and claw-like empodium, which is longer and slender than claws. Two claws similar in length, without terminal hooks, one—fimbriated along the ventral edge, the other one smooth.

**Distribution.** Madagascar: Mahajanga province (Fig. 50).

## Discussion

All species of *Latois* Stål, 1866 described so far are confined to moist habitats (littoral and humid forests) in the eastern part of Madagascar and the Comoros Islands. In contrast, the newly described species *L. nigrolineata* Świerczewski et Stroiński is widely distributed in the western part of the island and associated with the vegetation of sandy areas near streams and rivers.

Interestingly, here we describe for the first time the phenomenon of erythraeid mite parasitizing the representative of Flatidae family. Host–parasite associations between Hemiptera and Erythraeidae are not well documented, and the overview of data referring to this topic is contained in the article by Stroiński et al. (2013). Of 826 species of Erythraeidae known for science (Mąkol and Wohltmann 2012, 2013, and present data), the larva has been described for 554 species, and for 181 species, the host remains unknown. Up to the present, 66 erythraeid species have been reported to parasitize members of Hemiptera.

**Table 1. Morphometric data on larvae of *D. adonis* Mąkol et Moniuszko sp. nov.**

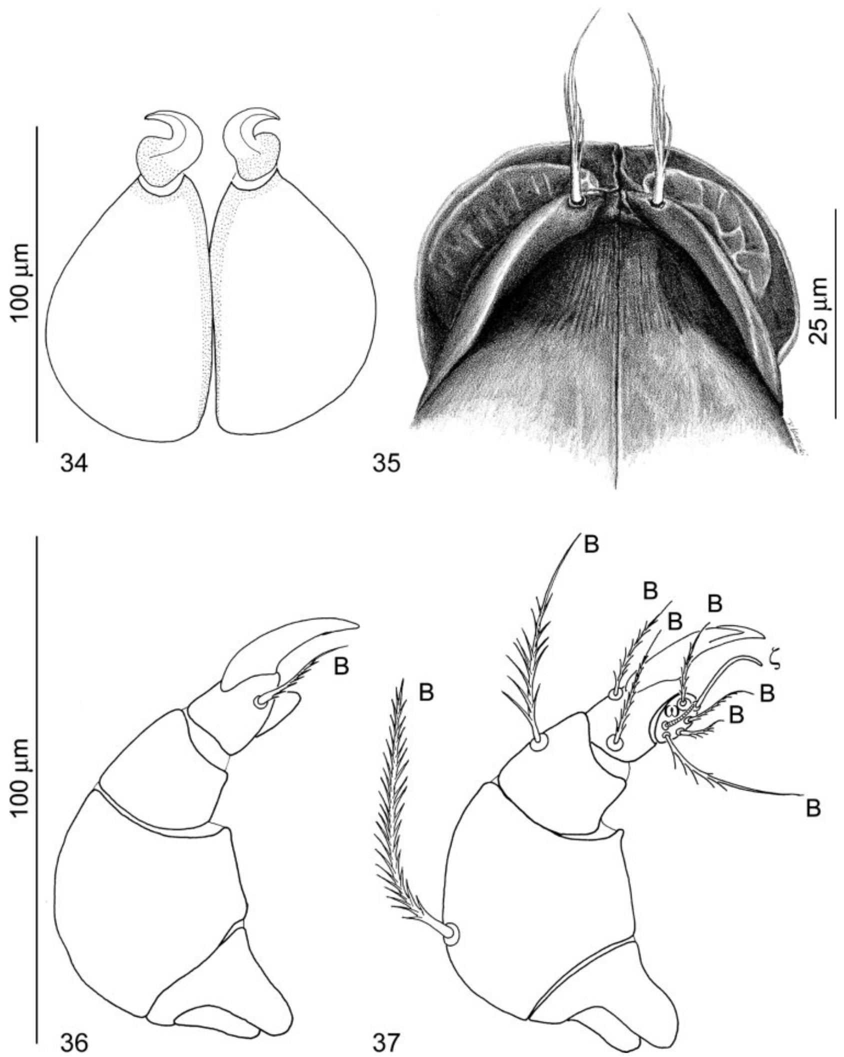
| Character | *D. adonis* Mąkol et Moniuszko sp. nov. | | | *D. piae* Haitlinger, 2001 |
|---|---|---|---|---|
| | Sample size | Mean (μm) | Range (μm) | Data for holotype (original description/present study) |
| Gnathosoma | | | | |
| GL | 13 | 112 | 99–137 | c. 120/120 |
| GW | 9 | 88 | 81–101 | –/71 |
| Pa Tr (L) | 13 | 20 | 16–24 | –/24 |
| Pa Fe (L) | 13 | 33 | 27–40 | –/26 |
| Pa Ge (L) | 13 | 18 | 14–21 | –/33 |
| Pa Ti (L) | 13 | 16 | 11–20 | –/21 |
| Odontus (L) | 13 | 28 | 23–32 | –/25 |
| Pa Ta (L) | 13 | 13 | 10–17 | –/15 |
| Idiosoma | | | | |
| IL | 13 | 245 | 209–303 | 1,130/1,127 |
| IW | 13 | 185 | 165–206 | c. 762/778 |
| IL/IW | 13 | 1.3 | 1.2–1.5 | c. 1.5/1.4 |
| L | 12 | 74 | 69–79 | 82/85 |
| W | 12 | 74 | 65–80 | 104/105 |
