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A new *Rhanidopsis* West, 1930 from the Malay Peninsula (Lepidoptera: Geometridae, Geometrinae)

J. Viidalepp & A. Lindt

Abstract

A new moth species from the oriental geometrid genus *Rhanidopsis* West, 1930 is described: *R. kogeri* Viidalepp & Lindt, sp. n., from Cameron Highlands, Peninsular Malaysia is added to the distribution area of the genus, formerly known from the Philippines and Borneo. Phenotypical similarity of the genus with Afrotropical *Dargeia* Herbulot, 1977 and Neotropical *Pyrochlora* Warren, 1895 is discussed. Some plesiomorphic characters of Neotropical and Indoaustralian genera of Nemoriini are compared.

KEY WORDS: Lepidoptera, Geometridae, Geometrinae, *Pyrochlora*, *Dargeia*, *Rhanidopsis kogeri*, new species, Malay Peninsula.

Un nuevo *Rhanidopsis* West, 1930 de Malasia (Lepidoptera: Geometridae, Geometrinae)

Resumen

Se describe una nueva especie del género geométrido oriental *Rhanidopsis* West, 1930: *R. kogeri* Viidalepp & Lindt, sp. n., de Cameron Highlands, Malasia, se añade al área de distribución del género, hasta ahora conocido de Filipinas y Borneo. Se discuten similitudes fenotípicas con el género afrotropical *Dargeia* Herbulot, 1977 y con el neotropical *Pyrochlora* Warren, 1895. Se comparan algunos caracteres plesiomórficos de los géneros Neotropicales e Indoaustralianos de Nemoriini.

PALABRAS CLAVE: Lepidoptera, Geometridae, Geometrinae, *Pyrochlora*, *Dargeia*, *Rhanidopsis kogeri*, nueva especie, Malasia.

Introduction

WEST (1930) described the genus and the first species as *Rhanidopsis neophantes* West (1930: 259), on the basis of a single female from Luzon, Philippines, and stressed the external similarity of *R. neophantes* to Neotropical *Pyrochlora rhanis* Cramer, (1777: 34, 150). PROUT (1934) referred to selected characters from the original description of the genus. HOLLOWAY (1996: 299) discussed generic characters of *Rhanidopsis*, in connection with the description of a new, Bornean species *R. alleni* Holloway (1996), and an unnamed but different in genitalia specimen from Palawan Island; he also mentioned *R. alleni* from Sumatra. The new record of *Rhanidopsis kogeri* Viidalepp & Lindt, sp. n., from Cameron Highlands, Peninsular Malaysia, enlarges slightly the distribution area of the genus *Rhanidopsis*. The external similarity of *Rhanidopsis* and *Pyrochlora* species has been repeatedly mentioned in literature (compare figs 1-2 with 3-4). Occasionally, the specimen described below, and a female *Dargeia micheleae* Herbulot, 1977 (HERBULOT, 1977: 49), were simultaneously submitted to the first author for determination. Their external similarity (especially in hind wing pattern) was striking and introduced a study of *Pyrochlora* Warren, 1895, for comparison. This study yielded three new morphospecies in addition to two formerly known, deceptively similar in their wing pattern and distinct in build of male and female genitalic structures (VIIDALEPP, 2009).

The geographical distribution of this Neotropical genus is disjunctive, associated with Brasilian and Guianan shields and the system of Andes and Cordilleras, records are lacking from the most part of the basin of the Amazonas.

Rhanidopsis kogeri **Viidalepp & Lindt, sp. n.** (Figs 1, 2, 9, 10)

Holotype, ♂: Peninsular Malaysia, Cameron Highlands 1380 m, 04º 27’ 41” N, 101 21’ 37” E, 26-III-2006, A. Lindt leg. Gen. prep. 7813 (J. Viidalepp). Holotype deposited in the collection of the Estonian Natural History Museum, Tallinn.

