

## On the Trichoptera of Korea with Eastern Palearctic relatives

J. OLÁH<sup>1</sup>, K.A. JOHANSON<sup>2</sup>, W. LI<sup>3</sup> & S.J. PARK<sup>4</sup>

<sup>1</sup>János Oláh, Residence postal address: Tarján u. 28, H-4032 Debrecen, Hungary  
E-mail: [profolah@gmail.com](mailto:profolah@gmail.com)

<sup>2</sup>Kjell Arne Johanson, Swedish Museum of Natural History, Department of Zoology, Box 50007,  
SE-10405 Stockholm, Sweden. E-mail: [kjell.arne.johanson@nrm.se](mailto:kjell.arne.johanson@nrm.se)

<sup>3</sup>Weihai Li, Department of Plant Protection, Henan Institute of Science and Technology, Xinxiang  
453003, China. E-mail: [wh7969@163.com](mailto:wh7969@163.com)

<sup>4</sup>Sun Jin Park, Department of Life Science, Kyonggi University, Suwon 16227, Korea.  
E-mail: [sjp7427@gmail.com](mailto:sjp7427@gmail.com)

**Abstract.** The caddisfly materials collected by Hungarian zoologists during 25 collecting trips between the years of 1970 and 2016 in the Korean Peninsula was identified and compared when required with Eastern Palearctic relatives. The appendicular genital terminology was adopted and applied to several representatives of Polyphorae taxa. We identified 95 caddisfly species, including 5 new records for the Korean Peninsula: *Tinodes higashiyamanus* Tsuda, 1942, *Apatania yenchingensis* Ulmer, 1932, *Neophylax relictus* (Martynov, 1935), *Limnephilus quadratus* Martynov, 1914, and *Hydatophylax soldatovi* (Martynov, 1914). We have described the following 12 species new to science: *Plectrocnemia ussurica* Oláh & Johanson sp. nov. (Russia); *Psychomyia tompa* Oláh & Johanson sp. nov. (Russia); *Psychomyia vandor* Oláh & Johanson sp. nov. (Russia); *Agapetus vastag* Oláh & Johanson sp. nov. (Russia); *Agapetus vekon* Oláh & Johanson sp. nov. (Russia); *Neophylax goguriensis* Oláh & Park sp. nov. (North Korea); *Neophylax sillensis* Park & Oláh sp. nov. (South Korea); *Dicosmoecus coreanus* Oláh & Park sp. nov. (South Korea); *Dicosmoecus juliarum* Oláh sp. nov. (Russia); *Dicosmoecus mongolicus* Oláh sp. nov. (Mongolia); *Asynarchus mongolicus* Oláh sp. nov. (Mongolia); *Psilotreta kerka* Oláh sp. nov. (North Korea).

**Keywords.** Trichoptera, new species, new records, Korean Peninsula, Russia, Mongolia.

### INTRODUCTION

Between 1970 and 2016 during 25 collecting trips a significant caddisfly material was collected by Hungarian zoologists from various aquatic habitats in the Korean Peninsula. This collection was stored unidentified in the the Hungarian Natural History Museum. In this paper we present the results of the elaboration and identification of this valuable material.

The northern part of the Korean Peninsula was explored by zoologist from Bulgaria, Czechoslovakia, East Germany and Poland. Most of the material has been examined and several new species have been described (Botosaneanu 1970,

Oláh 1985, Mey 1989, Kumanski 1990, 1991a, b, 1992, Kumanski & Weaver 1992).

During our study of the Korean material we faced taxonomical problems of several species described by Martynov from regions of cross-border Russia and recorded from Korea and even from Japan. To be able to exactly identify these specimens we compared our material with material from Russia (Amurland, Ussuriland), Japan, from the southern part of the Korean Peninsula as well as Mongolia. This was possible due to successful cooperation with researchers from majority of these countries. A significant material collected by Swedish colleagues in Ussuriland was available for our comparative study as well.

