Zootaxa 4712 (3): 434–444
https://www.mapress.com/j/zt/

Article

ISSN 1175-5326 (print edition)
ZOOTAXA
ISSN 1175-5334 (online edition)

https://doi.org/10.11646/zootaxa.4712.3.9
http://zoobank.org/urn:lsid:zoobank.org:pub:589F1326-FD61-4045-89BF-CA76E1259F80

Kelyflata gen. nov. adds to Selizini flatids in Madagascar (Hemiptera: Fulgoromorpha: Flatidae)

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Abstract

A new genus of flatid planthoppers (Hemiptera: Fulgoromorpha: Flatidae), *Kelyflata* **gen. nov.**, is described for *Kelyflata capensis* **sp. nov.** (type species) and *Kelyflata ilakakae* **sp. nov.** from the island of Madagascar. Habitus, male external and internal genital structures of the new species are illustrated. *Kelyflata* is probably endemic to Madagascar where it is known to date, only from a southern part of the island.

Key words: planthoppers, Fulgoroidea, Madagascar, taxonomy, morphology

Introduction

Madagascar, located in the south-western Indian Ocean with a distance of 450 km from the Africa, is renowned for its unparalleled species richness and levels of endemism (80% flora and fauna), making it one of eight the most important global biodiversity hotspots (Ganzhorn *et al.* 2001). On the other hand, the unprecedented rate of deforestation threatens the survival of its wildlife and therefore the sustainability of the diverse ecosystems (Myers *et al.* 2000, Buerki *et al.* 2013).

Flatidae are phytophagous insects found on the above-ground portions of a wide variety of woody and herbaceous plants, worldwide widespread, but especially common and abundant in the tropics (O'Brien 2002, Bartlett *et al.* 2014). They constitute the fifth largest family within planthoppers (Fulgoromorpha, Hemiptera) with 1442 species and 295 genera covering two subfamilies: Flatinae Spinola, 1839 and Flatoidinae Melichar, 1901 (Bourgoin 2019). The Flatidae fauna of Madagascar includes, in total, 22 genera with 53 species of Flatinae and 11 genera with 37 species of Flatoidinae. The Selizini tribe of Flatinae can be defined, according to Peng *et al.* (2010), by the following characters: body brown or dark brown, body length about 10 mm; antennal segment I very short, ring-like, segment II tubular; pronotum with postocular eminence conical; tegmen elongated, often twice as long as broad, with bulla at base of vein Sc, costal margin sinuate before apex or not, claval vein 2A and base of clavus strongly elevated and heavily pustulate. There are 50 genera of Selizini distributed worldwide, with 10 genera in Afrotropic and 3 genera with 5 species in Madagascar—*Urana paradoxa* Melichar, 1902, *Urana unica* Stroiński et Świerczewski, 2012, *Stenocyarda angustata* (Melichar, 1902), *Lembakaria saintemariae* Świerczewski et Stroiński, 2019 and *Lembakaria mikeae* Świerczewski et Stroiński, 2019.

In this paper, we describe an additional new genus from southern Madagascar, which can be assigned to Selizini flatids, taking into account the morphological characters listed above.

Material and methods

Material. The material studied comes from the collection of the California Academy of Sciences in San Francisco, USA (Dr N. Penny). Depositories of material are abbreviated as follows:

 Accepted by J. Szwedo: 13 Nov. 2019; published: 20 Dec. 2019

CAS—California Academy of Sciences, Department of Entomology, San Francisco (USA);

Label information of all specimens examined is in square brackets and provided verbatim with each line separated by a slash (/).

Preparations and illustration. The abdomens of the specimens examined were removed and cleared for 30 minutes in warm (50°C) 10% KOH solution with a few drops of chlorazol black (CAS No. 1937–37–7) for dying the ectodermic structures 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 glycerol using a camera lucida attached to a light microscope. The SEM photographs of uncoated specimens were taken in the Laboratory of Scanning Microscopy, Museum and Institute of Zoology, Polish Academy of Sciences (Warsaw), using a scanning electron microscope HITACHI S-3400N under low vacuum conditions.

Measurements and abbreviations. Measurements were made with an ocular micrometer. The following measurements, ratios and their abbreviations were used in this study:

Total length = length of specimen from head apex to tegmina apex (in dorsal view);
A/B = width of vertex / length of vertex at midline;
C/E = width of frons at upper margin / length of frons at midline;
D/E = maximum width of frons / length of frons at midline;
F/B = length of pronotum at midline / length of vertex at midline;
G/F = length of mesonotum / length of pronotum at midline;
G/B+F = length of mesonotum / cumulative length of vertex and pronotum at midline;
G/H = length of mesonotum at midline / width of mesonotum between lateral angles;
I/J = length of tegmen from the base to the apical margin in median portion / width of tegmen measured from the apex of clavus to the anterior margin;
I/K = length of tegmen from the base to the apical margin in median portion / width of tegmen at the widest part.

Terminology. The nomenclature of the forewing (tegmen) veins follows the standardized terminology of Bourgoin *et al.* (2015). Antennal structures are named in accordance with Stroiński *et al.* (2011). The terminology of the genitalia follows Bourgoin (1988) and Bourgoin & Huang (1990) for the male, and Bourgoin (1993) for the female.

The distribution map of the species was created using SimpleMappr (https://www.simplemappr.net).

