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Two new genera of flatid planthoppers from Socotra island (Hemiptera: Fulgoromorpha: Flatidae)

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Abstract. Two new monotypic genera of flatid planthoppers (Hemiptera: Fulgoromorpha: Flatidae) are described from Socotra island (Yemen): *Dixamflata* gen. nov. for *D. petri* sp. nov. and *Kesaflata* gen. nov. for *K. lubosi* sp. nov. Habitus, male and female external and internal genital structures of the new species are illustrated and compared to similar taxa. Both new genera share an "issid-like" habitus which evolved convergently in many unrelated planthopper groups distributed in arid and semi-arid zones of the world. They might be closely related to the western Palaearctic genera *Cyphopterum* Melichar, 1905 and *Riodeorolix* Lindberg, 1956. As both new species are sub-brachypterous and were collected in plant communities specific to Socotra, they may represent endemics of the island.

Key words. Auchenorrhyncha, Fulgoroidea, Flatidae, Flatinae, systematics, taxonomy, new species, endemism, Socotra, Afrotropical Region

Introduction

Socotra is the largest island of the Socotra archipelago, a governorate of the Republic of Yemen. It is situated in the Indian Ocean close to the Horn of Africa (Somalia) and the southern tip of the Arabian Peninsula. Socotra is well-known for its diverse flora and fauna including many endemic species (Wranik 2003, Miller & Morris 2004, Razzeti et al. 2011, Batelka 2012, Brown & Mies 2012). The island is relatively small (3625 km^2) but its origin as a continental fragment dates back to 15 million years ago at least, it has a diverse geology and geomorphology, and relatively intact ecosystems which can partly explain its unique biodiversity (Brown & Mies 2012, Leroy et al. 2012).

Despite a recent progress in inventories and taxonomy of insects in Socotra (Hájek & Bezděk 2012, 2014), some insect groups still remain inadequately known on the island. Planthoppers (Hemiptera: Fulgoromorpha), a species-rich group of phytophagous insects with the highest species diversity in the tropics and subtropics (O'Brien 2002, Bourgoin 2016), have been so far documented from Socotra only based on the lophopid *Elasmoscelis iram* Kirkaldy, 1899 (Kirkaldy 1899, 1903), which was later synonymized with the widely distributed Afrotropical species *E. trimaculata* Walker, 1851 (Distant 1910), and two endemic flatid genera – *Mosiona* Melichar, 1923, comprising three species (Melichar 1902, 1923), and the recently described monotypic *Kirkamflata* Świerczewski, Malenovský et Stroiński, 2014 (Świerczewski et al. 2014). However, the real planthopper diversity of the island is much higher as can be judged from unidentified material in museum collections and recent field work in Socotra. In this paper, we describe additional two new species and genera of Flatidae as another small step to a better knowledge of the Socotran fauna.

Material and methods

Material. The material studied is deposited in the entomological collections of the following institutions:

MMBC Moravian Museum, Brno, Czech Republic;
MZPW Museum and Institute of Zoology, Polish Academy of Sciences, Warsaw, Poland;
NMPC National Museum, Prague, Czech Republic.

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

Preparations and illustration. The abdomens of some specimens examined were removed and cleared for 30 min in warm (50°C) 10% KOH solution, for females with a few drops of chlorazol black (CAS No. 1937–37–7) 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 glycerol using a camera lucida attached to a light microscope. All colour images were taken using a stereomicroscope Leica MZ 16 with digital camera IC 3D; final images were produced using Helicon Focus and Adobe Photoshop software. 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	measured (in dorsal view) from head apex to tegmina apex;
A/B	width of vertex measured at anterior margin / length of vertex measured 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 measured from the base to the apical margin in median portion / width of tegmen measured from the apex of clavus to the anterior margin.

Terminology. The nomenclature of forewing (tegmen) veins follows the interpretation proposed by 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. Nomenclature of plants follows Miller & Morris (2004) and Brown & Mies (2012). Geographical names of localities are spelled according to Bezděk et al. (2012).

Taxonomy

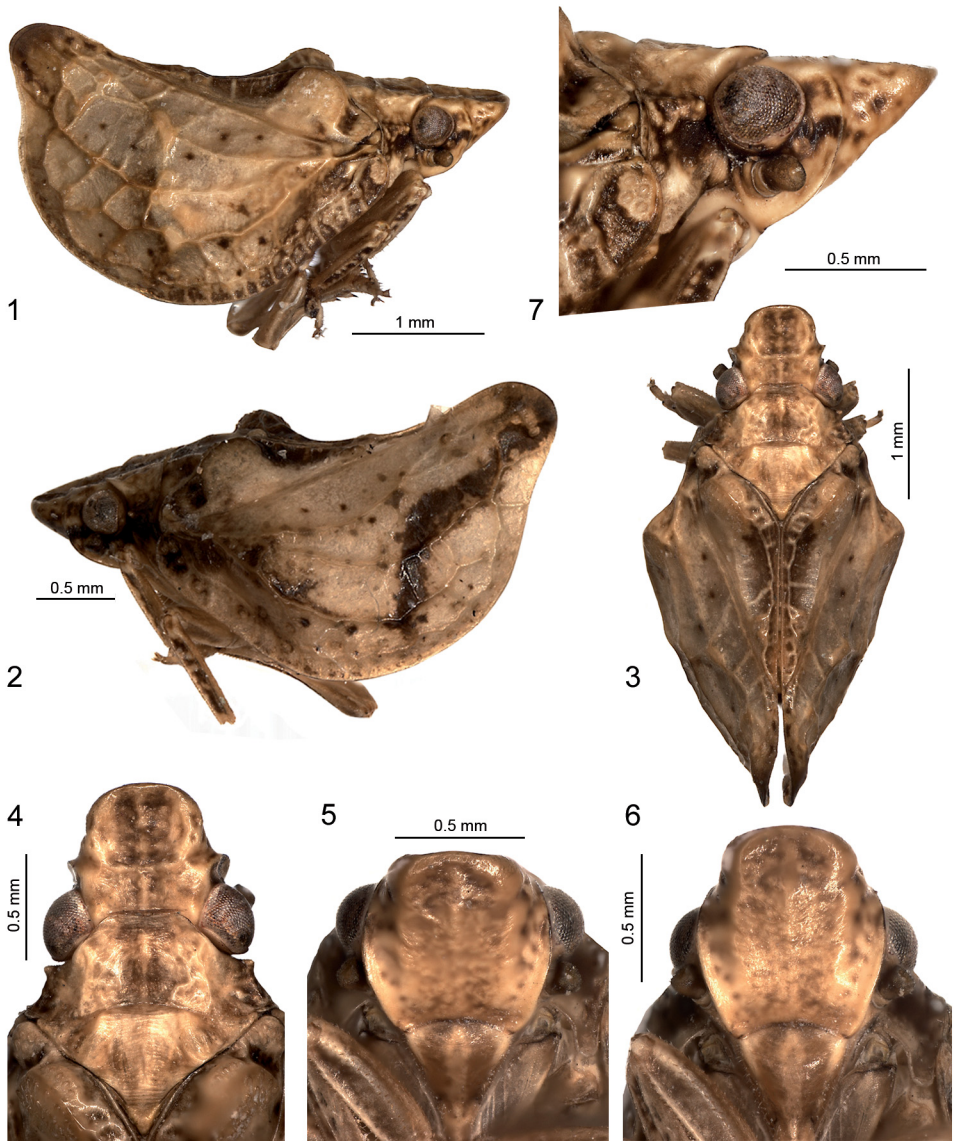
Dixamflata gen. nov.

(Figs 1–52)

Type species. *Dixamflata petri* sp. nov., here designated.

Diagnosis. Frons with large, apically broadly rounded crown in upper part, median carina, and intermediate carinae present as ridges forming horseshoe shaped bulge anteriorly. Tegmina short ("sub-brachypterous"), coriaceous with apical part produced and several groups of sensory sensilla (tubercles) on the surface; clavus with A_1 basally strongly elevated. Male and female anal tube, in lateral view, elongate and curved, tapering apicad; in dorsal view basal part wider than apical part, anus situated near midlength in males, in basal half in females. Genital style with short ventroapical tooth-like process on inner side. Dorsal part of periandrium with a single one-armed process; ventral part with median keel. Female anal tube reaching posterior margin of gonoplac. Gonoplac unilobate, sub-rectangular, posterior margin with two rows of teeth. Bursa copulatrix with single pouch.

Description. ***Head*.** Head with compound eyes, in dorsal view, narrower than thorax (Figs 3, 10, 11). Vertex transverse, shorter than pronotum, trapezoidal, with posterior margin carinate, lateral margins obsolete, anterior margin visible as transverse ridge at mid-length of head in dorsal view; disc without carina (Figs 4, 9–13). Frons with well-developed crown in dorsal view – semicircular, longer than vertex in midline, dorsal portion depressed medially and with short median ridge in anterior part that is visible in oblique anterior view; lateral margins of frons carinate, regularly arcuate in both lateral and ventral views, without incisions (Figs 5, 7, 8, 13–16); disc of frons, in ventral view, with intermediate carinae developed as obsolete ridges and forming horseshoe-shaped bulge anteriorly, median carina present; frontoclypeal suture arcuate, ventral margin of frons slightly concave (Figs 5, 6, 15, 16). Clypeus without carinae (Figs 15, 16). Rostrum with apical segment shorter than subapical one, narrowing to apex, apex reaching hind coxae (Fig. 17). Compound eyes rounded, with small callus at posterior and ventral margins. Lateral ocelli absent (Figs 1, 2, 7–9, 13, 14). Antenna located ventrally in respect to eye; scapus distinctly shorter than diameter of eye, cylindrical, scarcely covered with short setae; pedicel shorter than diameter of eye but distinctly longer than scapus, barrel-shaped, apical part concave, functional area at the top and on dorsal surface with trichoid sensilla type 1, antennal plate organs present on apical concavity and delimiting laterally dorsal functional surface (Figs 7, 18, 19).



Figs 1–7. *Dixamflata petri* gen. & sp. nov. 1 – habitus, lateral view; 2 – habitus of another specimen, lateral view; 3 – habitus, dorsal view; 4 – anterior part of body, dorsal view; 5–6 – same, frontal view; 7 – same, lateral view.

***Thorax*.** Pronotum disc with median ridge and lateral gibbosities, not reaching posterior and anterior margins; area between median ridge and gibbosities depressed; postocular eminences small and conical; anterior margin of pronotum medially produced till half of eye length, with median incision; posterior margin widely and shallowly concave (Figs 3, 4, 10–13). Mesonotum triangular; short keel-shaped median carina present only in median portion; lateral carinae in form of ridges, subparallel, reaching both anterior and posterior margins; area between median carina and lateral ridges depressed; scutellum posteriorly sharply angled (Figs 3, 4, 10–13).