## MORPHOLOGY

### Male appendicular genital terminology applied to limnophiloid Polyphorae

Getting first intimately acquainted with the genital structure of several representatives of the Polyphorae, here we adopt our appendicular genital terminology (Oláh & Johanson 2008) to males of limnophiloid Polyphorae (Schmid 1955). We suggest to replace the widely applied neutral, directional terms of preanal (before proct or rectum), superior (upper), external (outer), internal (inner)/intermediate (in-between) and inferior (lower) branches on the segment X(XI) as well as of the inferior (lower) appendages on segment IX with the appendicular terminology. It seems that Polyphorae has the most plesiomorphic state of the superanal complex in the Limnephiloidea superfamily (Vshivkova, 2007). Segment X (XI) is most produced and the genitalia primitively comprise 7 pairs of appendages: (1) dorsomesal lobes of segment IX; branches on segment X (XI): (2) preanal appendages; (3) external branches; (4) internal or intermediate branches; (5) inferior branches; (6) subanal plate; (7) inferior appendages on segment IX. These structures are variously present or absent in different genera; some of them often lost through specialization by simplification that could be an inherent complexity increase (Oláh *et al.* 2017). Complexity could arise, not only by incremental addition but by incremental subtraction in the Apataniidae, Uenoidae families and in the Dicosmoecinae subfamily of the limnophiloid Polyphorae.

At Oligophorae taxa the number of branches on segment X (XI) is reduced/fused and consistently comprised only 4 pairs of appendages: (1) cerci, one or the fused forms of setose cercal appendages (praeanal appendages and external branches of segment X (XI)); (2) paraproct appendages (the fused internal and inferior branches of segment X); (3) membranous or less pigmented subanal plate as well as (4) the subphallic complex of inferior appendages on segment IX with its basal plate. In Oligophorae limnephilids the

*paraproct complex* is formed by the fusion of internal and inferior branches of segment X (XI) due to the further reduced body of segment X (XI). The paraproct complex is represented by variously produced remnants of these branches and named in four different directional terminologies: (1) internal and inferior branches of Schmid (1955), (2) apparent dorsal and ventral branches of Vshivkova (2007), (3) apical and basal branches or (4) horizontal and vertical branches. Dorsal branches are produced caudad and more or less horizontal, ventral branches oriented more or less dorsoventrad. Combining the four directional nomenclatures of the paraproct branches we may summarize that the dorsal branch is internal (bilobate in plesiomorphy: external and internal), apical and horizontal; the ventral branch is inferior, basal and vertical. Branches may be partially or completely fused in various shape and forming a completely or partially sclerotized ring around anus. This paraproct complex could be fused with dorsum IX, segment X and with cerci forming together the *superanal genitalic complex* of Vshivkova (2007).

### Vaginal sclerite complex of limnophiloid Polyphorae

Here we present the structure and phenomic potential of the vaginal sclerite complex as we have developed and discussed for other than limnophiloid Polyphorae taxa (Oláh *et al.* 2013, 2014, 2015). The basic structural pattern of the vaginal sclerite complex composing of nine structural units seems to suit well to the primitive limnophiloid taxa of Polyphorae. However, some well discernible differences appear very pronounced compared to Oligophorae. Both (1) the dorsal articulation structures connecting the vaginal complex to dorsal vulvar lip and (2) the ventral articulation structures connecting the vaginal complex to the ventral vulvar lip are very produced and particularly structured at the primitive Polyphorae, offering probably high species-level diagnostic value.