Taxonomy

Class Insecta Linnaeus, 1758

Order Hemiptera Linnaeus, 1758

Suborder Fulgoromorpha Evans, 1946

Superfamily Fulgoroidea Latreille, 1810

Family Flatidae Spinola, 1839

Subfamily Flatinae Spinola, 1839

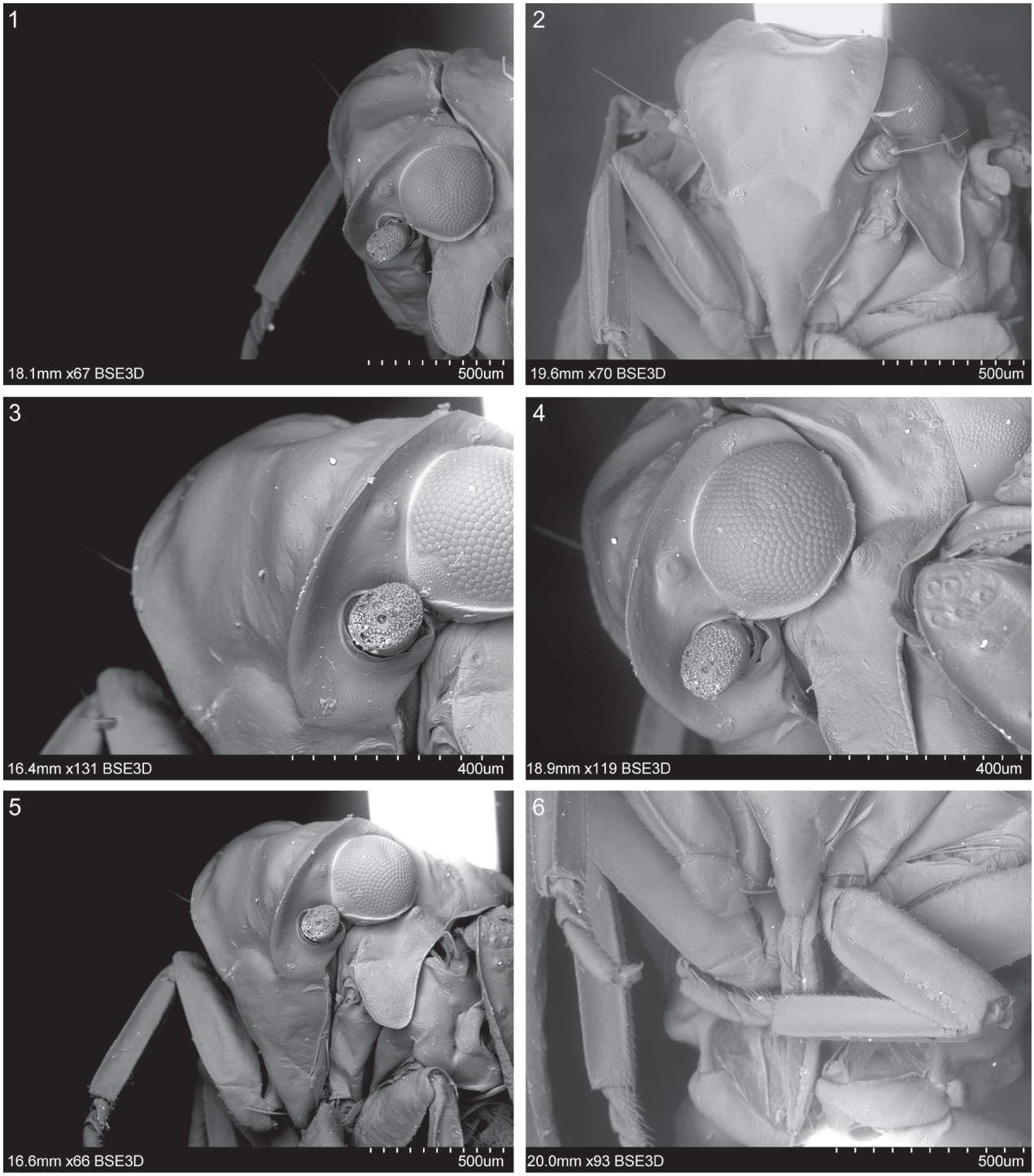
Tribe Selizini Distant, 1906

***Kelyflata* gen. nov.**
(Figs 1–29)

Type species. *Kelyflata capensis* **sp. nov.**, here designated.

Etymology. The generic name is an arbitrary amalgamation of the words "kely"—small in Malagasy language and "Flata", which is used here for the representative of the Flatidae family, and is descriptive for the small size of the specimen of the type species. Gender feminine.

Diagnosis. The new genus differs from the genus *Lembakaria* Świerczewski et Stroiński, 2019 by the following characters: frons with median carina (frons without median carina in *Lembakaria*), dorsal part of periandrium trilobate (dorsal part of periandrium bilobate in *Lembakaria*).