Tegmen coriaceous, irregularly convex with distinct venation; costal margin strongly arcuate, convex, weakly concave in apical one fifth, costal angle widely, bluntly rounded; sutural angle bearing a large, rounded hump produced dorsally, postclaval sutural margin short, ending a bit posterior to second ScRA terminal; apical part of tegmen produced posteriorly and narrowly rounded, relatively longer and slender in males, shorter and more robust in females (Figs 22–28). Costal area narrower than postcostal cell, with ca. 14–20 transverse veinlets, terminating anterior to level of clavus apex; postcostal cell with several (ca. 4) transverse veinlets. Basal cell long and narrow; ScRA+RP leaving basal cell with common stem, ScRA elevated, RP between basal cell and bulla obsolete; ScRA ending with two terminals, not extending to the level of clavus; RP single, terminating at posterior margin posterior to clavus apex; MP forking posterior to the sensory area, ending with 4–5 obsolete terminals; CuA single, terminating at postclaval margin. Clavus with A_1 basally strongly elevated, area between Pcu and A_1 concave; Pcu and A_1 fused anterior to clavus apex; several transverse veinlets between A_1 and A_2. Tubercles present on the whole tegmen with concentration in the following parts: basal part of clavus – between A_1 and A_2 and between Pcu and A_1, basal part of costal membrane, and on bulla between ScRA and RP (Figs 22, 24, 28). Sensory sensilla long and thin with blunt apex, present on whole tegmen except apical part, where shorter and thicker sensilla with sharp apex are present (mostly broken-off on dry specimens) (Figs 29, 30). Hindwing well developed.

Femora shorter than tibiae; hind tibiae weakly curved, triangular in cross section, with two lateral spines placed in distal half, apically with row of seven well-developed spines (5 short + 2 long); basitarsomere slightly longer than cumulative length of tarsomeres 2 and 3, with row of eight apical spines and setae; second tarsomere with two lateral spines and median pad with thick setae (Figs 20, 21).

***Male terminalia*.** Anal tube, in lateral view, elongate and curved, tapering apicad; anus placed at midlength (Figs 31, 32, 35); in dorsal view elongate, tapering apicad, apically concave in median portion, widest slightly anterior to anus (Figs 33, 34). Pygofer, in lateral view higher than long, dorsal part narrower than ventral part, anterior and posterior margins arcuate (Figs 31, 32, 35). Genital styles longer than wide and bearing long, dorsocaudal, arcuate capitulum; dorsal margin straight without concavity and extra fold, posterior and ventral margins weakly convex, posteroventral angle with short, blunt process on inner side (Figs 31, 32, 35).

Phallic complex. Periandrium elongate, upcurved, slightly longer than aedeagus, apical part wider than basal part; lateral split not reaching midlength (Figs 36, 37). Dorsal part of periandrium almost as long as ventral part, apically with distinct appendage divided into short base and one-armed process. Ventral part of periandrium, in cross-section, V-shaped, with additional distinct, median keel in apical two thirds; in ventral view, unilobate, tapering apicad, with lateral margins serrate. Basal part of periandrium with long and narrow lateral lobe. Aedeagus long, with apical, bulb-like, sclerotized appendages; deep median split reaching basal part; shaft of aedeagus curved (Figs 38, 39).

Female terminalia. Pregenital sternite with X-shaped, strong sclerotization in median portion; posterior margin with long and narrow, arcuate fold (Figs 42, 43, 46). Anal tube, in lateral view (Figs 41–43), curved ventrad, tapering apicad, with bluntly rounded apex; anal tube covering gonoplac and reaching its posterior margin; anus placed in basal half; in dorsal view, elongately oval; posterior margin in median portion with shallow incision (Figs 40, 44, 45). Gonoplac unilobate, sub-rectangular; posterior margin with two rows of teeth; dorsal part of posterior margin to the level of teeth limit well sclerotised, ventral part membranous without setae (Figs 41–43, 45, 47). Gonapophysis VIII (Fig. 48) triangular, laterally flattened; dorsal margin sinuate, ventral margin arcuate and slightly up-folded; both margins with subapical teeth; endogonocoxal process about as long as gonapophysis, distinctly tapering apicad, membranous with distinct spiniferous microsculpture. Gonospiculum as in Figs 49–50. Bursa copulatrix with single pouch, kidney-shaped, cells with weakly sclerotized central areas with microsculpture on the surface (Fig. 51). Spermatheca well developed, ductus receptaculi slightly longer than diverticulum ductus (Fig. 52).

Remarks. *Dixamflata* differs from the two flatid genera so far recorded from Socotra, i.e. *Mosiona* and *Kirkamflata*, in a much smaller size, short coriaceous tegmina and coloration (both *Mosiona* and *Kirkamflata* are large, macropterous, with membranous tegmina, and uniformly dark brown or yellowish-green, respectively: Melichar 1923, Świerczewski et al. 2014). *Dixamflata* is similar in habitus to *Kesaflata* gen. nov. described here below – see the Remarks section under the latter for diagnostic characters as well as the Discussion for a comparison with other similar genera in a wider region.

Etymology. The generic name is a combination derived from "*Dixam*", a local name of the highland plateau on southern slopes of the Hagher mountains where the type species was collected, and "*Flata*" which is used here for a representative of the Flatidae family. Gender feminine.

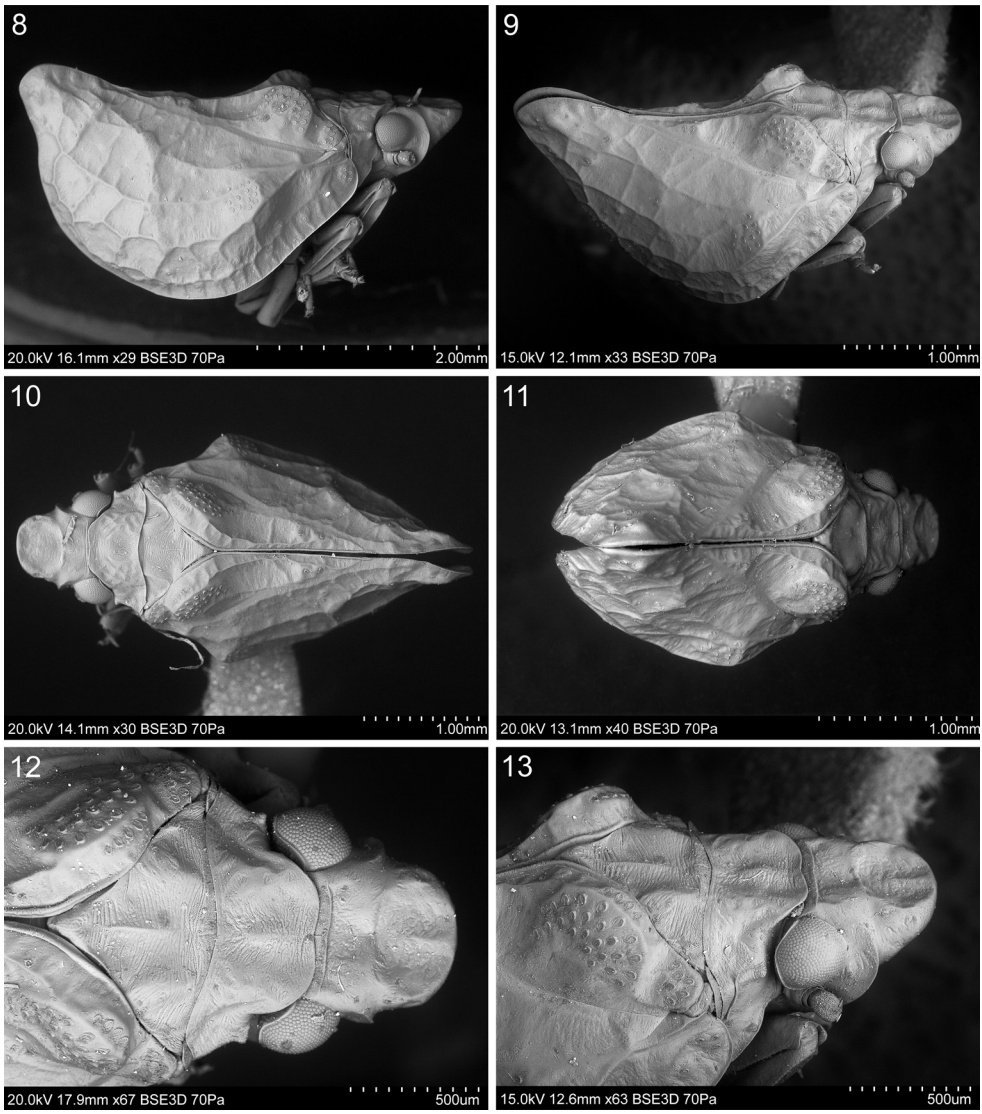
Distribution. Yemen: Socotra island.

Dixamflata petri sp. nov.