As we have discussed in our first study (Oláh *et al.* 2013) the diversity potential of the sclero-

tized structure functioning in the female genital chamber and named as vaginal sclerite complex is underutilized in distinguishing among the closely related caddisfly species. Female internal apparatus cleared in caustic potash was first recognised and applied by Morton (1902), later by Nielsen (1943) to separate *Apatania* females. In limnephilids the vulval opening formed and surrounded by the lower lip (*vulvar scale* of McLachlan (1874-1880), the *gonopods of segments VIII and IX* by Nielsen (1980)) and by the upper lip (*supragenital plate*, part of segment X) is the vestibule to vagina. The vaginal chamber is formed by fusion of the distal parts of the common oviduct and the duct of the accessory or collateral glands. These glands usually are very large filling most part of the female abdomen and their ducts are rather wide at their section opening to the vaginal chamber. This may divide the vaginal chamber into a ventral and dorsal branch. The *vaginal sclerite complex* (*internal sclerite* of Morton (1902), *spermathecal sclerite* of Nielsen (1980)) developed along the junction of oviduct and the duct of the accessory glands and receiving also the spermathecal duct plus the duct of bursa copulatrix. It is a rather diverse and complex organ, but this potential was not yet explored to differentiate among caddisfly species.

Species specificity of female genitalia, higher than at male, was demonstrated only recently in families of dipteran Sepsidae (Puniamorthy *et al.* 2010) and mecopteran Panorpididae (Ma *et al.* 2012). Its complex nature as well as difficulties in understanding and drawing, have limited its use in taxonomy. The vaginal sclerite complex evolved with flexing, bracing, holding and stretching functions for the structural organisation of the four ducts entering and forming the vaginal chamber. Its dorsal position to oviduct and anterad position to the duct of accessory gland as well as the variously developed sclerotized substructures to receive duct of bursa copulatrix and the duct of spermatheca explain this basic function. Starting from Morton's original terminology we have differentiated 6 substructures in the vaginal sclerite complex for our taxonomic purposes. (1) Morton's *paired lateral blades* are the *vaginal sclerite*

*plate* itself on the dorsum of the vagina. The vaginal sclerite plate may form variously sclerotized lateral folds, flanks and subdivided structures in different groups. We have separated two additional substructures of the plate with particular functions. (2) The substructure of mostly sclerotic articulation to the internal continuation of the lateral processes of the vulval scales, the paired gonopods of segment IX, is usually a double layered *folding plica* ensuring a firm flexible attachment or suspension of the membranous genital chamber and its tubing complex to the exoskeleton of the vulvar scale. (3) The vaginal sclerite plate has a pair of sclerotized wing-shaped substructure laterad serving stretch function to the vagina and apodemic function anterad to receive vaginal muscles. (4) Morton's *central triangular piece* is the usually hood-shaped *junction sclerite* holding and stretching the junction where the ducts of ovarium and accessory gland meet. (5) Morton's *central foot-shaped piece* is the *spermathecal process* (*processus spermathecae* of Nielsen 1980) receiving the ductus spermathecae and forming frequently a longitudinal keel on the ventrum of the vaginal sclerite. The opening of the spermathecal duct forms variously sclerotized window on the spermathecal process. (6) This small sclerite was not specified by Morton. The ductus bursae open between the spermathecal process and the common oviduct at the anterior margin of the vaginal sclerite. The mesoanterior margin of the vaginal sclerite plate is bulking and bending upwards elevating the position of the duct opening. These substructures and functions constitute the vaginal sclerite complex, but their development and sclerotization are highly varying in the different groups.

As we have examined more limnephilid genera and species we have separated three more substructures for practical taxonomic purposes in addition to the six substructures distinguished in our first study (Oláh *et al.* 2013) and listed them together with the previously distinguished ones (Oláh *et al.* 2014, 2015). (1) *Vaginal sclerite plate* itself on the dorsum of the membranous vagina and ventrum of the membranous accessory gland duct; this basal plate integrates all the substructures