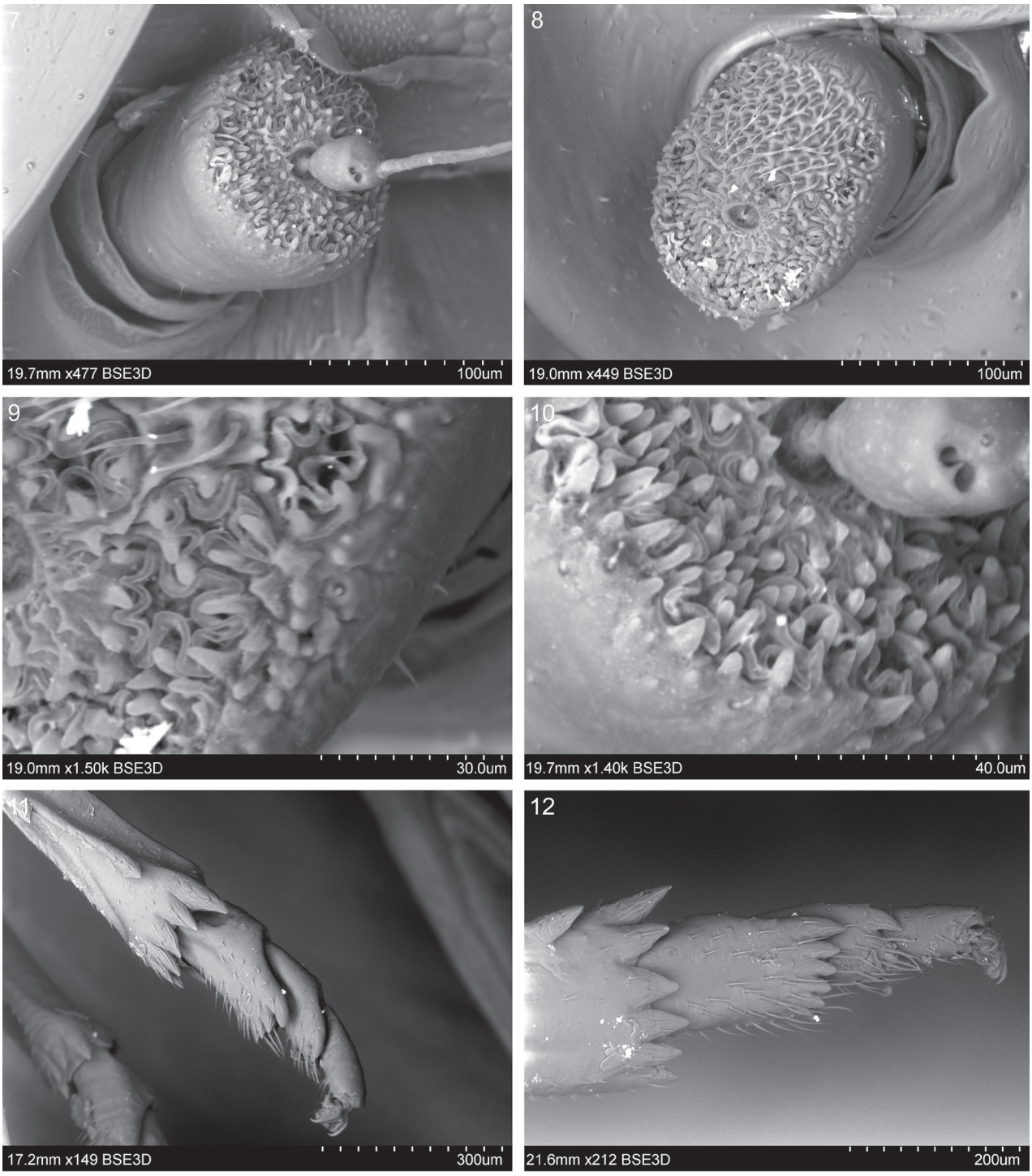


FIGURES 1–6. *Kelyflata capensis* **sp. nov.**, SEM photographs. (1) Anterior part of body, dorso-lateral view; (2) same, frontal view; (3) same, fronto-lateral view; (4) same, latero-dorsal view; (5) same; fronto-ventral view; (6) rostrum.

The new genus differs from the genus *Urana* Melichar, 1902 by the following characters: frons with median carina not diverged (frons with Y-shaped median carina in *Urana*), mesonotum without gibbosities (mesonotum

with four gibbosities in *Urana*), costal margin sinuate before apex, postclaval sutural margin straight (costal margin not sinuate before apex, postclaval sutural margin convex in *Urana*), clavus with slightly elevated base of A_1 vein (clavus with strongly elevated base of A_1 vein in *Urana*).

Description. HEAD. Head with compound eyes, in dorsal view, narrower than thorax. Vertex transverse, in the shape of hourglass, with very narrow median portion, medially slightly overlapped by pronotum; lateral margins carinate and subparallel, anterior margin carinate, arcuate (Fig. 1). Frons convex, widest at its lower third in frontal view; lateral margins carinate, arcuate and elevated, without incisions; upper margin almost straight; disc of frons with single carina, laterally with ridges; frontoclypeal suture strongly arcuate (Figs. 2, 3).