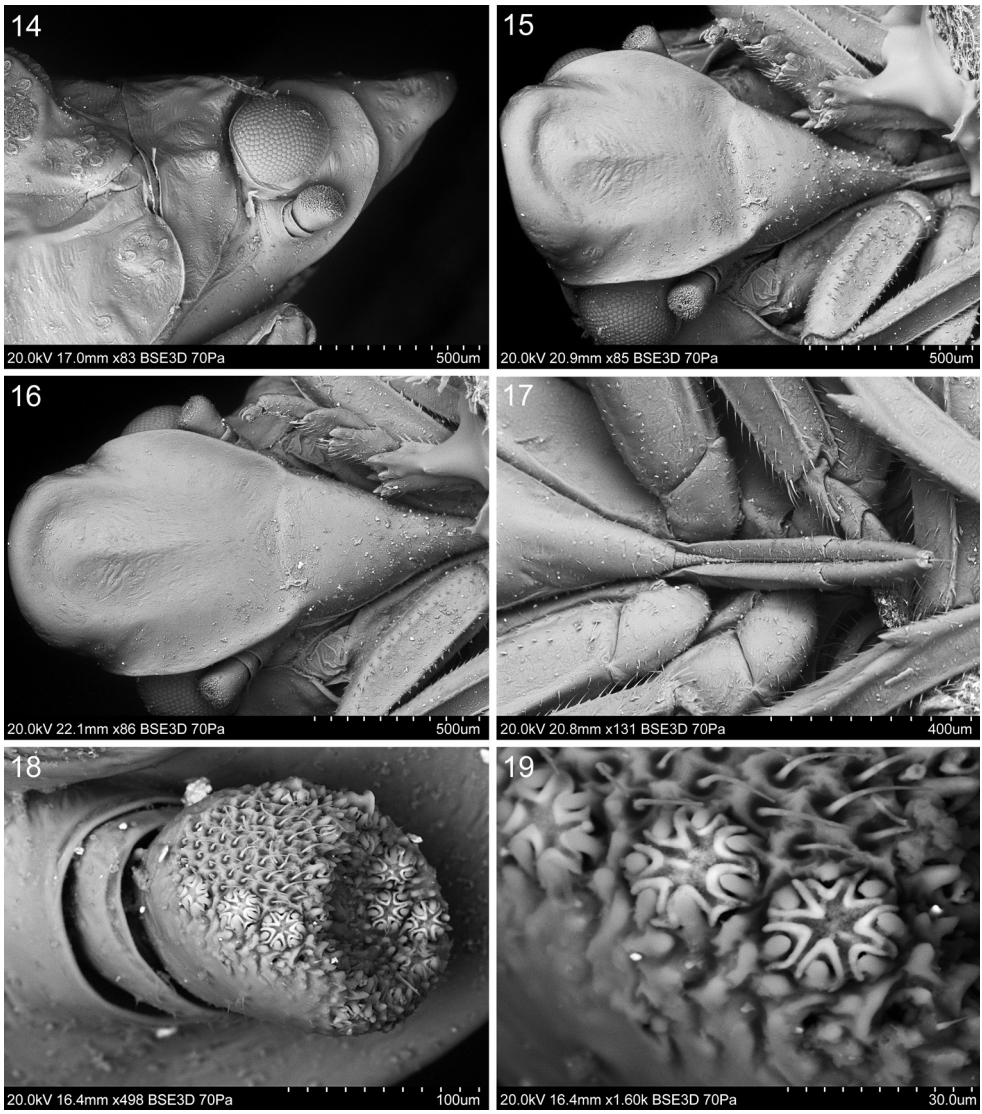
(Figs 1–52)

Type locality. Yemen, central Socotra, southern slopes of the Hagher mountains on the edge of the Dixam plateau, Tudhen, 12°32.7′N, 53°59.9′E, 1135 m a.s.l. (Fig. 75).

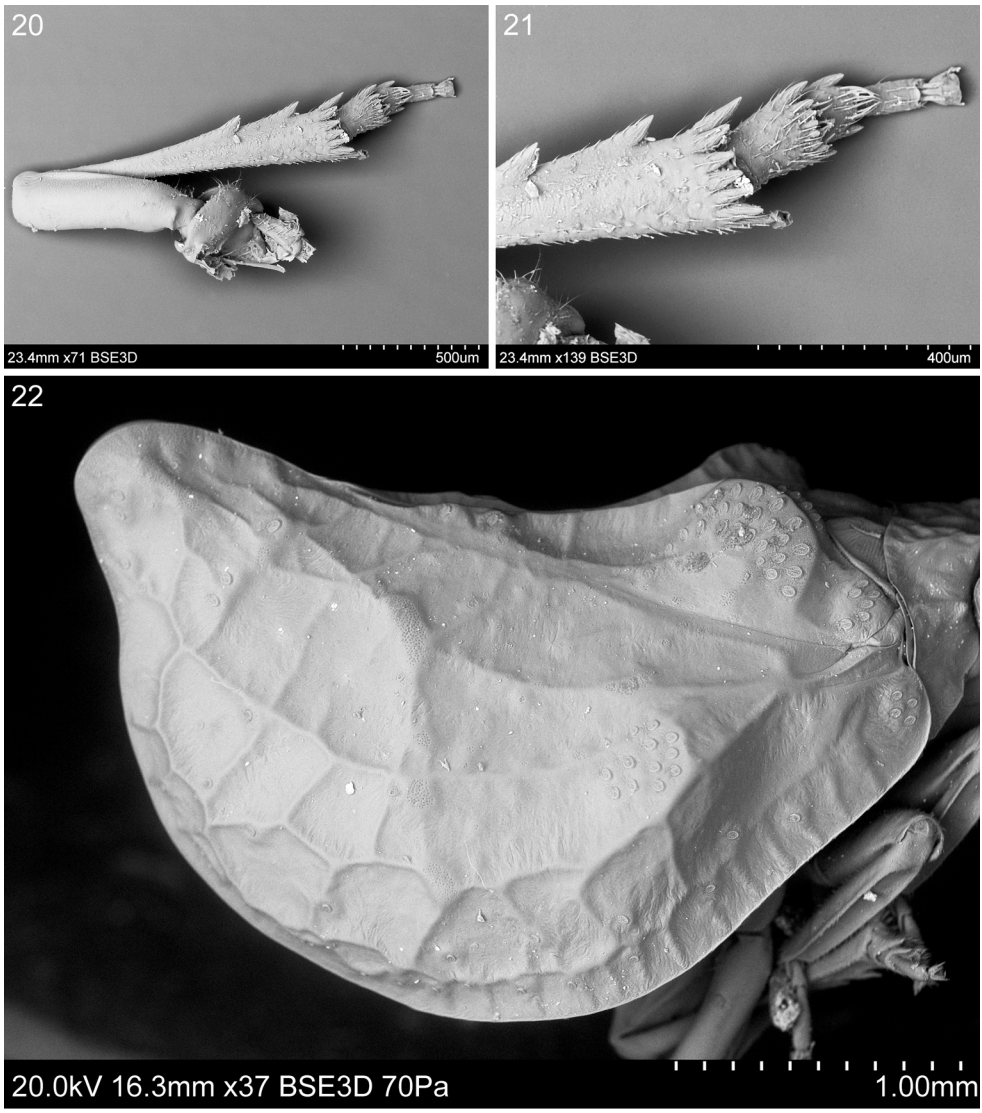
Type material. Holotype: ♂, "YEMEN, SOCOTRA Island / Dixam Plateau, Tudhen / 12°32.7′N, 53°59.9′E, 1135 m / montane shrubland with / *Commiphora planifrons*, 22.vi.2012 // SOCOTRA expedition 2012 / I. Malenovský, P.



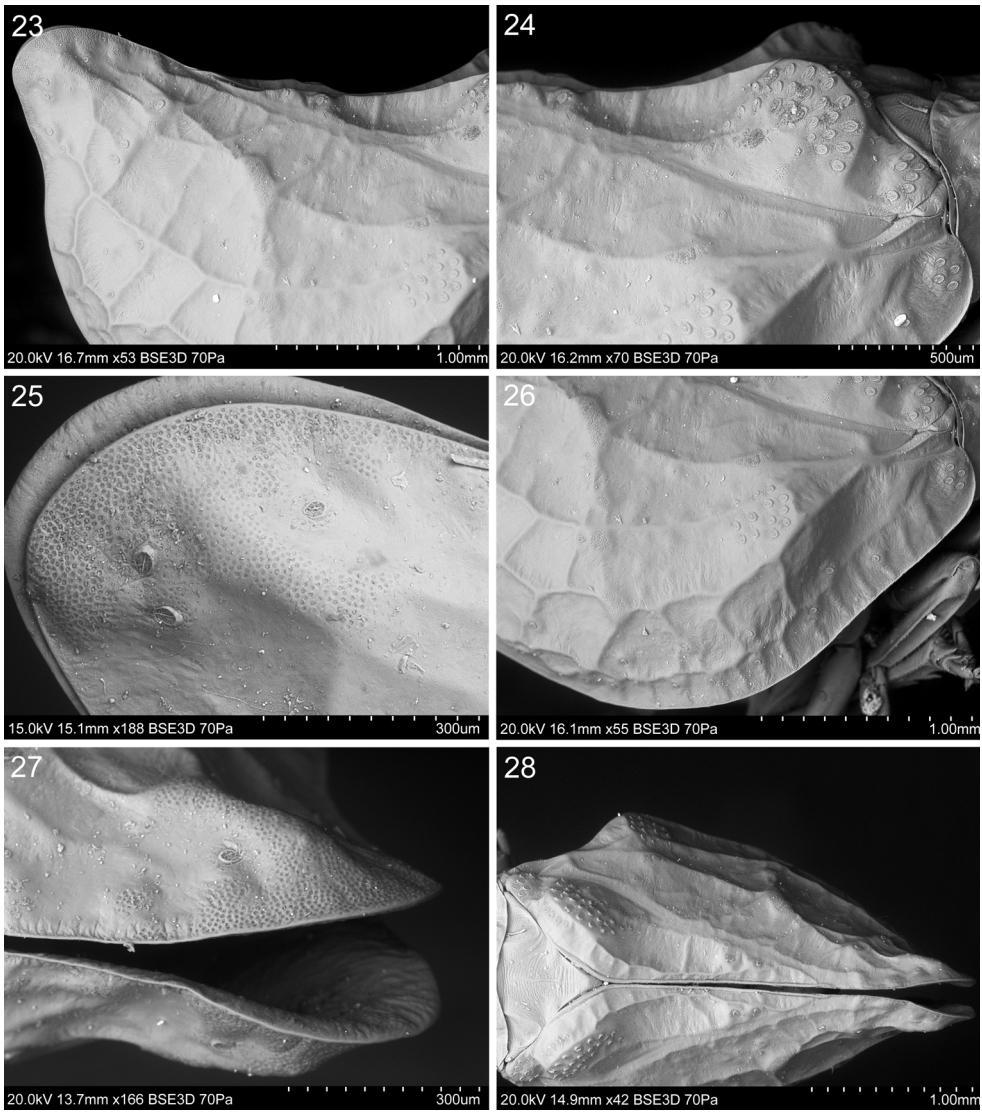
Figs 8–13. *Dixamflata petri* gen. & sp. nov., SEM micrographs. 8 – habitus, lateral view; 9 – same, dorso-lateral view; 10 – same, dorsal view; 11 – same, dorso-caudal view; 12 – anterior part of body, dorsal view; 13 – same, dorso-lateral view.