Description: Wing span 17.5 mm (forewing length 9.5 mm). The ground colour of forewings and distal third of hind wings dull greyish green, slightly paler distally, forewing hind margin below the discal cell with a light ochreous stripe, ending in a larger and lighter spot at the place of postmedial. Tornus indistinctly suffused greyish. Basal two-thirds of hind wing ochreous with some rosy tint and indistinct greenish grey patches, one in cell and two at anal margin. Distinct transverse lines absent in forewing, the postmedial line blackish, fine, characteristically curved in hind wing. Underneath of wings silky, off-white, forewing innermarginal area scaled whitish in its proximal 2/3, bearing two oblong greyish patches at tornus. Head. Male antennae pectinate in basal 2/3, pectinations long (external pectinations up to 0.6, inner ones up to 0.28 mm). Palpi thin and short, hardly reaching frons, haustellum absent. Frons and vertex greenish, fillet between antennae white, antennal shaft dorsally scaled white. Thorax and abdomen dorsally dull greenish, ventrally off-white. Hind legs slender, with one (distal) pair of short spurs, tarsus slightly longer than tibia. Abdomen dorsally scaled, without tufts. Venation of wings as described by PROUT (1934) for the genus: forewing with R_1 free, R_2-M_1 short-stalked, R_2 branching out after R_5, M_3 free. Hind wing with Sc touching the costal margin of discal cell in one point near base, veins $Rs+M_1$ short-stalked, M_3 free, CuA_1 branching out close to cell end.

Male genitalia (Figs 9, 10): Scaphium (uncus + socii) very strongly sclerotized lyre- or U-shaped, gnathos small, ring-shaped and bilobed at cochlear apex. Tegumen shorter than vinculum, saccus projecting long, conical (conical, but as long as tegumen in *R. alleni*, and squarish in Luzon species according to HOLLOWAY (1996)).Valve costa shorter than valvula, with a short apical spine (bearing a conical tuft of setae in *R. alleni*). Aedeagus long, slender, without cornuti. Last abdominal segment in male undifferentiated, sternite A8 slightly shorter than the tergite.

Female and immature stages are unknown.

The holotype was collected at light in a cultivated clearing within rich primary forest at 1380 m elevation. An allied species *R. alleni* is associated with lowland dipterocarp forest in Borneo (HOLLOWAY, 1996).

Derivatio nominis: The new species is named in honour of Mr. Andres Koger who subsidized the expedition in part.

Shared pattern, convergence or vicariance?

PROUT (1934) stressed the similarity of the wing pattern in the Oriental genus *Rhanidopsis* and Neotropical *Pyrochlora* Warren, consisting of *P. rhanis* (the type species) and *P. majorcula* Dyar (DYAR, 1925: 7). The three *Rhanidopsis* species known are alike externally (compare fig. 1 with the figures (Plate 10, fig. 32 and plate 11, fig. 11) in HOLLOWAY (1996)) but well differentiated in their genitalia structures.

The external similarity of the two genera might refer to convergence, moths resembling a bird dropping on a half dried leaf. However, the same pattern of wing markings and external morphology occurs in an Afrotropical moth from rain forests of Cameroon, *Dargeia micheleae*, (Figs 5-6) (one male paratype on loan from ZSM and one female from coll. A. Selin (Tallinn) studied). Especially, the shape of postmedial line in hind wing is almost the same in *Rhanidopsis* and *Dargeia*.

The original description of *Dargeia micheleae* (HERBULOT, 1977: 49-50) is complemented as follows.

Abdomen. Pregenital segment A8: tergite quadrate, sternite a little shorter, centrally sclerotized triangular (Fig. 17); both with posterior margin straight. Sternite A3 without patches of deciduous setae.

Male genitalia capsule with tegumen larger than vinculum, bilobed posteriorly (Figs 15, 16). Socii large, setose, attached ventrodistally to these lobes. Tegumen and vinculum capacious, jointed rectangularly, not fused (Fig. 14); valva joined to vinculum, short, costa incurved medially, with a triangular dens at basal one-third, apex of valva bearing short irregular spicules and setae. Sacculus fused to valva, without apical projection, medial surface of valva largely membranous. Anellus membranous, without sclerotization in region of juxta and transtilla. Gnathos absent (Fig. 16). Vinculum strong, slightly dilated medially but without obvious saccus. Tegumen stretched, with a slenderer "neck" (Fig. 16), no suture or fovea between tegumen and uncus observed: uncus supposed reduced. The setose pads ventrad to tegumen with some reticulate structure, hollow, open anteriorly. The reticulate structure indicates adjoining area of flexor muscles, always inserted into socii and not connected with uncus or gnathos (SNODGRASS, 1963; KUZNETSOV & STEKOLNIKOV, 2001; OGATA *et al*., 1957). Male genitalia fragile, tegumen cracked when mounted under cover slip (Fig. 18).