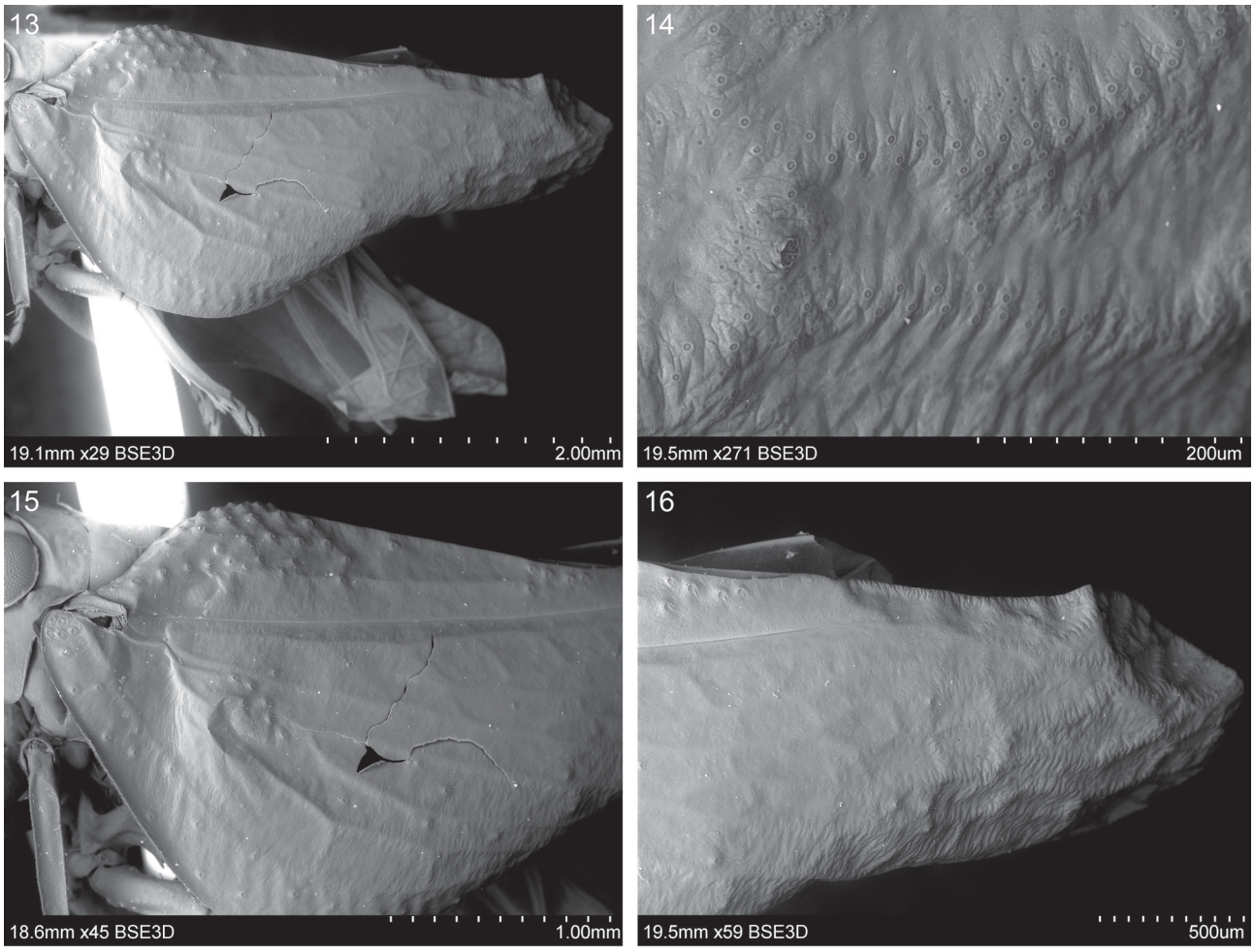


FIGURES 7–12. *Kelyflata capensis* **sp. nov.**, SEM photographs. (7–10) Antenna; (11) apical part of metatibia and metatarsus; (12) metatarsus, ventral view.

Clypeus smooth, weakly convex, without carinae (Fig. 2). Rostrum with apical segment shorter than subapical one, apex reaching between hind coxae (Fig. 6). Compound eyes oval, with narrow callus at posterior margin. Lateral ocelli present (Figs 4, 5). Antenna inserted very close to medio-ventral margin of eye; scapus small, ring-like, without setae; pedicel shorter than diameter of eye but distinctly longer than scapus, bulbous, functional area at the top and on dorsal surface with trichoid sensilla type 1, antennal plate organs present on apical concavity and basally delimiting lateral margins of dorsal functional surface (Figs 7–10).

Thorax. Pronotum, in dorsal view, shorter than mesonotum at midline; anterior margin arcuate, reaching the midlength of compound eyes, posterior margin slightly concave; pronotum disc wrinkled, without carinae, with lateral impressions and central pit; postocular eminences conical (Figs 1, 4). Mesonotum with scutellum widely deltoid, wider than long at midline; disc of mesonotum medially depressed with groove; lateral carinae as ridges, reaching posterior margin; scutellum with acute, elevated apex.

Tegmina longer than wide, subrectangular, with distinct venation and numerous transverse veinlets, without nodal line and with single apical line; costal margin sinuate, costal and sutural angle rounded, apical margin rounded, postclaval sutural margin straight (Figs 13–16). Costal area short, with dense transverse veinlets, ending before the level of fusion of claval veins. Costal cell about the same width as costal area, tapering apicad. Basal cell longer than wide. Tegmen with longitudinal veins ScRA and RP arising as short common stem from basal cell before bulla. Vein ScRA with fork distinctly after RP fork, ending on costal margin; vein RP with fork before MP fork, ending on costal margin; vein MP with fork distinctly basad to CuA fork, ending on apical and postclaval margins; CuA single or bifurcate after the postclaval suture. Apical cells subrectangular. Veins of apical half of tegmen wrinkled. Clavus in basal half elevated, posterior part concave; A_1 weakly elevated; Pcu and A_1 joined slightly anterior to clavus apex. Sensory and wax gland-plates concentrated on bulla, basal and apical part of clavus, costal area, with a few scattered on the whole tegmen (Figs 13, 15–16).



FIGURES 13–16. *Kelyflata capensis* **sp. nov.**, SEM photographs. (13) Left tegmen, general view; (14) same; vein sensory structures; (15) same, basal half; (16) same, apical half.