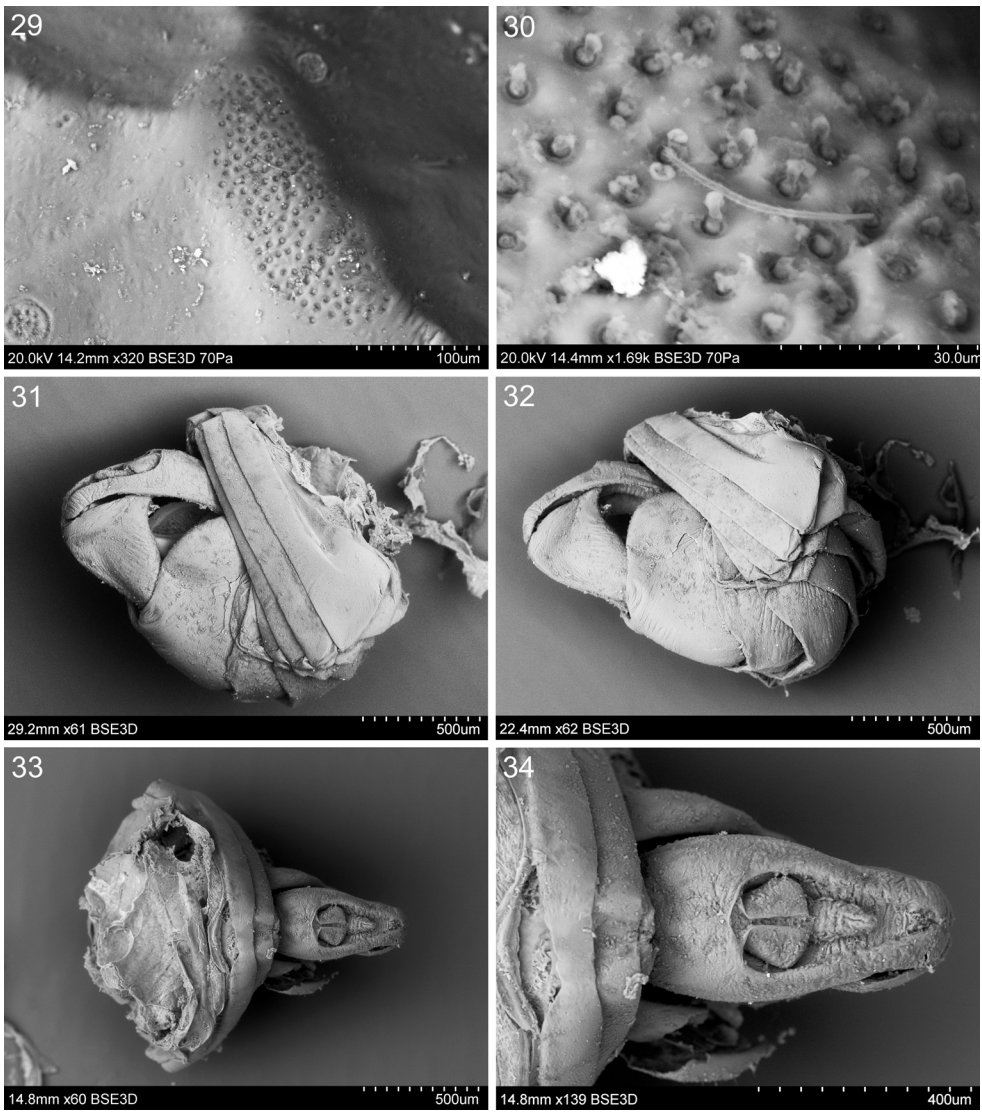
Figs 14–19. *Dixamflata petri* gen. & sp. nov., SEM micrographs. 14 – anterior part of body, lateral view; 15–16 – frons, frontal view; 17 – rostrum, ventral view; 18 – antenna, dorso-lateral view; 19 – antennal plate organs.



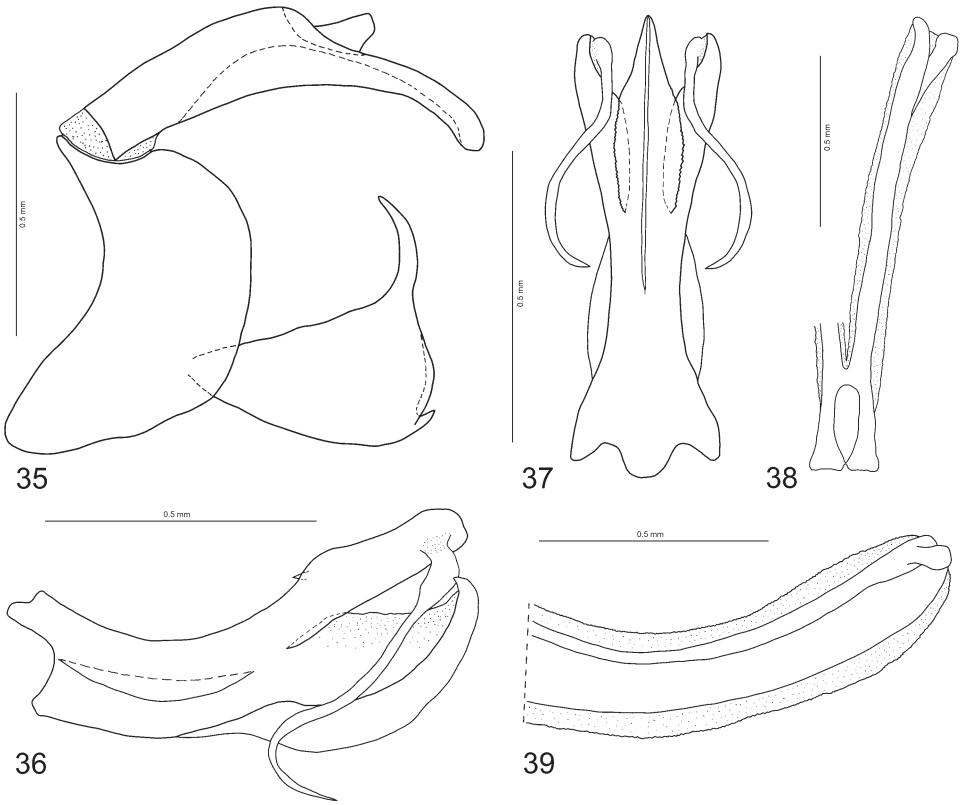
Figs 20–22. *Dixamflata petri* gen. & sp. nov., SEM micrographs. 20 – hind leg, general view; 21 – hind leg, apical part; 22 – tegmen, lateral view.



Figs 23–28. *Dixamflata petri* gen. & sp. nov., tegmen, SEM micrographs. 23 – apical part; 24 – basal part; 25 – caudal part, lateral view; 26 – ventral part; 27 – caudal part, dorsal view; 28 – clavus, dorsal view.



Figs 29–34. *Dixamflata petri* gen. & sp. nov., SEM micrographs. 29–30 – tegmen, sensory area; 31–32 – male abdomen, lateral view; 33 – same, dorsal view; 34 – anal tube, dorsal view.

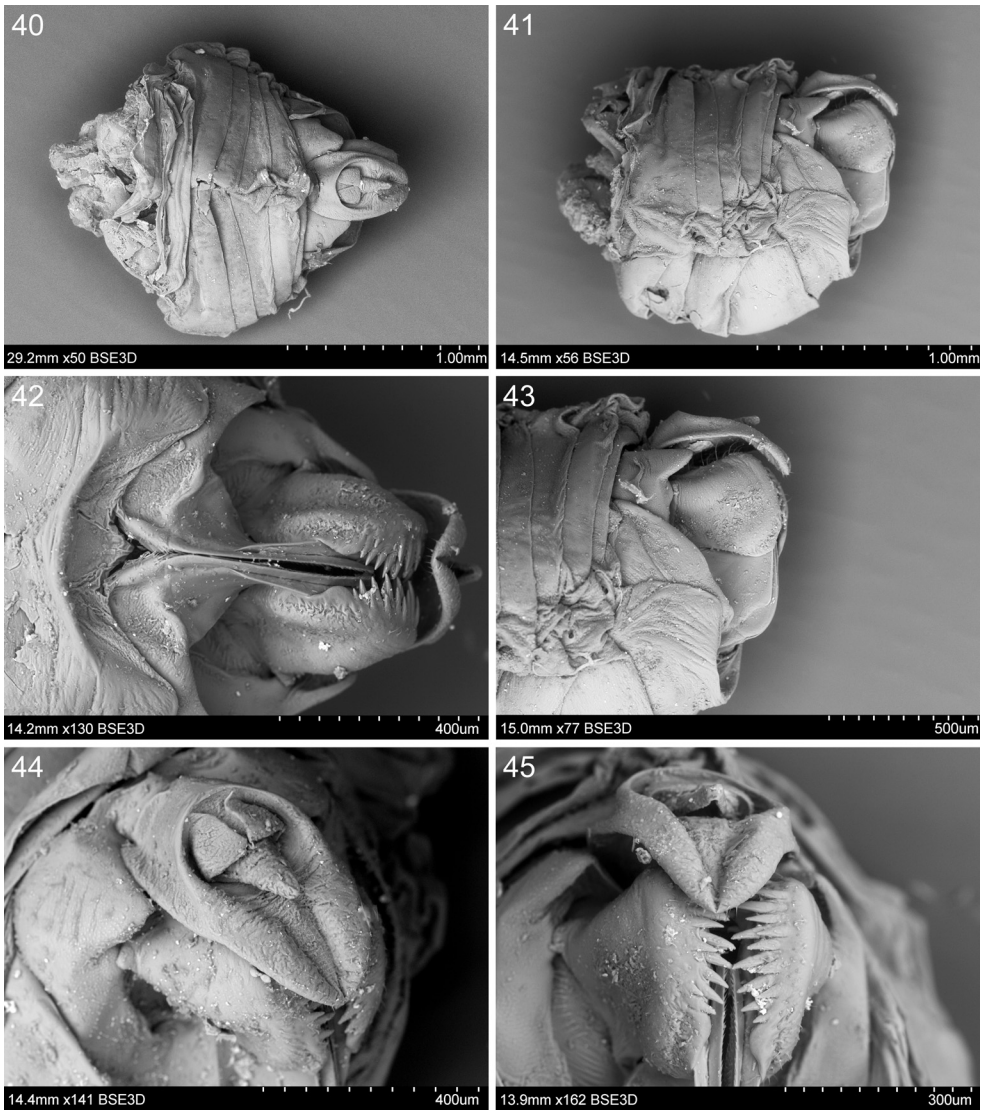


Figs 35–39. *Dixamflata petri* gen. & sp. nov., male. 35 – male terminalia, left lateral view; 36 – periandrium, lateral view; 37 – same, ventral view; 38 – aedeagus, ventral view; 39 – aedeagus, lateral view.