| L/W | 12 | 1.0 | 0.9–1.1 | 0.8/0.8 |
| ASens | 10 | 30 | 27–34 | c. 40/34 |
| SBa | 12 | 18 | 15–21 | 14/14 |
| PSens | 9 | 49 | 43–56 | 52/59 |
| SBp | 13 | 13 | 11–14 | 14/16 |
| ASBa | 12 | 40 | 32–46 | 58/49 |
| PSBp | 12 | 4 | 2–5 | 4/5 |
| AL | 13 | 30 | 23–32 | 34/42 |
| AW | 13 | 46 | 43–50 | –/50 |
| ML | 13 | 106 | 96–112 | 100/110 |
| MW | 12 | 39 | 34–44 | 52/40 |
| PL | 13 | 30 | 27–35 | 52/56 |
| PW | 13 | 53 | 49–58 | 70/69 |
| ISD | 13 | 30 | 26–33 | 20/28 |
| AW/AL | 13 | 1.6 | 1.3–2.0 | –/1.2 |
| AW/ISD | 13 | 1.6 | 1.3–1.7 | –/1.8 |
| AL/PL | 13 | 1.0 | 0.9–1.1 | –/0.8 |
| PW/AW | 13 | 1.1 | 1.1–1.2 | –/1.4 |
| DS max. | 13 | 35 | 29–40 | 36–60 (DS)/52 |
| VS max. | 13 | 28 | 26–29 | –/33 |
| 2a | 12 | 34 | 26–39 | –/32 |
| 3a | 12 | 26 | 22–32 | –/40 |
| 3a/2a | 12 | 0.8 | 0.6–1.0 | –/1.3 |
| LEGS | | | | |
| Cx I (L) | 13 | 55 | 47–64 | 74/76 |
| Tr I (L) | 13 | 33 | 26–37 | 44/36 |
| bFe I (L) | 13 | 65 | 57–73 | 56/64 |
| tFe I (L) | 13 | 64 | 58–72 | 60/52 |
| Ge I (L) | 13 | 101 | 93–112 | 98/97 |
| Ti I (L) | 13 | 134 | 123–145 | 124/127 |
| Ta I (L) | 13 | 118 | 102–129 | 120/120 |
| Ta I (W) | 13 | 21 | 18–25 | –/19 |
| LEG I (∑) | 13 | 571 | 538–601 | 576/572 |
| Cx II (L) | 13 | 58 | 44–67 | 68/65 |
| Tr II (L) | 13 | 38 | 30–43 | 44/43 |
| bFe II (L) | 13 | 62 | 56–67 | 62/60 |
| tFe II (L) | 13 | 64 | 61–72 | 60/52 |
| Ge II (L) | 13 | 98 | 93–109 | 102/98 |
| Ti II (L) | 13 | 124 | 111–129 | 130/128 |
| Ta II (L) | 13 | 108 | 93–124 | 120/123 |
| Ta II (W) | 13 | 19 | 16–26 | –/16 |
| LEG II (∑) | 13 | 553 | 524–578 | 586/569 |
| Cx III (L) | 13 | 54 | 47–67 | 68/81 |
| Tr III (L) | 13 | 36 | 27–48 | 44/34 |
| bFe III (L) | 13 | 76 | 70–85 | 84/74 |
| tFe III (L) | 13 | 79 | 70–91 | 90/85 |
| Ge III (L) | 13 | 114 | 102–127 | 102/102 |
| Ti III (L) | 12 | 178 | 162–188 | 190/187 |
| Ta III (L) | 12 | 123 | 108–132 | 128/117 |
| Ta III (W) | 12 | 18 | 11–23 | –/21 |
| LEG III (∑) | 12 | 659 | 630–683 | 706/680 |
| IP | 12 | 1,779 | 1,692–1,844 | 1,868/1,821 |
| Ti I/AW | 13 | 2.9 | 2.6–3.2 | –/2.5 |
| Ti I/Ge I | 13 | 1.3 | 1.2–1.4 | 1.3/1.3 |
| Ti II/PW | 13 | 2.4 | 2.1–2.6 | 1.9/1.9 |