Pro- and mesofemur slightly shorter than tibiae, subrectangular in cross section. Pro- and mesotibia with shallow groove on external side; apical tarsomere of both legs longer than cumulative length of second and basal tarsomeres. Metatibia longer than metafemur, triangular in cross section with two lateral spines and apical row of spines—first lateral spine placed subapically, second lateral spine placed a bit after midlength, apical spines in formula 2 longer (external) + 5 shorter (internal); basitarsomere of metatarsus a bit longer than cumulative length of second and apical tarsomeres, with apical spines lined as semicircle—2 external spines a bit longer than 6 shorter internal spines; second tarsomere with lateral spines and median pad with setae. Metatibiotarsal formula: 2-2+5/8/2 (Figs 11–12).

Male terminalia. Anal tube, in lateral view, elongate, with breaking point before anus, tapering apicad; anus placed a bit after midlength (Figs 17, 23); in dorsal view, with rounded apex (Figs 18, 24). Pygofer, in lateral view, subrectangular with dorsal margin shorter than ventral margin, anterior margin concave. Genital style bearing short, hook-like capitulum with apex oriented anteriad (Figs 17, 23).

Phallic complex. Periandrium without any additional processes, about as long as aedeagus, in lateral view; lateral split reaching almost basal part of periandrium (Figs 19, 25).

Dorsal part of periandrium, in dorsal view, shorter than ventral part, trilobate, median lobe longer then lateral lobes, with spiniferous microsculpture. Ventral part of periandrium unilobate (Figs 21, 27). Aedeagus, in lateral view, long and narrow, apically with small, acute process oriented apicad and 1–2 processes oriented basad (Figs 20, 26); in ventral view, with deep median split, reaching almost basal part (Figs 22, 28).

Female terminalia. Female unknown.

Distribution. Madagascar: Toliara and Fianarantsoa provinces (Fig. 29).

Kelyflata capensis sp. nov

(Figs 1–22, 29)

Etymology. The specific epithet *capensis* refers to the *locus typicus* of the type species—Cape Sainte Marie, which is the southernmost point of Madagascar.

Diagnosis. The species differs from *Kelyflata ilakakae* by the following characters of male terminalia: anal tube elongate end ensiform (anal tube club-like in *K. ilakakae*); genital style triangular (genital style ovoid in *K. ilakakae*); periandrium elongate, tapering apicad (periandrium stout, with rounded apex in *K. ilakakae*); dorsal part of periandrium with median lobe short, club-like (dorsal part of periandrium with median lobe long and narrow in *K. ilakakae*); aedeagus with 1short process placed medially (aedeagus with 2 long processes placed in apical part in *K. ilakakae*)

Description. Measurements. Total length—4.75 mm. Vertex: ratio A/B = 21.00. Frons: ratio C/E = 1.10; D/E = 1.25. Pronotum: ratio F/B = 10.00. Mesonotum: ratio G/F = 3.80; G/B+F = 3.45; G/H = 0.90. Tegmina: I/J = 4.25; I/K = 2.30.

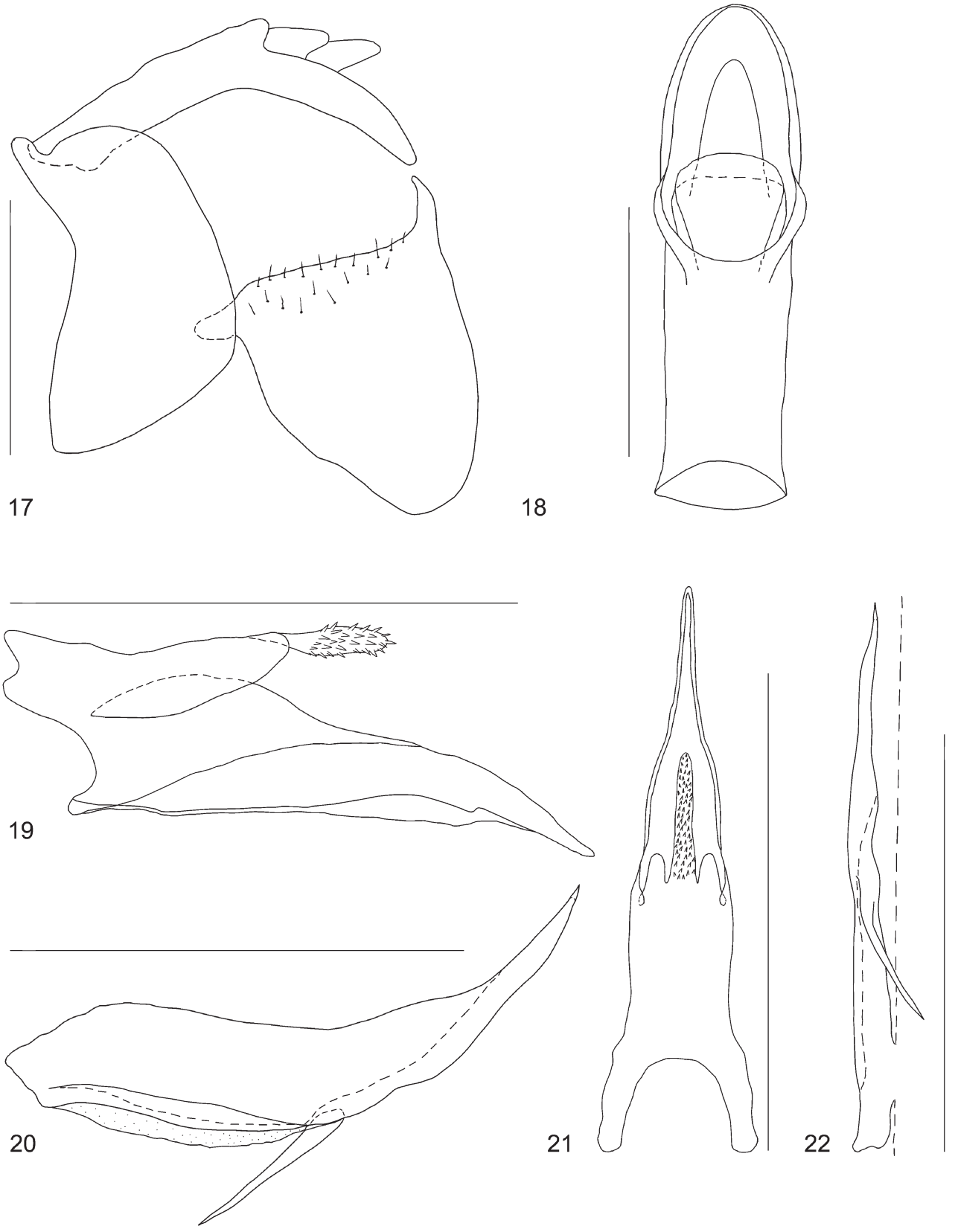
Male terminalia. Anal tube, in dorsal view, elongate end ensiform (Fig. 18). Pygofer, in lateral view, with sharp antero-ventral angle; anterior margin deeply concave, dorsal margin convex, postero-dorsal angle widely rounded, posterior margin convex. Genital style triangular (Fig. 17). Phallic complex. Periandrium elongate, tapering apicad (Fig. 19). Dorsal part of periandrium, in lateral view, distinctly shorter than ventral part, median lobe short, club-like. Ventral part of periandrium, in dorsal view, distinctly tapering apicad (Fig. 19). Aedeagus, in lateral view, with 1short process placed medially (Fig. 20).