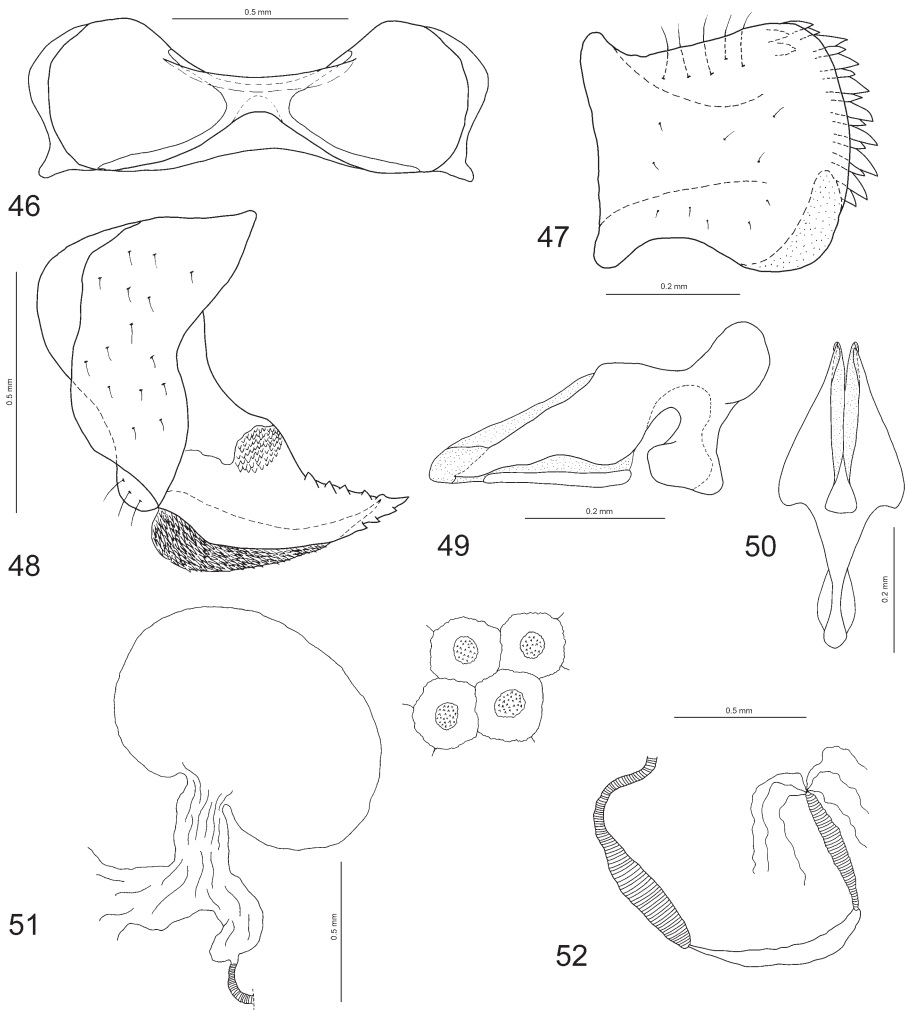
Kment, / J. Bezděk, J. Hájek, V. Hula / J. Niedobová & L. Purchart leg. // HOLOTYPE / *Dixamflata* / *petri* sp. nov. / det. A. Stroiński, I. Malenovský / & D. Świerczewski 2016" (MMBC, dry-mounted, abdomen detached, dissected and stored in plastic vial with glycerol under the specimen). Paratypes: 13 ♂♂ 4 ♀♀, same data as holotype (6 ♂♂ 2 ♀♀ MMBC, 3 ♂♂ 1 ♀ MZPW, 4 ♂♂ 1 ♀ NMPC); 1 ♂, "YEMEN, SOCOTRA Island / Hagher Mts., wadi Madar / 12°33.2′N, 54°00.4′E, 1170 m / montane shrubland with / *Cephalocroton socotranus*, 18.vi.2012 // SOCOTRA expedition 2012 / I. Malenovský, P. Kment, / J. Bezděk, J. Hájek, V. Hula / J. Niedobová & L. Purchart leg. (MMBC); 1 ♂, "YEMEN, SOCOTRA Island, Zemhom area [= Aloove village env., see Bezděk et al. (2012)], 270-350m, N 12°30′58″ E 54°06′39″, 3.-4.ii.2010, at light, L. Purchart & J. Vybiral leg." (MMBC); 1 ♂ 1 ♀, "YEMEN, SOCOTRA Island, Scant area, 1300-1500m, N 12°34′33″ E 54°01′31″E, 31.i.-1.ii.2010, L. Purchart" (MMBC). Each paratype bearing "PARATYPE / *Dixamflata* / *petri* sp. nov. / det. A. Stroiński, I. Malenovský / & D. Świerczewski 2016" label.

Diagnosis. The only species in the genus.

Description. ***Measurements***. Total length 3.1–3.8 mm. Vertex: A/B 2.50–3.64. Frons: C/E 0.58–0.71; D/E 0.88–1.02. Pronotum: F/B 1.43–2.45. Mesonotum: G/F 1.33–1.80; G/B+F 0.90–1.11; G/H 0.50–0.62. Tegmina: I/J 1.62–2.09.



Figs 40–45. *Dixamflata petri* gen. & sp. nov., female, SEM micrographs. 40 – abdomen, dorsal view; 41 – abdomen, lateral view; 42 – terminalia, ventral view; 43 – terminalia, lateral view; 44 – anal tube, dorso-lateral view; 45 – terminalia, caudal view.



Figs 46–52. *Dixamflata petri* gen. & sp. nov., female. 46 – pregenital sternite, flattened, ventral view; 47 – right gonoplac, external view; 48 – gonapophysis VIII, lateral view; 49 – gonapophyses IX and gonospiculum bridge, lateral view; 50 – same, dorsal view; 51 – bursa copulatrix with cells, lateral view; 52 – spermatheca.

***Coloration*.** General coloration light brown, mottled darker brown (Figs 1–7); darker spots concentrating and fusing into dark bands in some specimens, especially on tegmen subapically and apically, along sutural margin of clavus and costal margin (Fig. 3), as well as on head and thorax along dorsal midline (Figs 3, 4). Legs ochreous, outer surface of tibiae mottled dark brown. Male abdomen dark yellow to brown, terminalia lighter than abdomen, ochreous; female abdomen light brown.

Structure. *Head.* Vertex slightly widening anterior to eyes; disc weakly depressed in median portion (Figs 4, 12, 13). Frons with median carina distinct only in median portion (Figs 15, 16). Clypeus weakly convex (Figs 16, 17).

Thorax. Pronotum with median ridge weakly visible, incision of anterior margin shallowly depressed (Figs 12, 13).

Male genitalia. Process of periandrium well-sclerotized, long, oriented ventro-basad with apical part bent posteriorly (Fig. 36). Lateral lobe of periandrium less chitinized than ventral periandrium. Ventral and dorsal margins of aedeagus denticulate (Fig. 38).

Female terminalia and genitalia. Pregenital sternite with anterior margin weakly arcuate and posterior margin shallowly concave (Fig. 46). Gonoplac with row of larger teeth and row of smaller teeth (Figs 42, 45, 47). Gonapophysis VIII with teeth of ventral margin placed more distally than teeth of dorsal margin (Fig. 48). Bursa copulatrix kidney-shaped, cells with weakly sclerotized central areas with microsculpture on the surface (Fig. 51). Spermatheca with ductus receptaculi ribbed, with narrow basal part and widened apical part; diverticulum ductus smooth, widening apicad (Fig. 52).

Etymology. Dedicated to our friend and colleague Petr Kment (National Museum, Prague) in acknowledgement of his vital help to Igor Malenovský on the field trip to the Hagher mountains during which the major part of the type series was collected.

Habitat and occurrence in Socotra. Probably hygrophilous and confined to herbaceous vegetation in open marshy patches at high altitudes of the Hagher mountains in central Socotra. All specimens from the type locality (Tudhen) were found in a relatively small open area of a helocrene spring, where they were collected by suction sampling and sweeping from herbaceous vegetation dominated by rigid tussocks of *Juncus socotranus* (Juncaceae), swards of *Cyperus* sp. (Cyperaceae), and low dense cushions of *Bacopa monieri* (Plantaginaceae) and *Exacum caeruleum* (Gentianaceae), some of which may be the host plant(s). The area was grazed by cattle and situated within an extensive sparse montane shrubland dominated by *Commiphora planifrons*, *Cephalocroton socotranus*, *Croton sulcifructus*, and *Croton socotranus* (Figs 75–76). Another specimen was collected in very similar conditions in a small marsh along a mountain brook (wadi Madar, Fig. 77).

Distribution. So far only known from the highlands in central Socotra.

Kesaflata **gen. nov.**

(Figs 53–74)

Type species. *Kesaflata lubosi* sp. nov., here designated.

Diagnosis. Frons not produced anteriad, with median carina, and short sinuate intermediate carinae. Vertex, pronotum and mesonotum with a median groove. Tegmina short ("sub--brachypterous"), coriaceous, with apex narrowly rounded; clavus with A_1 basally strongly elevated. Female anal tube, in lateral view, with convex lateral lobes, reaching posterior margin of gonoplac; in dorsal view, widest medially, anus placed in posterior half. Gonoplac unilobate, sub-rectangular, posterior margin with two rows of teeth, ventral margin with large membranous lobe. Bursa copulatrix with single pouch.

Description. ***Head*** with compound eyes, in dorsal view, narrower than thorax (Figs 54, 57, 60–62). Vertex transverse, shorter than pronotum; anteriorly produced anterior margin

obsolete; lateral margins elevated, carinate, parallel; posterior margin weakly concave; disc without carina, but with median groove (Figs 54, 57, 60–62). Frons without protrusion in dorsal view, with median and short intermediate carinae; median and intermediate carinae connected at base, point of connection elevated (Figs 56, 65); in lateral view, lateral carinae of frons joining lateral carinae of vertex in right angle (Fig. 64); frontoclypeal suture arcuate (Figs 56, 65). Clypeus without carinae (Figs 56, 65). Rostrum with apical segment shorter than subapical, reaching hind coxae. Compound eyes rounded, with small callus at posterior and ventral margins; lateral ocelli absent (Figs 53, 55, 58, 64). Antenna located ventral in respect to eye; scapus distinctly shorter than diameter of eye, cylindrical, scarcely covered with short setae; pedicel shorter than diameter of eye, slightly longer than scapus, barrel-shaped, apical part concave, functional area at the top and on dorsal surface with trichoid sensilla type 1 on apical and dorsal surface, antennal plate organs present on apical concavity and delimiting laterally dorsal functional surface (Figs 58, 64, 65).