(*continued*)

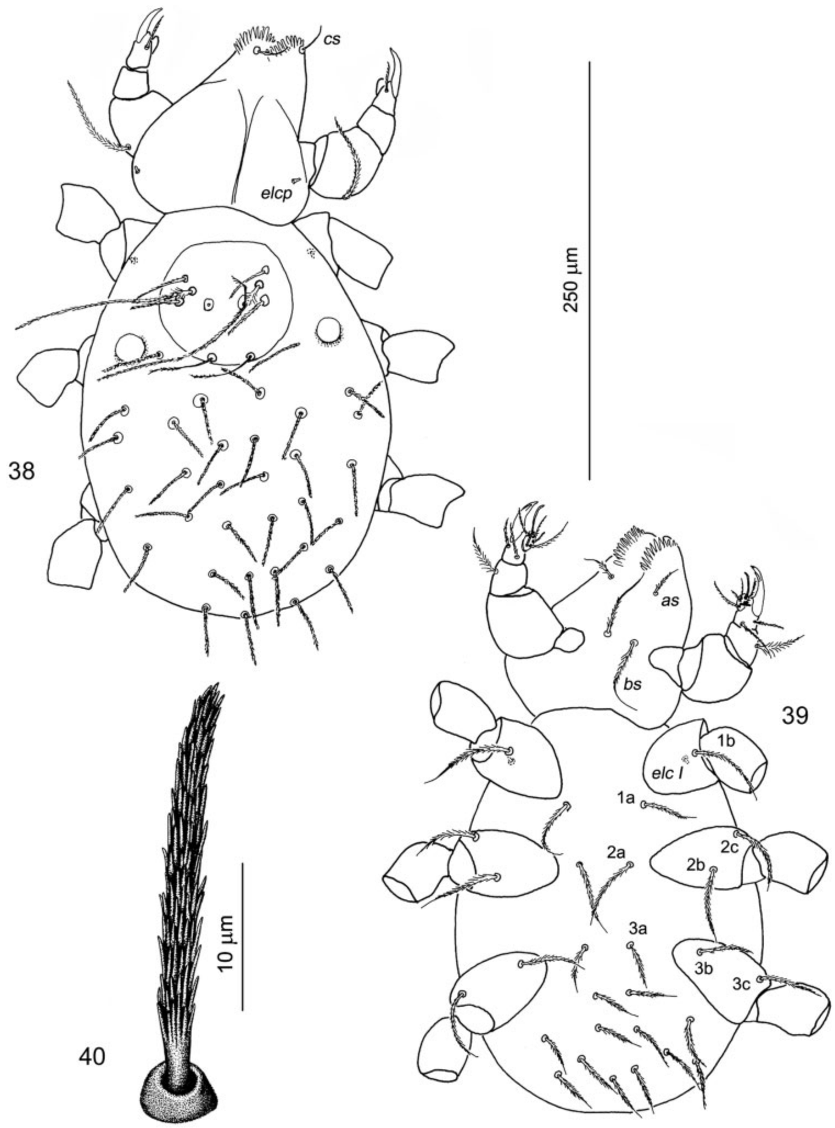
**Table 1. Continued**

| Character | *D. adonis* Mąkol et Moniuszko sp. nov. | | | *D. piae* Haitlinger, 2001 |
|---|---|---|---|---|
| | Sample size | Mean (μm) | Range (μm) | Data for holotype (original description/present study) |
| Ti II/Ge II | 13 | 1.3 | 1.1–1.4 | 1.3/1.3 |
| Ti III/AW | 12 | 3.9 | 3.5–4.2 | –/3.7 |
| Ti III/Ge III | 12 | 1.6 | 1.5–1.8 | 1.9/1.8 |
| Ti III/Ti I | 12 | 1.3 | 1.2–1.4 | 1.5/1.5 |