Female terminalia. Female unknown.

Coloration. Ochreous, mottled, with scattered dark brown markings on tegmen, mesonotum and scutellum; tubercles orange.

Type material. Holotype, ♂: [CASENT 8107179], [MADAGASCAR:Tulear/ Province, Cap Ste Marie/ Special Reserve, el 37 m,/ 74 km S of Tsihombe, 25 Feb–7 March 2003], [25° 35.26’ S, 45° 09.78’ E/California Acad of Sciences / colls: M. Irwin, F. Parker,/R. Harin’Hala. malaise trap/spiny bush MA-02-23-39], [HOLOTYPE], [*Kelyflata capensis* **sp. nov**/det. D. Świerczewski & A. Stroiński]—(dry-mounted, abdomen dissected, terminalia in the vial pinned below the specimen, CAS)

Distribution and habitat. Madagascar: Toliara province (Fig. 29). The species occurs in southernmost part of the island, confined to spiny bush formation.

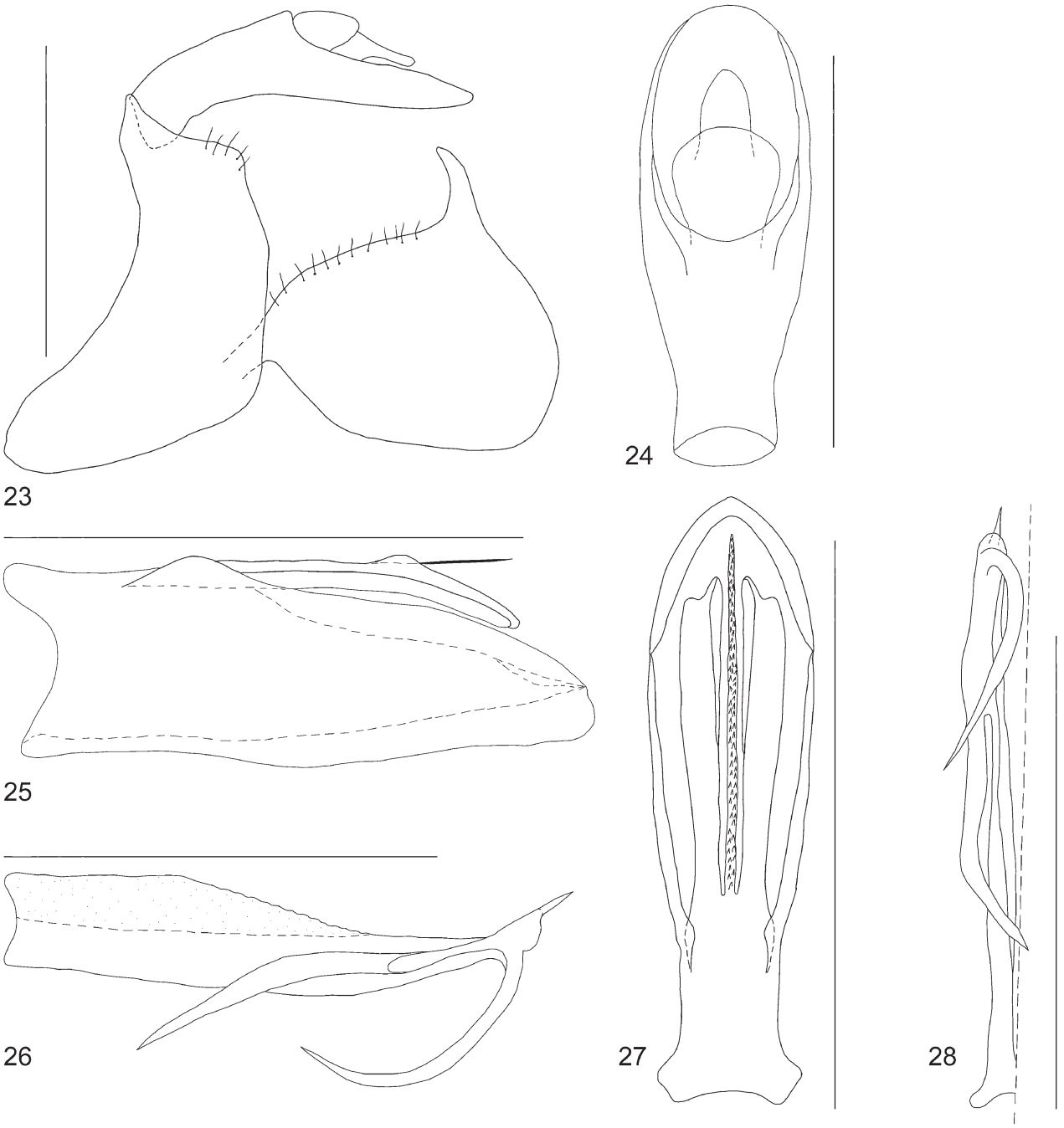


FIGURES 17–22. *Kelyflata capensis* **sp. nov.**, male, drawings. (17) Pygofer and anal tube, lateral view; (18) anal tube, dorsal view; (19) periandrium, lateral view; (20) aedeagus, lateral view; (21) periandrium, dorsal view; (22) aedeagus, ventral view. Scale bar-0.5 mm.

***Kelyflata ilakakae* sp. nov.**
(Figs 23–28, 29)

Etymology. The specific epithets is derived from the name of *locus typicus* of the species—Ilakaka, a small town in Ihorombe Region in the south western part of Madagascar.

Diagnosis. The species differs from *Kelyflata capensis* by the following characters of male terminalia: anal tube club-like (anal tube elongate end ensiform in *K. capensis*); genital style ovoid (genital style triangular in *K. capensis*); periandrium stout, with rounded apex (periandrium elongate, tapering apicad in *K. capensis*); dorsal part of periandrium with median lobe long and narrow (dorsal part of periandrium with median lobe short, club-like in *K. capensis*); aedeagus with 2 long processes placed in apical part (aedeagus with 1short process placed medially in *K. capensis*).