Males of Neotropical *Pyrochlora* have a wing span of 20-28 mm, whereas females of both *P. rhanis* and *P. majorcula* measure 26 - 33 mm. *Rhanidopsis* females are also larger than males, (see figures in HOLLOWAY, 1996) and HERBULOT gives 10.0-11.5 mm and 14.5 mm for forewing length in male and female *D. micheleae*, accordingly.

Pyrochlora species have hind wing provided with frenulum, thin but present (0.75 - 0.62 mm long in eastern species *P. rhanis* and in Mesoamerican *P. motilonia* Viidalepp, 2009, accordingly, 0.4 - 0.45 mm long in *P. majorcula* Dyar, 1925 and western species *P. kuklase* Viidalepp, 2009). Short frenulum means that the wing coupling system is malfunctional, rudimentary. Frenulum has been lost both in *Rhanidopsis* and *Dargeia.*

Pyrochlora is characterized by the presence of two pairs of spurs in hind tibia, while both *Dargeia* and *Rhanidopsis* possess one (distal) pair of spurs.

Dargeia has vein R_1 in forewing fused along with the subcostal vein, and in hind wing the subcostal vein is fused with discal cell at one point near the wing base. *Rhanidopsis* and *Pyrochlora* species share vein R_1 free in forewing, and the subcostal vein in hind wing merely touches the fore margin of discal cell near the base of wing.

Females of both genera have antennae pectinated, the pectinations 2 - 2.5 times longer than the shaft thickness in *Pyrochlora* and in *Dargeia*, and antennae are variable in female *Rhanidopsis* (lamellate, according to WEST, 1930; shortly pectinate, according to HOLLOWAY, 1996).

According to male genitalia, there are few common traits present if we compare oriental *Rhanidopsis* with Neotropical *Pyrochlora* (see figs 9 - 10 for *Rhanidopsis kogeri* and Figs. 11 - 13 for *P. majorcula*). PITKIN (1996) describes and figures the type species of *Pyrochlora*, *P. rhanis*. The sclerotized part of male sternite A8 of *P. majorcula* is triangular, not excised posteriorly, and its valve has a small dorsobasal projection analoguous to that in *Nemoria* Hübner, 1818, the sternite of *P. rhanis* differing in a U-shaped excision at its hind margin, and its valva lacking the dorsobasal projection (PITKIN, 1996 and figs. 80, 121, 171 therein). *Pyrochlora* is grouped with the tribe Nemoriini (PITKIN, 1996), the other two genera, *Dargeia* and *Rhanidopsis*, are not associated with any genus group. The two genera share the reduction of frenulum and the loss of proximal spurs in hind tibia.

INOUE (1961) created the tribe Ochrognesiini for *Chloromachia* Warren, 1899 and *Ochrognesia* Warren, 1894 based on venation of wings, absence of abdominal crests, on long, apically spatulate and bilobed, uncus associated with small socii, a. o. genitalia characters.

FERGUSON (1969) diagnosed the tribe Nemoriini as a relatively generalized group of genera of geometrine moths, with „simple valves and well developed, generalized uncus, socii, gnathos, juxta and transtilla, … specialized in presence of a costal basal process on the valve“. He mentioned that the conspicuous dorsolateral protuberances on thoracic and anterior abdominal segments of Nearctic nemoriine larvae are characteristic as well.

HOLLOWAY (1996) defined the tribe on features of the male abdomen: a central longitudinal thickening of the bilobed sternite A8; sclerotization of the posterior margin of the tergite A8; spatulate or bilobed, elongate uncus and moderate to well developed socii; sclerotized and often modified valve costa; the presence of coremata at the base of valve; saccus sometimes bilobed.