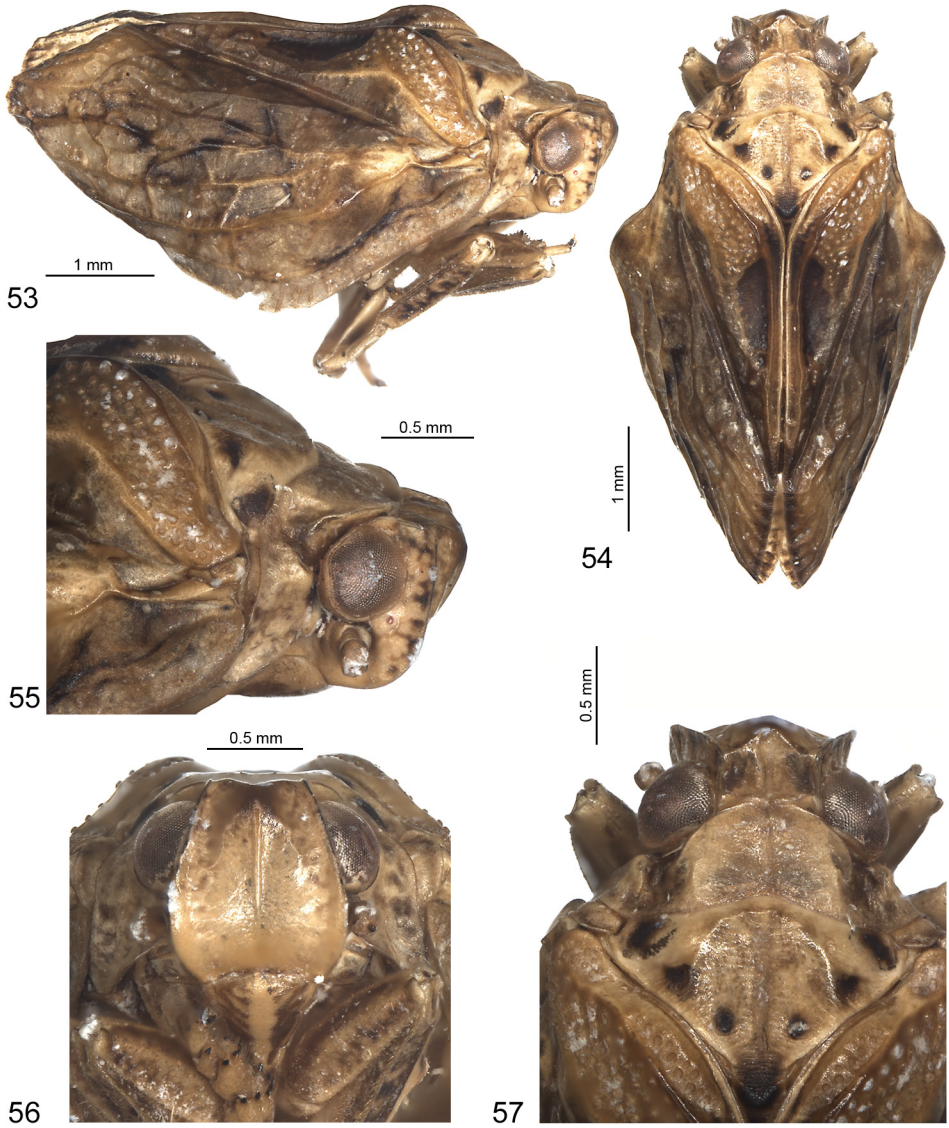
***Thorax*.** Pronotum with anterior margin medially produced till half of eye length; disc with median groove; postocular eminences bluntly rounded; posterior margin concave (Figs 54, 57, 59–63). Mesonotum triangular, with groove in median portion; lateral carinae as ridges, obsolete, connected at base in form of horseshoe; area between median groove and ridges depressed; scutellum bluntly rounded apically (Figs 54, 57, 59–63).

Tegmen coriaceous, irregularly convex with distinct venation; costal margin strongly arcuate medially, relatively straight in basal half and posterior portion, costal angle widely, bluntly rounded, sutural angle obtuse, postclaval sutural margin absent (Figs 53, 54, 66–69). Costal area narrower than postcostal cell, with transverse veinlets (Figs 58, 68), terminating posterior to the level of apex of clavus; postcostal cell with several transverse veinlets. Basal cell long and narrow; ScRA+RP leaving basal cell with common stem, ScRA elevated, RP at the level of bulla obsolete; ScRA ending with two terminals; RP forking posterior to clavus apex, ending with four terminals at posterior margin; MP forking posterior to CuA fork, ending with four terminals; CuA with fork anterior to apex of bulla. Clavus with A_1 basally strongly elevated, disc between Pcu and A_1 and posterior to it depressed (Figs 58–60, 66–69); Pcu and A_1 fused anterior to apex of clavus; several transverse veinlets between A_1 and A_2. Tubercles scattered on the whole tegmen with concentration in the following parts: basal part of clavus – between A_1 and A_2 and between Pcu and A_1, basal part of costal membrane, and on bulla between ScRA and RP. Sensory sensilla on tegmen absent. Hindwing well developed.

Femora shorter than tibiae; hind tibiae almost straight, triangular in cross section, with two lateral spines placed in apical half, apically with row of seven well-developed spines (5 short + 2 long); basitarsomere slightly longer than cumulative length of tarsomeres 2 and 3, with row of eight apical spines and setae; second tarsomere with two lateral spines and median pad with thick setae.

Male unknown.

***Female terminalia and genitalia*.** Pregenital sternite with X-shaped strong sclerotization in median portion, without fold. Anal tube, in lateral view (Fig. 70) slightly curved ventrad,



Figs 53–57. *Kesaflata lubosi* gen. & sp. nov., holotype, female. 53 – habitus, lateral view; 54 – same, dorsal view; 55 – anterior part of body, lateral view; 56 – same, frontal view; 57 – same, dorsal view.

tapering apicad, with nearly pointed apex and large convex lateral lobes; anal tube covering gonoplac and reaching its posterior margin; anus placed posterior to midlength; in dorsal view (Fig. 71) elongately oval, posterior margin with shallow incision medially. Gonoplac unilobate, sub-rectangular (Fig. 72); posterior margin with two rows of teeth; dorsal part of posterior margin to the level of teeth limit well sclerotized, ventral part with wide membranous, wrinkled lobe. Gonapophysis VIII (Fig. 73) sabre-shape, laterally flattened; dorsal margin sinuate, with subapical, sharp teeth; ventral margin arcuate, slightly up-folded with keels, ending with teeth; endogonocoxal process about as long as gonapophysis, distinctly tapering apicad, membranous with distinct spiniferous microsculpture. Gonospiculum as in *Dixamflata*. Bursa copulatrix with single pouch, with cells, but without sclerites. Spermatheca (Fig. 74) well developed; ductus receptaculi about the same length as diverticulum ductus.

Remarks. Within the Socotran fauna of Flatidae, *Kesaflata* is similar to *Dixamflata* gen. nov. in the following characters: frons with median keel, tegmen short, coriaceous, clavus with A_1 basally strongly elevated, gonoplac unilobate, sub-rectangular, posterior margin with two rows of teeth. *Kesaflata* differs from *Dixamflata* in the following characters: vertex, pronotum and mesonotum with median groove (with median keel in *Dixamflata*), frons not produced anteriad (with a large, rounded crown in *Dixamflata*), apical part of tegmen not produced (with a finger-like apex in *Dixamflata*), tegmen lacking sensory sensilla on most of its surface (with numerous sensilla arranged in several groups over the tegmen surface in *Dixamflata*), female anal tube with large convex lateral lobes and anus placed posterior to midlength (ventrolaterally concave, lacking lateral lobes and with anus placed in basal half in *Dixamflata*), ventral part of gonoplac with membranous lobe (lacking such a lobe in *Dixamflata*). See also the Discussion for a comparison with other similar taxa in a wider region.

Etymology. The generic name is derived from "*Qeysoh*" (sometimes also spelled as "*Kesa*"), a local name of the settlement in Socotra near where the type species was collected, and "*Flata*" which is used here for a representative of the Flatidae family. Gender feminine.

Distribution. Yemen: Socotra island.

***Kesaflata lubosi* sp. nov.**

(Figs 53–74)

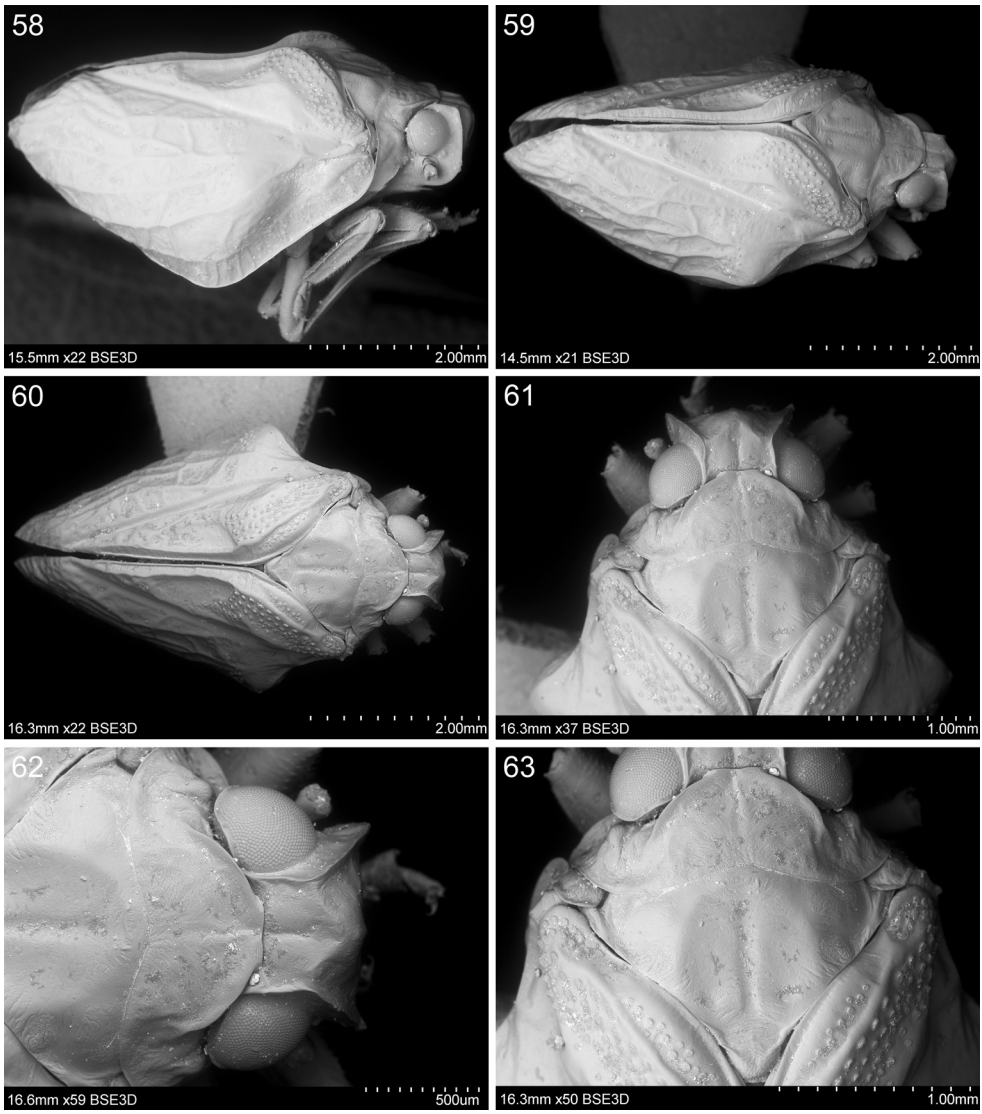
Type locality. Yemen, north-western Socotra, 5.5 km SW Qalansiyah, Qeysoh settlement environs, northern foothills of Maaleh hills, 12°39′37″N 53°26′42″E, 220–300 m a.s.l. (Figs 78, 79).