FIGURES 23–28. *Kelyflata ilakakae* **sp. nov.**, male, drawings. (23) Pygofer and anal tube, lateral view; (24) anal tube, dorsal view; (25) periandrium, lateral view; (26) aedeagus, lateral view; (27) periandrium, dorsal view; (28) aedeagus, ventral view. Scale bar-0.5 mm.

Description. Measurements. Total length—6.25 mm. Vertex: ratio A/B = 25.00 Frons: ratio C/E = 0.93; D/E = 1.11. Pronotum: ratio F/B = 11.00. Mesonotum: ratio G/F = 4.36; G/B+F = 4.00; G/H = 0.87. Tegmina: I/J = 4.25; I/K = 2.50.

Male terminalia. Anal tube, in dorsal view, club-like (Fig. 24). Pygofer, in lateral view, with bluntly rounded antero-ventral angle; anterior margin shallowly concave, dorsal margin descendent and shallowly concave, postero-dorsal angle sharp, posterior margin with breaking point before midlength. Genital style ovoid (Fig. 23). Phallic complex. Periandrium stout, with rounded apex (Fig. 25). Dorsal part of periandrium, in lateral view, a bit shorter than ventral part, median lobe long and narrow (Figs 25, 27). Ventral part of periandrium, in dorsal view, club-like (Fig. 27). Aedeagus with 2 long processes placed in apical part (Figs 26, 28).

Female terminalia. Female unknown.

Coloration**.** Similar to that of *K. capensis*.

Type material. Holotype, ♂: [CASLOT 044750], [MADAGASCAR: Province/ Fianarantsoa, radio tower/ 22 km SW of Ilakaka, near/ Fianarantsoa/Tulear border/27 Feb–6 March 2002], [22° 46.75'S, 45° 1.50'E/ coll: M. Irwin, R. Harin'Hala/ California Acad of Sciences/ malaise in Uapacca forest/ elev 1100 m, MA-02-12-10], [HOLOTYPE], [*Kelyflata ilakakae* **sp. nov**/det. D. Świerczewski & A. Stroiński]—(dry-mounted, abdomen dissected, terminalia in the vial pinned below the specimen, CAS).

Distribution and habitat. Madagascar: Fianarantsoa province (Fig. 29). The species is associated with *Uapaca* (tapia) woody formation.