PITKIN (1996) characterized the Neotropical nemoriine genera as did HOLLOWAY (1996), discussing also the variation of tribal characters. The „midrib“, i. e. the central sclerotization of the sternite A8 is evaluated as missing e. g. in *Chavarriella* Pitkin, 1993 and *Chloractis* Warren, 1895 (*loc. cit*., figs 64-65). These genera have sternite A8 with central patch of sclerotization at posterior margin just like in *Dargeia* and some *Pyrochlora* species (VIIDALEPP, 2009). A spatulate uncus is characteristic for *Chavarriella* and some other genera not associated with tribes.

According to HOLLOWAY (1996) the Nemoriini, speciose in the Neotropics, is represented in Old World tropics by *Eucyclodes* Warren, 1894. The allied groups such as *Ochrognesia* Warren, 1894, *Chloromachia* Warren, 1899 (both treated as the tribe Ochrognesiini by INOUE (1961 a. o.), are synonymized with *Eucyclodes* by HOLLOWAY (1996). The spatulate shape of uncus may be evaluated as a derived condition compared to the complex scaphium (i.e. uncus + socii) in *Rhanidopsis* and *Dargeia* (Table 1), the triangular sclerotization of the sternite A8 as plesiomorphic if compared to more derived „midrib” of posteriorly bilobed sternite in derived nemoriine genera. Male sternite A8 is usually smoothly bilobed in Nearctic nemoriine taxa but provided with a pair of digitate, sclerotized projections in *Eucyclodes* (compare INOUE, 1961 and figs 226-234 in HOLLOWAY, 1996). The characteristic wing pattern of *Dargeia* is quite similar to that in *Eucyclodes* (*Ochrognesia*) *difficta* Walker, 1861 and *E.* (*Chloromachia*) *infracta* Wileman, 1911, the similarity somehow not mentioned in literature.

State of a character / Genus	*Rhanidopsis*	*Dargeia*	*Pyrochlora*	*Eucyclodes*
Costal sclerotization of valva	present	present	present	present
Rolling of bases of sacculi	present	present	present	absent
Central sclerotization of st A8	absent	absent	absent	weak
Posterior sclerotization of A8	absent	present	present	weak
Sternite A8 bilobed posteriorly	no	no	no / yes	yes
Scaphium spatulate or rod-like	bipartite	bipartite	finger-shaped	spatulate

Table 1.– Distribution of some apomorphic nemoriine character states in the genera under study

Ochrognesia and *Chloromachia* occur in the subtropical East of the Oriental region, while *Eucyclodes* is Australasian and associated with rich tropical rain forest biome. While *Dargeia* is monotypic and confined to mountainous forests in Cameroon, *Rhanidopsis* has radiated in tropics of the south of the Oriental region. *Pyrochlora* contains two sections - the eastern one with three species distributed from the Brazilian shield via the Guiana shield to North Venezuela, and the western group of species occurring in the Andes and in Mesoamerica.

Palaeogeographical and -geological evidences date the Andean uplift and marine transgression in the South American continent, dividing ancient forests into the western and the eastern part, as of the Miocene age (LAMB, 2004; HAFFER, 1997; NOONAN & WRAY, 2006). The *Pyrochlora* species of both groups are deceptively similar to one another in their wing pattern since then (VIIDALEPP, 2009), diverging in genitalia characters. The three known *Rhanidopsis* species are also externally similar to one another, too, and differ in genitalia characters. And *Dargeia*, *Rhanidopsis*, *Chloromachia* and *Ochrognesia* are remarkably similar one to another in wing pattern, while their genitalia sclerites present genus-rank differences.

Does this case represent phenotypical similarity as an underlying apomorphy? An ancient wing pattern of an ancestor and morphological differentiation in the three genera discussed above since their vicariance? And if these are vicariant genera, how to date their common ancestor?