AL, length of anterior nonsensillary seta on scutum; ASBa, distance between the anterior margin of scutum and the level of anterior sensilla; ASens, length of anterior sensillum on scutum; AW, distance between the bases of anterior nonsensillary setae on scutum; bFe … (L), length of basifemur; Cx … (L), length of coxa; DS, length of dorsal idiosomal seta; Ge … (L), length of genu; GL, length of gnathosoma; GW, width of gnathosoma; IL, length of idiosoma; ISD, distance between the level of anterior and posterior sensilla on scutum; IW, width of idiosoma; L, length of scutum; ML, length of nonsensillary seta of second pair on scutum; MW, distance between the bases of nonsensillary setae of second pair on scutum; Odontus (L), length of palp tibial claw (odontus); Pa Fe (L), length of palp femur; Pa Ge (L), length of palp genu; Pa Ta (L), length of palp tarsus; Pa Ti (L), length of palp tibia; Pa Tr (L), length of palp trochanter; PL, length of posterior nonsensillary seta on scutum; PSBp, distance between the posterior margin of scutum and the level of posterior sensilla; PSens, length of posterior sensillum on scutum; PW, distance between the bases of posterior nonsensillary setae of second pair on scutum; SBa, distance between the bases of anterior sensilla; SBp, distance between the bases of posterior sensilla; Ta … (L), length of tarsus; Ta … (W), width of tarsus; tFe … (L), length of telofemur; Ti … (L), length of tibia; Tr … (L), length of trochanter; VS, length of ventral idiosomal seta; W, width of scutum; 2a, medial seta at the level of coxa II; 3a, medial seta at the level of coxa III.

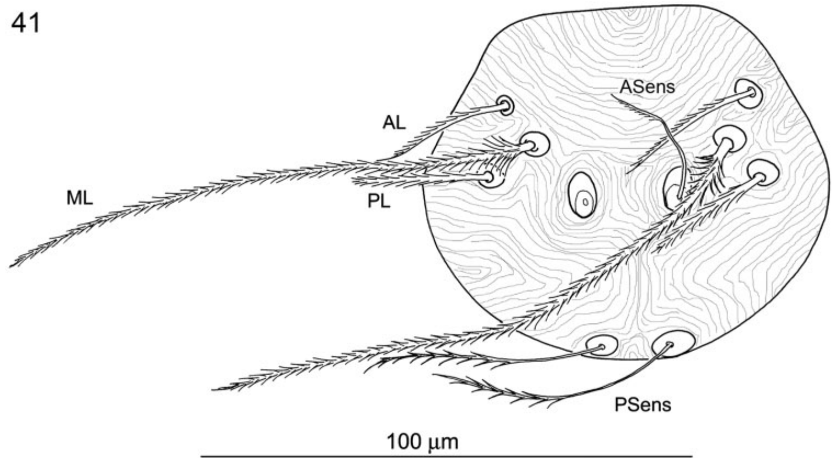



**Figs. 34–37.** *D. adonis* Mąkol et Moniuszko sp. nov. (34) Chelicerae. (35) Anterior part of gnathosoma; cheliceral sheath. (36) Palp, medial face. (37) Palp, lateral face.