Type material. Holotype: ♀ "YEMEN, SOCOTRA Island, Kesa env., 220-300m, N 12°39′37″ E 53°26′42″, 28.-29.i.2010, L. Purchart leg. // HOLOTYPE / *Kesaflata* / *lubosi* sp. nov. / det. A. Stroiński, I. Malenovský / & D. Świerczewski 2016" (MMBC, dry-mounted, abdomen detached, dissected and stored in a plastic vial with glycerol under the specimen).

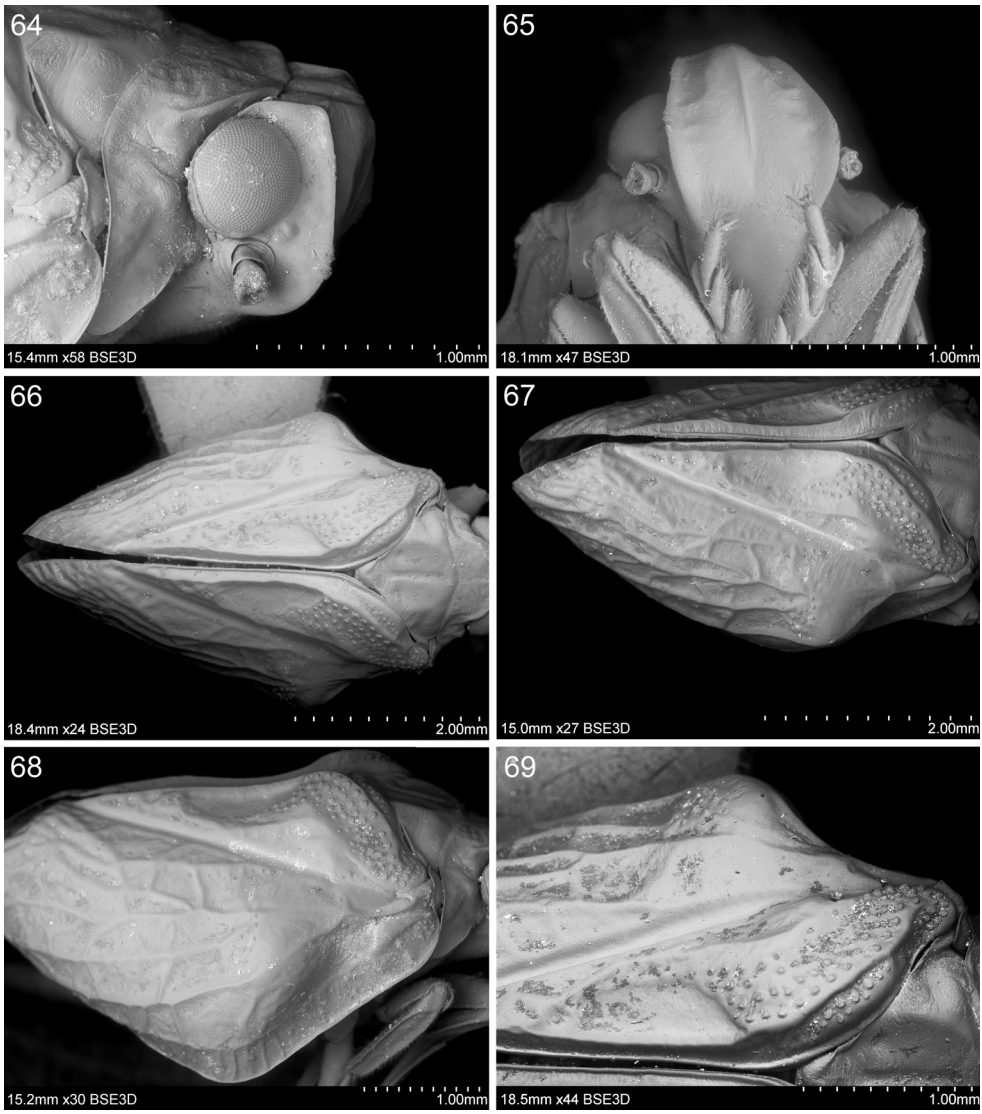
Diagnosis. The only species in the genus.

Description. ***Measurements.*** Total length 5.65 mm. Vertex: A/B 2.33. Frons: C/E 0.50; D/E 0.93. Pronotum: F/B 2.20. Mesonotum: G/F 2.27, G/B+F 1.56, G/H 0.70. Tegmina: I/J 2.25.

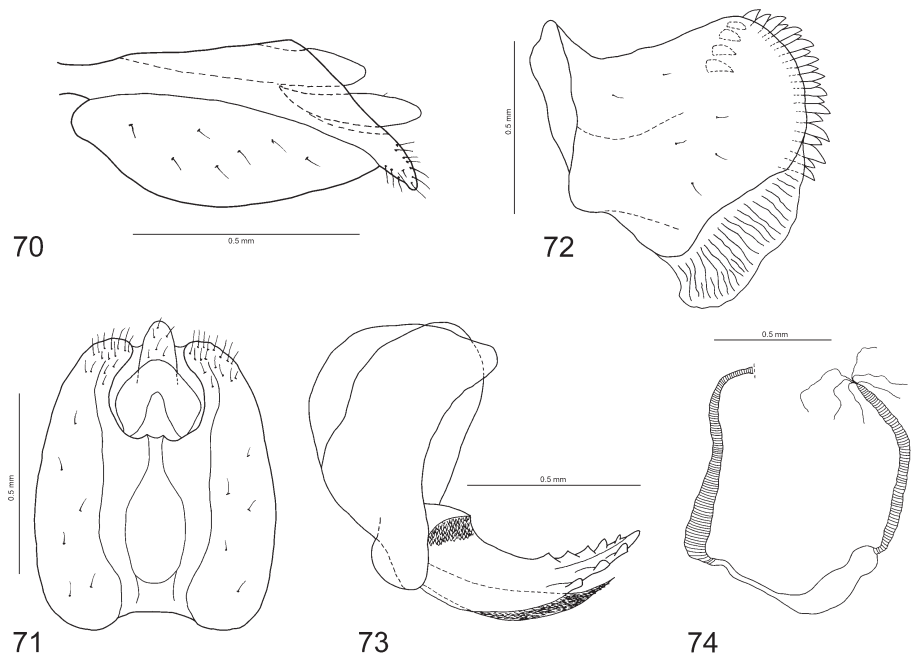
Coloration. General coloration light brown with darker patches on the apical top of frons, lateral margins of vertex, pronotum and mesonotum as well as tegmen – alongside sutural angle and MP vein and on claval disc and depression; abdomen brownish (Figs 53–57).



Figs 58–63. *Kesaflata lubosi* gen. & sp. nov., habitus, holotype, female, SEM micrographs. 58 – habitus, lateral view; 59 – same, dorso-lateral view; 60 – same, dorsal view; 61 – anterior part of body, dorsal view; 62 – vertex and pronotum, dorsal view; 63 – pronotum and mesonotum, dorsal view.



Figs 64–69. *Kesaflata lubosi* gen. & sp. nov., holotype, female, SEM micrographs. 64 – anterior part of body, lateral view; 65 – head, frontal view; 66 – tegmen, dorsal view; 67 – same, dorso-lateral view; 68 – same, lateral view; 69 – same, clavus.



Figs 70–74. *Kesaflata lubosi* gen. & sp. nov., holotype, female terminalia. 70 – anal tube, lateral view; 71 – same, dorsal view; 72 – right gonoplac, external view; 73 – gonapophysis VIII, lateral view; 74 – spermatheca.

Structure. *Head.* Median carina of frons sharp, lateral carinae short, sinuate, apically curved to lateral margins (Figs 56, 65). Clypeus convex (Fig. 56).

Thorax. Posterior margin of pronotum deeply concave. Groove of mesonotum short (Figs 57, 61–63).

Male unknown.

Female terminalia. Pregenital sternite with anterior margin weakly arcuate and posterior margin convex. Gonoplac posterior margin with row of larger teeth and row of smaller teeth (Fig. 72). Gonapophysis VIII with keels of ventral margin short and parallel; ventral margin ending with blunt teeth (Fig. 73). Spermatheca with ductus receptaculi ribbed, widening apicad; diverticulum ductus smooth, basal part tubular, apical part widened with subapical, shallow incision (Fig. 74).

Etymology. Named after our dear colleague Luboš Purchart (Mendel University, Brno) who collected the holotype.

Habitat and occurrence in Socotra. The only specimen available was collected in a semi--arid shrubland dominated by *Jatropha unicostata*, *Croton socotranus*, *Euphorbia arbus-*

cula, *Adenium obesum*, *Dendrosicyos socotrana*, *Sterculia africana*, and *Cissus subaphylla* on lower altitude rocky slopes at foothills of the Maaleh hills at the north-western coast of Socotra (Figs 78, 79).

Distribution. So far only known from the semi-arid zone of north-western Socotra.

Discussion

Both new taxa from Socotra resemble three other flatid genera present in the south-western parts of the Palaearctic Region which share similarly small size and short (called "sub-brachypterous" by some authors) coriaceous tegmina, giving them a "box-like" or "beetle-like" appearance: *Cyphopterum* Melichar, 1905, *Riodeorolix* Lindberg, 1956, and partly also *Persepolia* Dlabola & Safavi, 1972. Another such taxon is *Cyclopterum* Gnezdilov & O'Brien, 2014 from the Caribbean (Gnezdilov & O'Brien 2014). Most other flatid taxa are relatively larger and have well-developed membranous tegmina. Outside of Flatidae, similar habitus occurs also in most representatives of the families Issidae and Caliscelidae, as well as in some taxa of Acanaloniidae, Nogodinidae, Ricaniidae, and Tropiduchidae, and is generally considered as a result of convergent evolution of these taxa and adaptation to a life in semi-arid and arid conditions, in association with low-growing sclerophyllous vegetation (Fennah 1967, Stroiński et al. 2011, Gnezdilov 2013).