PACKARD (1905) paid attention to the similarity of Lepidoptera of South America and Africa as early as 1904, at the VIIIth International Geographical Congress (DEXTER, 1981). He argued for the former land connection between the continents. Eight years later, WAGENER (1912) published his generally accepted theory of continental drift. Half a century later, the discovery followed that the majority of oceanic crust had formed during the Cenozoic. The theory of expanding Earth has enlighted the causes of continental drift. A huge literature has been devoted to the biogeographical history of this phenomenon since that, reviewed, e. g., by SANMARTÍN & RONQUIST (2004) from the viewpoint of vicariance and by de JONG (2007) from the dispersalists' point of view; see also GOLDBLATT (1993). The development of the biogeographical pattern in the Oriental fauna is discussed in several publications by HOLLOWAY (2003 a. o.). McCARTHY (2003) has documented relations of trans-Pacific sister areas.

MATILE (1990), studying keroplatid gnats (Mycetophiloidea, Keroplatidae) used the theory of expanding Earth to explain disjunct sister-group relations between genera and subgenera, localized in Brazil, tropical Africa and Indonesia. He dated the separation of some vicariant genera of gnats of similar distribution (e. g., *Ctenoceridion* Matile, 1972 and *Heteropterna* Skuse, 1888: MATILE, 1990: 595 and figs.) as possibly of the Jurassic age, the vicariance of Neotropical and Afrotropical distributions as *terminus post quem non* Late Jurassic.

YAMAMOTO & SOTA (2007) and DE JONG (2007) have very elegantly associated the differentiation and subsequent radiation of geometrid subfamilies with that of bats dated as from the Eocene age. The speciose radiation of trichopterygine geometrids (Larentiinae: Trichopterygini) in Asia coincided with Pliocene cooling of climate (YAMAMOTO & SOTA, 2007). This event resulted in vicariant species, so similar to each other that numerous species of Trichopterygini have been described during the recent decades (INOUE, 1982; XUE & ZHU, 1999) according to minor differences in their genitalia structures.

DE JONG (2007) argues for the Tertiary age of most groups of Lepidoptera based on timing of their food plants supported both by molecular clock hypothesis and age of known fossils (WIKSTRÖM *et al*., 2001), avoiding paleogeographical argumentation of disjunct distributions. However, if *Pyrochlora* species groups have maintained their uniform wing pattern and disjunct distribution since the Amazon-Orinoco distribution barrier dated as from the Miocene age, then the vicariance of the ancestor of genera *Pyrochlora*, *Dargeia* and *Rhanidopsis* must be much earlier and may be associated with the breakup of the Gondwana supercontinent.

The homologous wing pattern may be more ancient than the differences in genitalic morphology of moths due to different tempos of evolutionary changes in different character systems of moths. Insect genital diversification is said to be rapid and the presence / absence of coremata hair pencils associated with precopulatory chemical communication of noctuid moths in sibling species pairs is also evaluated as recent evolutionary modifications (MIKKOLA & LAFONTAINE, 1986).

The conditions of wet tropical forest biome may have conserved the putative ancestral wing pattern of saturniids too - to recall here well known emperor moths *Archaeoattacus* Watson, 1914, *Samia* Hübner, 1819 and *Attacus* Linnaeus, 1767 in Asia, *Epiphora* Wallengren, 1860 in tropical Africa, and *Rothschildia* Grote, 1896 in the New World fauna (Saturniidae), the vicariant genera becoming different trends of morphological modification since the vicariance and maintaining similar wing shape and pattern.