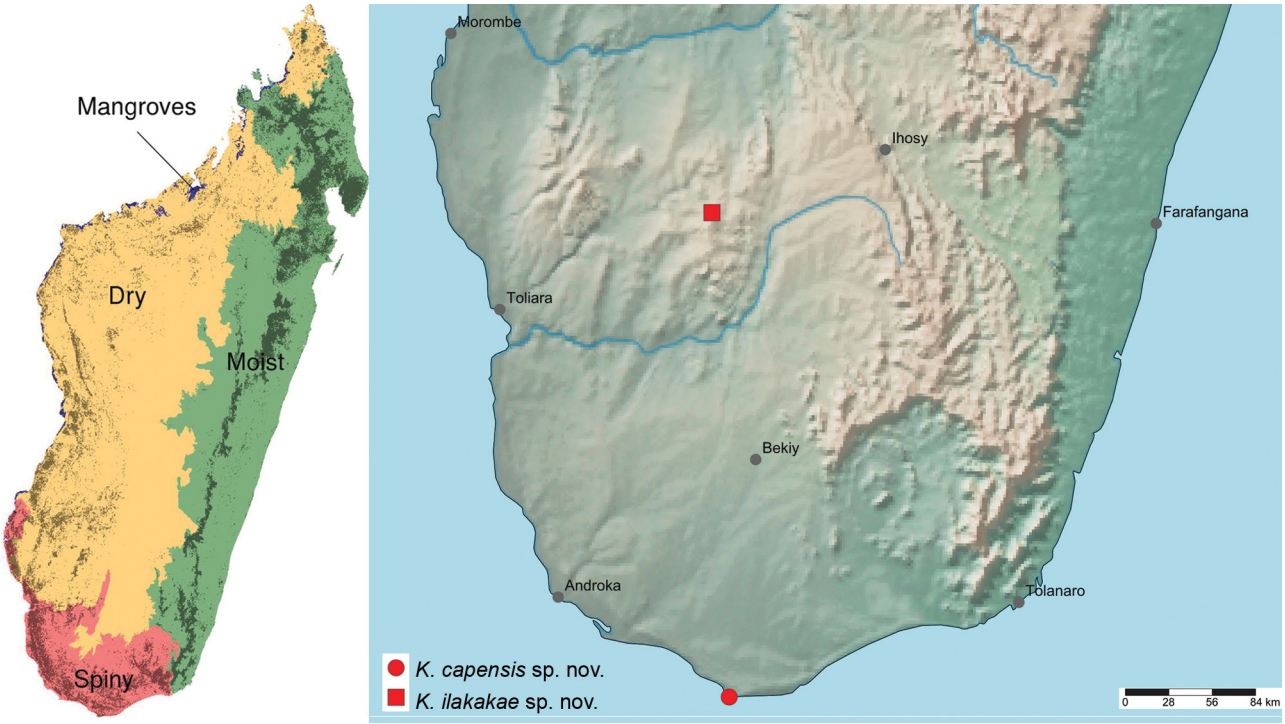


FIGURE 29. Ecoregions of Madagascar after Vieilledent *et al.* (2018). *Kelyflata* **gen. nov.**, distribution map.

Discussion

The newly described genus *Kelyflata* is another example of associations between Flatidae as phytophagous hemipterans and Madagascar vegetational formations they inhabit.

Kelyflata capensis was collected within the limits of Cap Sainte-Marie Special Reserve. The area belongs to the Androy region of Madagascar, also known as the "southern domain" extending from the Mandrare River in the east to the Menarandra River in the west, and from the sea to 150 km inland (Clark *et al.* 1998) and the cape is the southernmost point of this region. The climate is similar to those of semiarid deserts with average yearly rainfall less than 500 mm. The reserve was established to protect the biologically unique dry coastal spiny forests, one of the most threatened habitats within Madagascar, also classified as Didiereaceae-Euphorbia bush forest. The vegetation is dwarfed to less than 3 m in height due to coastal winds, which are an important factor in shaping the local land-

scape (Kelley 2011). The fauna of the region is highly endemic, including several representatives of vertebrates such as spider tortoise *Pyxis arachnoides* (Walker & Rafeliarisoa 2012) and two birds—littoral rock thrush (*Monticola imerinus*) and Verreaux's coua (*Coua verreauxi*) (Gardner & Jasper 2014, Wilmé *et al*. 2012).

Kelyflata ilakakae, together with previously described *Phlebopterum tapiae* Świerczewski et Stroiński, 2012, is associated with an endemic and endangered vegetation formation known as tapia woodlands, which in the past formed the transition zone between eastern rainforests and western dry forests (Koechlin *et al.* 1974). They are found in several widely scattered clusters, from Imamo just west of the capital, south to the Isalo Massif, ranging from 800 to 1.600 m above sea level (Kull 2002). Tapia woodlands are the most xerophytic of the broad-leaf evergreen forests of Madagascar, growing on the western slopes of the central highlands, where the dry season lasts up to seven months and the climate is warmer, drier and sunnier than the rest of the highlands. This forest type occurs as short, endemic, sclerophyllous formation with the dominance of tapia trees *Uapaca bojeri* and understory composed of immature trees, shrubs, various herbs and grasses.

In conclusion, both forest cover loss in Madagascar, together with degradation and fragmentation of its particular habitats are detrimental to the future survival of insects associated with endemic ecosystems. Moreover, the deep-in studies on particular insect groups will give us better understanding how the unique wildlife of the island was formed. The example can be Selizini flatids here, which seems to be more diverse in Madagascar than expected before, thus further studies on their associations with dry forests and scrubs can lead to more effective conservation practices in respect to current levels of habitat degradation and continued high rates of deforestation.

Acknowledgements

We would like to thank Dr Norman Penny for the privilege of studying the flatid material from the entomological collection of California Academy of Sciences (San Francisco, USA).

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