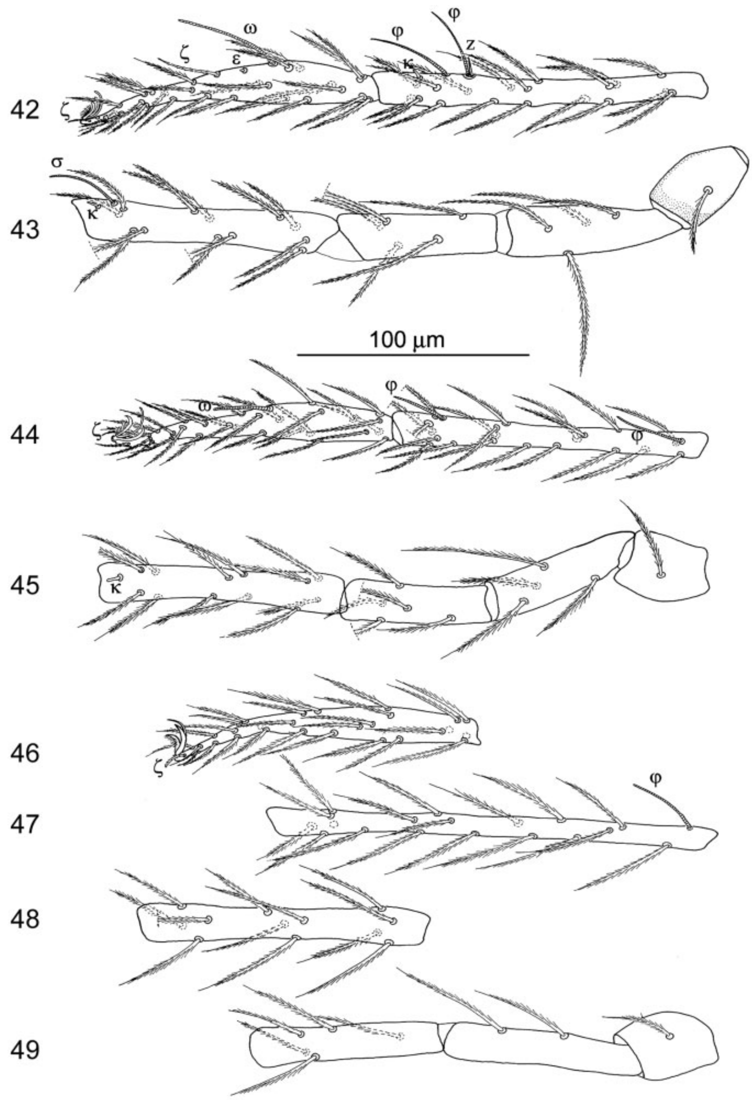



**Figs. 38–40.** *D. adonis* Mąkol et Moniuszko sp. nov. (38) Dorsal side of the body (legs omitted beyond trochanters). (39) Ventral side of the body (legs omitted beyond trochanters). (40) Dorsal idiosomal seta.

41




**Figs. 41.** *D. adonis* Mąkol et Moniuszko sp. nov. (41) Details of scutum.




**Figs. 42–49.** *D. adonis* Mąkol et Moniuszko sp. nov. (42) Leg I (tibia—tarsus). (43) Leg I (trochanter—genu). (44) Leg II (tibia—tarsus). (45) Leg II (trochanter—genu); (46) Leg III (tarsus). (47) Leg III (tibia). (48) Leg III (genu). (49) Leg III (trochanter—telofemur).

**Table 2. Leg chaetotaxy of *D. adonis* Mąkol et Moniuszko sp. nov., larvae**

| Leg segment | Chaetotaxy | |
|---|---|---|
| | *D. adonis* Mąkol et Moniuszko sp. nov. ($N = 13$) | *D. piae* Haitlinger, 2001 data for holotype (original description/present study) |
| Cx I | 1 n, 1 supracoxal seta | 1 n/1 n |
| Tr I | 1 n | 1 n/1 n |
| bFe I | 4 n | 4 n/4 n |
| tFe I | 5 n | 5 n/5 n |
| Ge I | 12 n, 1 σ, 1 κ | 12 n, 1 σ/12 n, 1 σ, 1 κ |
| Ti I | 17–19 n, 2 φ, 1 z, 1 κ | 15 n, 2 φ, 1 κ/15 n, 2 φ, 1 z, 1 κ |
| Ta I | 22–26 n, 2 ζ, 1 ω, 1 ε | 24 n, 2 ζ, 1 ω/24 n, 2 ζ, 1 ω, 1 ε |
| Cx II | 2 n | 2 n/2 n |
| Tr II | 1 n | 1 n/1 n |
| bFe II | 4 n | 4 n/4 n |
| tFe II | 5 n | 5 n/5 n |
| Ge II | 12 n, 1 κ | 12 n/12 n, 1 κ |
| Ti II | 15–19 n, 2 φ | 14 n, 2 φ/16 n, 2 φ |
| Ta II | 23–28 n, 1 ζ, 1 ω | 21 n, 1 ζ, 1 ω/21 n, 1 ζ, 1 ω |
| Cx III | 2 n | 2 n/2 n |
| Tr III | 1 n | 1 n/1 n |
| bFe III | 2 n | 2 n/2 n |
| tFe III | 5 n | 5 n/5 n |
| Ge III | 12 n | 12 n/12 n |
| Ti III | 18–20 n, 1 φ | 15 n, 1 φ/15 n, 1 φ |
| Ta III | 24–28 n, 1 ζ | 23 n/23 n, 1 ζ |