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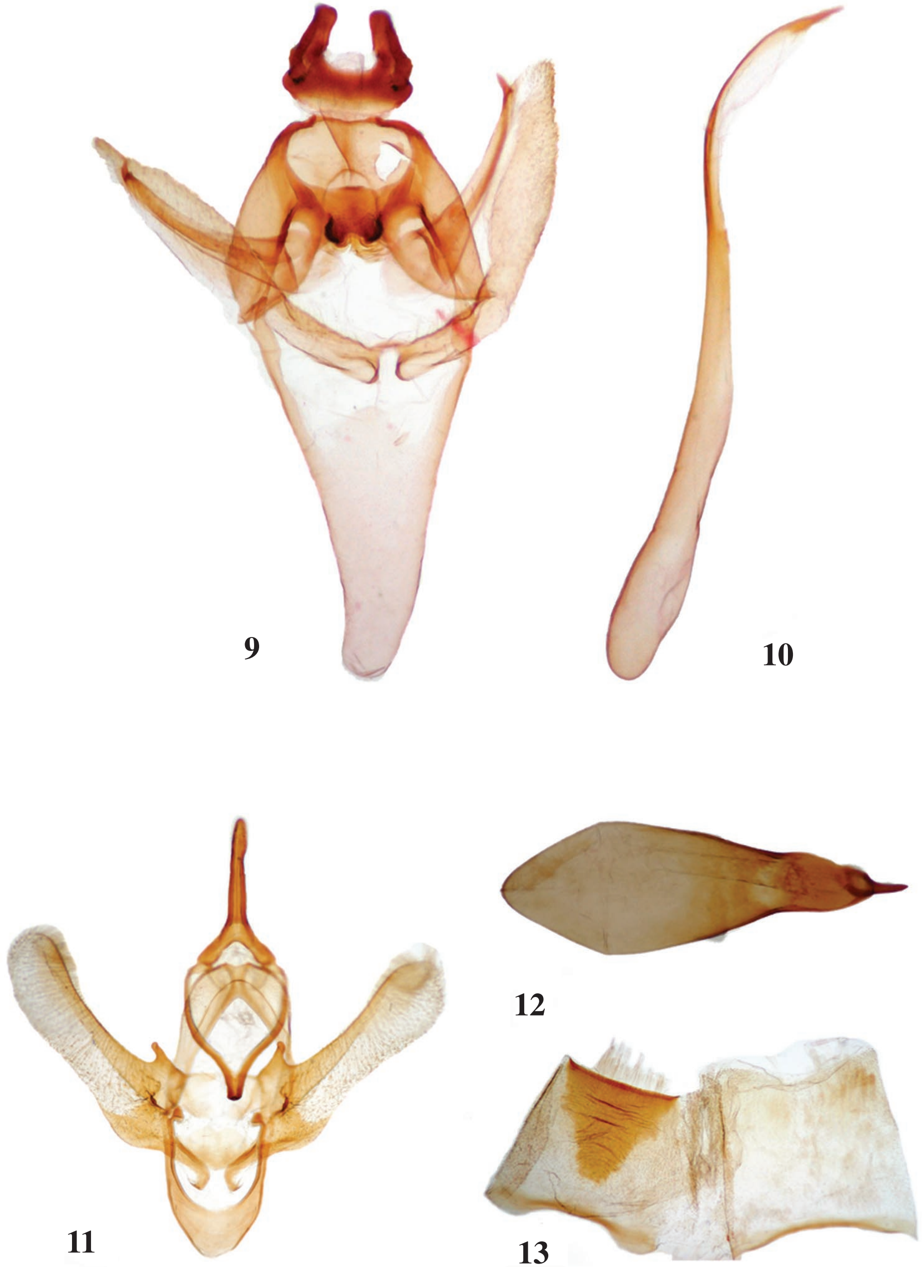
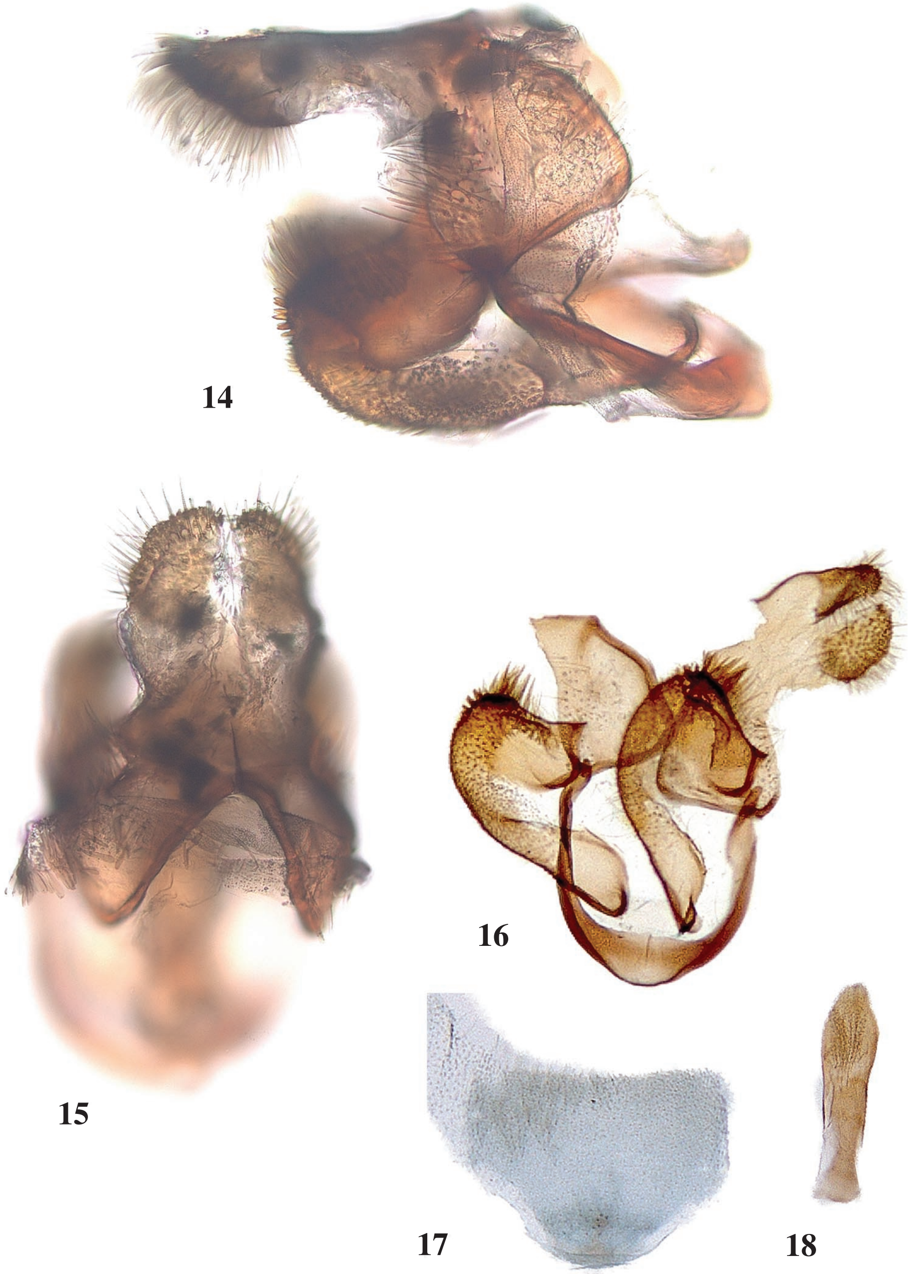
Figs. 1-8.– 1-6. Upperside and underside of emerald moths. **1.** *Rhanidopsis kogeri* Viidalepp & Lindt, sp. n., male holotype, forewing length 9,5 mm. **2.** *Rhanidopsis kogeri* Viidalepp & Lindt, sp. n., male, underside. **3.** *Pyrochlora vogli* Viid., female, forewing length 11 mm. **4.** *Pyrochlora vogli* Viid., female, underside. **5.** *Dargeia micheleae* Herbulot, female, forewing length 13 mm. **6.** *Dargeia micheleae* Herbulot, female, underside. **7.** *Ochrognesia difficta* Walker, male, forewing length 16.5 mm. **8.** *Dargeia micheleae* Herbulot, paratype male, forewing length 10 mm.



Figs. 9-13.– Male genitalia of *Rhanidopsis* and *Pyrochlora*. **9.** *Rhanidopsis kogeri* Viidalepp & Lindt, sp. n., male genitalia. **10.** *Rhanidopsis kogeri* Viidalepp & Lindt, sp. n., aedeagus. **11.** *Pyrochlora majorcula* Dyar, male genitalia. **12.** *Pyrochlora majorcula* Dyar, aedeagus. **13.** *Pyrochlora majorcula* Dyar, male sternite and tergite A8.



Figs. 14-18.– Male genitalia of *Dargeia micheleae* Herbulot. **14.** Male genital capsule, lateral view, without cover slip in water. **15.** Male genital capsule, dorsal view, without cover slip in water. **16.** Male genitalia, ventral view (tegumen broken). **17.** Male sternite A8. **18.** Aedeagus of *Dargeia micheleae* Herbulot.