Cyphopterum currently includes 44 described species, many of which are endemic to the islands of Macaronesia and few are distributed in the mainland north-western Africa and south-western Europe (Lindberg 1953, 1954, 1958, 1959, 1960, 1961, 1962, 1965a,b; Leise & Remane 1994; Bourgoin 2016). *Riodeorolix* is a monotypic genus known only from the coast of Western Sahara and Morocco. It might be closely related to *Cyphopterum* (Lindberg 1956, 1962, 1963), however, a phylogenetic analysis is required to prove this statement. Besides the short coriaceous tegmen, both *Cyphopterum* and *Riodeorolix* share with *Dixamflata* and *Kesaflata* a regularly arcuate costal margin and a conspicuously convex area on the clavus of tegmen, as well as the general design of the head, tegmen venation and male terminalia (which is, however, unknown in *Kesaflata*). Some *Cyphopterum* spp. and *R. mateui* Lindberg, 1956, also resemble *D. petri* sp. nov. in size, strongly convex bulla and the slightly produced tegmen apex with sinuate ventral margin subapically. However, *Dixamflata* differs from *Cyphopterum* and *Riodeorolix* in the following characters:

- frons with large, apically broadly rounded crown in dorsal view – in both *Cyphopterum* and *Riodeorolix*, the crown is absent or there is only a small anterior protrusion of vertex and frons in dorsal view (Lindberg 1953, 1956, 1958; Leise & Remane 1994);
- frons with intermediate ridges forming horseshoe-shaped bulge – in *Cyphopterum* and *Riodeorolix* intermediate ridges are absent, only median carina is present;
- male genital style with a short ventroapical process on inner side – male genital style lacking any distinct process ventro-apically in *Cyphopterum* and *Riodeorolix*;
- periandrium curved in lateral view and bearing a single one-armed process on each side – periandrium bearing a two-armed process on each side, the outer arm of which is further ramified in most *Cyphopterum* spp., except for six species from

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Figs 75–76. Habitat of *Dixamflata petri* gen. & sp. nov. at the type locality in Tudhen, Hagher Mts. in Socotra. 75 – helocrene spring with a mosaic of tussocks of *Juncus socotranus* and low herbaceous vegetation and *Commiphora planifrons* shrubland in the background; 76 – detail of vegetation with *Juncus socotranus*, *Cyperus* sp. (background) and *Bacopa monieri* (low cushions in foreground). Photographs by Petr Kment.

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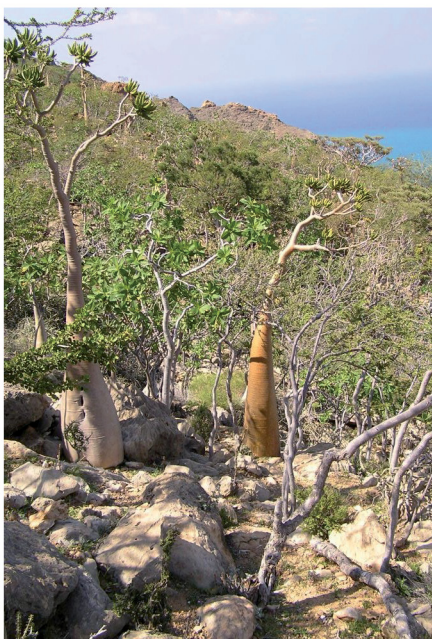

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Figs 77–79. 77 – Habitat of *Dixamflata petri* gen. & sp. nov. in Wadi Madar, Hagher Mts. in Socotra. 78 – Habitat of *Kesaflata lubosi* gen. & sp. nov. at the type locality near Qeysoh in north-western Socotra. 79 – Detail of vegetation of semi-arid shrubland with dominant *Jatropha unicostata* and *Adenium obesum* from Fig. 78. Photographs by Petr Kment (77) and Luboš Purchart (78, 79).

Cape Verde Islands which have a single one-armed process on each side but in which periandrium is straight (Lindberg 1958); in *Riodeorolix*, periandrium bears two one-armed processes on each side (Lindberg 1963).

Riodeorolix also differs from both *Dixamflata* and *Cyphopterum* in the shape of the male anal tube which is broad, with convex, rounded lateral margins in dorsal view in *Riodeorolix* but slender, parallel-sided or narrowing apically in dorsal view in *Dixamflata* and *Cyphopterum*.

A comparison of *Kesaflata* is more difficult as it is known for the time being only from a female. However, *Kesaflata* differs from *Cyphopterum* and *Riodeorolix* (as well as *Dixamflata*) in the presence of a median groove on the vertex, pronotum and mesonotum (the other genera have a more or less distinct median keel there) and the presence of a membranous lobe on the gonoplac ventral margin which seems to be a distinctive feature too, although the female genitalia in *Cyphopterum* and *Riodeorolix* have not been studied and described in detail yet. Male specimens are, however, needed to evaluate additional similarities and differences of *Kesaflata* from the other sub-brachypterous flatid genera.

The other genus similar to *Dixamflata* and *Kesaflata* in habitus, *Persepolia*, includes four species, all endemic to Iran (Dlabola & Safavi 1972; Dlabola 1981, 1982; Bourgoin 2016). Based on a study of the type and other material deposited in NMPC, the type species of the genus, *P. columbaria* Dlabola & Safavi, 1972, differs from the three other species, *P. secunda* Dlabola, 1981, *P. jasmuriana* Dlabola, 1982, and *P. servadeina* Dlabola, 1982, in the body size, head morphology as well as the structure of the male genitalia, particularly the genital styles and phallic complex, and *Persepolia* thus requires a systematic revision which is outside of the scope of this paper. *Dixamflata petri* sp. nov. is particularly similar to *Persepolia servadeina* in body shape, especially the tegmen which is coriaceous, short, with strongly convex costal margin medially, finger-like projection apically, and a distinct convex bulge on clavus basally. Another similar species is *P. jasmuriana* which differs from *D. petri* and *P. servadeina* in the tegmen apex being more rounded, not produced into a finger-like edge (Dlabola 1982) and resembles thus, to a certain extent, also *Kesaflata lubosi*. However, both above-mentioned *Persepolia* species, as well as a more slender looking *P. secunda* differ from *Dixamflata petri* and *Kesaflata lubosi* in the following details:

- frons with small crown, which is shorter or only slightly longer than vertex in midline in dorsal view – crown is large in *Dixamflata*, absent in *Kesaflata*;
- tegmen with costal margin bent in a distinct right or obtuse angle – costal margin regularly arcuate in *Dixamflata* and *Kesaflata*;
- costal area broader, about as wide as postcostal cell – distinctly narrower than postcostal cell in *Dixamflata* and *Kesaflata*;
- postcostal cell usually lacking distinct cross-veins – with a few well-marked cross-veins in *Dixamflata* and *Kesaflata*;
- CuA vein forked – CuA vein single in *Dixamflata*, forked in *Kesaflata*;
- clavus basally and vein A_1 only weakly bulging – strongly convex in *Dixamflata* and *Kesaflata*;
- male pygofer, in lateral view, with posterior margin truncate or weakly sinuate – regularly convex in *Dixamflata*, unknown in *Kesaflata*;

- male anal tube short, robust, not extending beyond genital styles, in lateral view straight, not curved ventrad and with convex ventral margin, anus placed in basal half – elongate, slender, extending beyond genital styles, in lateral view curved ventrad and with concave ventral margin, anus placed slightly posterior to mid-length in *Dixamflata*, unknown in *Kesaflata*;
- male genital style relatively convex laterally, with a short, robust, tooth-like capitulm and with another tooth-like process subapically and an extra fold on dorsal margin, posteroventral angle lacking short, blunt process on inner side – relatively flat, bearing long, dorsocaudal, curved, apically pointed capitulum; dorsal margin straight without concavity and extra fold, posterior and ventral margins weakly convex, posteroventral angle with short, blunt process on inner side in *Dixamflata*, unknown in *Kesaflata*;
- male phallic complex with periandrium relatively short and robust, tubular, apical part not wider than basal part, process of periandrium very short, inconspicuous (in *P. servadeina* and *P. jasmuriana*) to moderarely long (shorter than half of periandrium length in *P. secunda*), weakly sclerotized, aedeagus s. str. split only apically or more basally but median split not reaching basal part – periandrium relatively slender and elongate, apical part wider than basal part; process of periandrium long (nearly as long as periandrium), well-sclerotised, aedeagus s. str. with deep median split reaching basal part in *Dixamflata*, unknown in *Kesaflata*;
- female gonoplac lacking a membranous lobe on ventral margin – this lobe is also absent in *Dixamflata* but present in *Kesaflata*.

Dixamflata and *Kesaflata* might be more closely related to *Cyphopterum* and *Riodeorolix* than to any species currently classified in *Persepolia* and can even be sister-taxa to either *Cyphopterum* or *Riodeorolix*. This would imply a relatively big geographical disjunction. However, there are several plant groups (e.g. *Dracaena* and *Euphorbia balsamifera*) that have similar disjunct distribution patterns between the Macaronesian islands, Morocco, East and South Africa, southern Arabia and Socotra. These disjunctions are regarded as evidence for a continuous flora that once existed across northern Africa in the Late Miocene (Brown & Mies 2012). Given that both *Dixamflata petri* and *Kesaflata lubosi* are sub-brachypterous, their dispersal capacities are probably limited. The both species could therefore represent palaeoendemics of Socotra, possibly similar to the dragon blood tree, *Dracaena cinnabari*, a flagship endemic species in Socotra (Brown & Mies 2012). However, *Cyphopterum* which is also sub-brachypterous must have colonised the different Macaronesian islands which are volcanic in origin (in contrast to Socotra which is a continental fragment) with no evidence of any landbridge connecting them with mainland; so a long-distance dispersal in this group of taxa is obviously also possible (the case of *Cyphopterum* resembles the plants *Dracaena draco* and *E. balsamifera* that have heavy seeds that are difficult to transport but still reached the Canary Islands; Brown & Mies 2012). More studies, using particularly phylogenetic methods with accurately calibrated molecular clock, are, however, needed to explain the phylogenetic relationships and the historical biogeography of these sub-brachypterous flatid taxa.

Both *D. petri* and *K. lubosi* were found in Socotra restricted to very small areas. Due to their supposed limited dispersal capacities, stenotopic habitat requirements and association with local endemic plant communities, they probably represent highly endangered taxa, threatened

by habitat degradation and desertification which is currently taking place in Socotra (van Damme & Banfield 2011, Brown & Mies 2012). Particularly overgrazing and deforestation are factors that are likely to bring these planthopper species to extinction unless conservation actions can be successfully undertaken in the localities where they are known to occur.

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