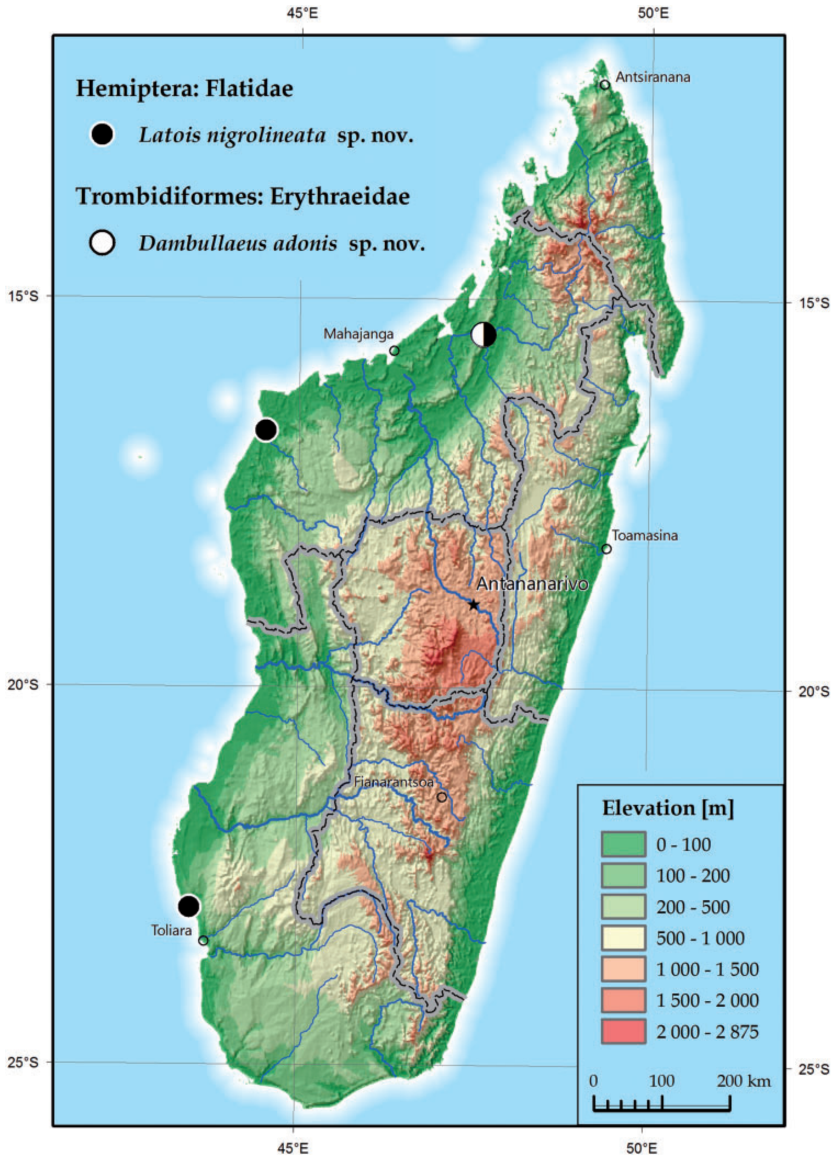



**Fig. 50.** *L. nigrolineata* Świerczewski et Stroiński sp. nov. and *D. adonis* Mąkol et Moniuszko sp. nov., distribution map.

In many cases, however, the host is defined at the level of order, which hinders further conclusions on host specificity. Only one species hitherto recorded from Madagascar, i.e., *L.* (*L.*) *madagascariensis*, is known to parasitize heteropteran bug *Euchelichir longipes* Jeannel, 1942 (André 1941), whereas for the remaining taxa, the representatives of unidentified Odonata, Orthoptera, Neuroptera, and Lepidoptera are exploited as host or the host remains unknown. The limited knowledge of host spectrum but also the various level of host specificity anticipated for erythraeid larvae (Wohltmann 2000; Łaydanowicz and Mąkol 2010; Mąkol et al. 2012b), make each record, with precised specific affiliation of host and parasite, seem much more important.

Representatives of *Dambullaeus* are reported from Madagascar for the first time. All larvae were found attached to abdomen of the female host, between tergites and sternites. The only hitherto record concerning the distribution of the genus originated from Sri Lanka. The distribution encompassing Sri Lanka and Madagascar, set apart from each other for c. 4,000 km, may support the hypothesis on the Gondwanan vicariance. The time of splitting the IndoMadagascar subcontinent and separation of India's from Madagascar has been variably dated from 100 to 80.3 Ma (Yoder and Nowak 2006 and references therein). The transoceanic dispersal seems unlikely, even when larvae constituting the instar with the highest dispersal potential facilitated by host, are concerned.

Other erythraeid genera known from Madagascar, i.e., *Abrolophus* Berlese, 1891, *Charletonia* Oudemans, 1910, *Leptus* Latreille, 1796 are represented in continental Africa and in India. However, these genera of world distribution comprise 114, 115, and 275 nominal species, respectively (Mąkol and Wohltmann 2012, 2013), and for all these genera, the taxonomic revisions should precede the conclusions concerning biogeographic patterns. In this light, the data concerning *Dambullaeus* can constitute a contribution to the discussion on the origin of Malagasy fauna and also on the age of main parasitengone taxa.

## Acknowledgments

We are grateful to Dr. Ryszard Haitlinger for the loan of holotype of *Dambullaeus piae* Haitlinger, 2001. J.M. was partly supported by the National Science Centre (grant in aid of research: N N303-301737).

## References Cited


**André, M. 1941.** Sur une nouvelle forme larvaire d'Acarien parasite d'un Hemiptere de Madagascar. Revue Française d'entomologie 8: 188–195.

**André, M. 1946.** Un *Erythraeus* (Acarien) nouveau recueilli a Madagascar (*E. Milloti* n. sp.). Bulletin du Muséum d'histoire naturelle Paris, 2e sér. 18: 268–269.

**Berlese, A. 1891.** Acari, Myriapoda et Scorpiones hucusque in Italia reperta. Padova. Fasc. 59.

**Bourgoin, T. 1988.** A new interpretation of the homologies of the Hemiptera male genitalia, illustrated by the Tettigometridae (Hemiptera, Fulgoromorpha), pp. 113–120. *In* **C. Vidano and A. Arzone** (eds.), 6th Auchenorrhyncha Meeting, 7–11 September 1987, Turin, Italy. CN R-IPRA, Turin, Italy.

**Bourgoin, T. 1993.** Female genitalia in Hemiptera Fulgoromorpha, morphological and phylogenetic data. Ann. Soc. Entomol. Fr. (N.S.) 29: 225–244.

**Bourgoin, T. 2013.** FLOW (fulgoromorpha lists on the web): a knowledge and a taxonomy database dedicated to planthoppers (Insecta, Hemiptera, Fulgoromorpha, Fulgoromorpha). Version 8, updated (3 November 2013) (http://hemiptera-databases.org/flow/).

**Bourgoin, T., and J. Huang. 1990.** Morphologie compare des genitalia males des Trypetimorphini et remarques phylogénétiques (Hemiptera: Fulgoromorpha: Tropiduchidae. Ann. Soc. Entomol. Fr. (N.S.) 26: 555–564.

**Carayon, J. 1969.** Emploi du noir chlorazol en anatomie microscopique des insectes. Ann. Soc. Entomol. Fr. (N.S.) 5: 179–193.

**Ganzhorn, J. U., P. P. Lowry, II, G. E. Schatz, and S. Sommer. 2001.** The biodiversity of Madagascar: one the world's hottest hotspots on its way out. Oryx 35: 346–348.

**Haitlinger, R. 1987.** Larval Erythraeidae (Acari, Prostigmata) from Madagascar. Polskie Pismo Entomol. 57: 701–723.

**Haitlinger, R. 2001.** *Dambullaeus piae* gen.n., sp.n. (Acari: Prostigmata: Erythraeidae) from Sri Lanka. Zeszyty Naukowe Akademii Rolniczej we Wrocławiu, Seria Zootechnika XLVIII 429: 51–54.

**Haitlinger, R. 2007.** New records of mites (Acari: Prostigmata: Erythraeidae) from Africa with descriptions of four new species. Zeszyty Naukowe Uniwersytetu Przyrodniczego we Wrocławiu, Seria Biologia i Hodowla Zwierząt LV 559: 55–69.

**Karsch, F. 1890.** Afrikanische Fulgoriden. Berliner Entomol. Zeitschrift 35: 57–70.

**Latreille, P. A. 1796.** Précis de caractères génériques des Insectes disposés dans un ordre naturel, Prèvôt, Paris. xiii+201 pp.

**Łaydanowicz, J., and J. Mąkol. 2010.** Correlation of heteromorphic life instars in terrestrial Parasitengona mites and its impact on taxonomy – the case of *Leptus molochinus* (C. L. Koch, 1837) and *Leptus ignotus* (Oudemans, 1903) (Acari: Trombidiformes: Prostigmata: Erythraeidae). J. Nat. Hist. 44: 669–697.

**Mąkol, J., and A. Wohltmann. 2012.** An annotated checklist of terrestrial Parasitengona (Actinotrichida: Prostigmata) of the World, excluding Trombiculidae and Walchiidae. Ann. Zool. 62: 359–562.

**Mąkol, J., and A. Wohltmann. 2013.** Corrections and additions to the checklist of terrestrial Parasitengona (Actinotrichida: Prostigmata) of the World, excluding Trombiculidae and Walchiidae. Ann. Zool. 63: 15–27.

**Mąkol, J., M. Felska, H. Moniuszko, and G. Zaleśny. 2012a.** Redescription of *Leptus kattikus* Haitlinger, 2009 (Actinotrichida, Parasitengona, Erythraeidae) and molecular identification of its host from DNA barcoding. Zootaxa 3569: 67–78.

**Mąkol, J., A. Kłosińska, and J. Łaydanowicz. 2012b.** Host–parasite interactions within terrestrial Parasitengona (Acari, Trombidiformes, Prostigmata). Int. J. Acarol. 38: 18–22.

**McNeely, J. A., K. R. Miller, W. V. Reid, R. A. Mittermeier, and T. B. Werner. 1990.** Conserving the world's biological diversity. International Union for the Conservation of Nature and Natural Resources, World Resources Institute, Conservation International, WWF — US and World Banks, Gland, 193 pp.

**Melichar, L. 1901.** Monographie der Acanaloniiden und Flatiden (Homoptera) (Fortsetzung). Ann. des k.k. Naturhistorischen Hofmuseums Wien 16: 178–258.

**Myers, N., R. A. Mittermeier, C. G. Mittermeier, G.A.B. da Fonseca, and J. Kent. 2000.** Biodiversity hotspots for conservation priorities. Nature 403: 853–858.

**O'Brien, L. 2002.** The wild wonderful world of Fulgoromorpha. Denisia (NF) 4: 83–102.

**O'Brien, L., and S. W. Wilson. 1985.** Planthopper systematics and external morphology, pp. 61–102. *In* **L. R. Nault and J. G. Rodriguez** (eds.), The leafhoppers and planthoppers. John Wiley & Sons, New York, NY.

**Oudemans, A. C. 1910.** Acarologische Aanteekeningen XXXI. Entomol. Berichten 3: 43–51.

**Signoret, V. 1860.** Faune des hémiptères de Madagascar. 1ère partie. Homoptères. Ann. Soc. Entomol. Fr. (Ser. 3) 8: 177–206.

**Southcott, R. V. 1948.** Larval Smarididae (Acarina) from Australia and New Guinea. Proc. Linn. Soc. N. S. W. 72: 252–264.

**Southcott, R. V. 1961.** Studies on the systematics and biology of the Erythraeoidea (Acarina), with a critical revision of the genera and subfamilies. Aust. J. Zool. 9: 367–610.

**Stål, C. 1866.** Hemiptera Homoptera Latr. Hemiptera Africana 4: 1–276.

**Storey, M., J. J. Mahoney, A. D. Sounders, R. A. Duncan, S. P. Kelley, and M. F. Coffin. 1995.** Timing of hot spot-related volcanism and the breakup of Madagascar and India. Science 267: 852–855.

**Stroiński, A., M. Felska, and J. Mąkol. 2013.** Host-parasite associations between Hemiptera (Insecta) and Erythraeidae (Trombidiformes). Ann. Zool. 63: 195–221.

**Świerczewski, D., and A. Stroiński. 2012.** A new species of the genus *Latois* Stål, 1866 from Madagascar (Hemiptera: Fulgoromorpha: Flatidae). Acta Zool. Cracoviensia 55: 65–77.

**Świerczewski, D., and A. Stroiński 2013.** Madagascar Flatidae (Hemiptera, Fulgoromorpha): state-of-the-art and research challenges, pp. 293–301. *In* **A. Popov, S. Grozeva, N. Simov, and E. Tasheva** (eds.), Advances in hemipterology. Pensoft Publishers, Sofia, vol. 319.

**Szwedo, J., and D. Żyła. 2009.** New Fulgoridiidae genus from the Upper Jurassic Karabastau deposits, Kazakhstan (Hemiptera: Fulgoromorpha: Fulgoroidea). Zootaxa 2281: 40–52.

**Trägårdh, I. 1908.** Arachnoidea. Acari. Wissenschaftliche Ergebnisse der Schwedischen Zoologischen Expedition nach dem Kilimandjaro, dem Meru und den Umgebenden. Massaisteppen Deutsch-Ostafrikas 1905–1906 unter Leitung von Prof. Dr. Yngve Sjöstedt 20: 31–57.

**Vences, M., K. C. Wollenberg, D. R. Vieites, and D. C. Lees. 2009.** Madagascar as a model region of species diversification. Trends Ecol. Evol. 24: 456–465.

**Walter, D. E., and G. W. Krantz. 2009.** Collection, rearing, and preparing specimens, pp. 83–96. *In* **G. W. Krantz, and D. E. Walter** (eds.), A manual of acarology, 3rd ed. Texas Tech University Press, Lubbock.

**Wohltmann, A. 2000.** The evolution of life histories in Parasitengona (Acari: Prostigmata). Acarologia 41: 145–204 [2001].

**Yoder, A. D., and N. D. Nowak. 2006.** Has vicariance or dispersal been the predominant biogeographic force in Madagascar? Only time will tell. Annu. Rev. Ecol. Evol. Syst. 37: 405–431.


*Received 21 April 2013; accepted 30 November 2013.*