tural components of the vaginal sclerite complex. (2) *Dorsal articulation sclerites*, a variously sclerotized internal continuation of the supragenital plate (upper vulvar lip). The internal dorsal articulation sclerites and external supragenital plate together participate to receive the stimulating or harm effect of the male parameres in the processes of sexual selection. Much developed if accessory duct enlarged laterad or elongated anterad and gives additional support to help the function of the junction sclerite. Heavily sclerotized if male parameres function as harm device in the sexually antagonistic coevolution. (3) *Ventral articulation sclerites* attach the sclerite complex to the internal continuation of the lateral processes of the vulvar scales (lower vulvar lip), that is to the paired gonopods of segment IX. (4) *Lateral joints* of the upper and lower lips. Usually not, or less sclerotized, but sometimes enlarged and bloated by proliferation of hard tissue. (5) *Wing sclerites* with stretch function for vagina and with apodemic function anterad to receive vaginal muscles, variously combined with ventral articulation sclerites. (6) Hood-shaped *junction sclerite* holding and stretching the junction where the ducts of accessory gland and ovarium meet as well as separating accessory duct from spermathecal duct. (7) *Spermathecal process* receiving ductus spermathecae and forming frequently a longitudinal keel on the ventrum of the vaginal sclerite. (8) *Bursal sclerite* receiving ductus bursae that opens between the spermathecal process and the common oviduct at the anteriomesal margin of the vaginal sclerite. These substructures and functions constitute the vaginal sclerite complex, but their development and sclerotization are highly varying in the different groups. (9) *Anterior apodemes* appear as the anteriomost lateral extension of the vaginal plate separated by the mesal bursal sclerite. Receive muscles and frames the space for the bursal sclerite ensuring to receive ductus bursae.

## MATERIALS AND METHODS

On the basis and in the frame of the signed agreement between Hungary and the Democratic People's Republic of Korea, the Hungarian Natu-

ral History Museum has realised 16 zoological collecting trips between 1970 and 1994 in different regions of the northern part of the Korean Peninsula at various seasons (Mahunka & Steinmann 1971, Mészáros & Zombori 1995). In 1990 cooperation was initiated by direct contact between the Center for Insect Systematics in Chuncheon, the Republic of Korea and the Hungarian Natural History Museum. This cooperation, producing another 9 Korean zoological collecting trips, was part of the bilateral Agreement signed between the Korea Science and Engineering Foundation and the Hungarian Academy of Sciences in the general framework of the interstate agreement between Hungary and the Republic of Korea (Ronkay & Vojnits 1992, Zombori 1992).

During these Korean trips there was no collectings conducted by Trichoptera specialist. Most of the Trichoptera material collected was by-catches of light collections organised and carried out by lepidopterologists. Caddisfly collection requires specialised daytime sweeping procedures in particular roosting habitats both in low and high canopies as well as night-time light collections nearby of particularly selected aquatic habitats. Over the years significant and rich caddisfly materials was collected by nonspecialists but, mostly larger-sized taxa were selected. For instance, there is no single microcaddisfly present, and other small sized taxa are also underrepresented. Other reason of the lower diversity than expected in the material is due to the fact that almost the same area and habitats have been visited repeatedly year by year.

*Depositories.* Department of Plant Protection, Henan Institute of Science and Technology, China (DPP-HIST).

Hungarian Natural History Museum, Budapest, Hungary (HNHM).

Kyonggi University, Suwon, Korea (KGU).

Natural Institute of Biological Resources, Incheon, Korea (NIBR).

Oláh Private Collection, Debrecen, Hungary, under national protection of the Hungarian Natural History Museum (OPC).

Swedish Museum of Natural History, Stockholm, Sweden (SMNH)

## TAXONOMY

### Suborder Annulipalpia

#### Superfamily Philopotamoidea Stephens, 1829

#### Family Stenopsychidae Martynov, 1924

##### *Stenopsyche bergeri* Martynov, 1926

*Material examined.* **North Korea**, South Hwanghae Province, Haeju, Mt Suyong-san, 16.X.1987. Material collected in a deciduous forest of the SE slope, leg. Z. Korsós & L. Ronkay (3 males, 1 female; HNHM). **North Korea**, Gang-won Province, district On-dzong, Kumgang-san, near Hotel Go-song, 250 m, 6.VIII.1975, collected at Mv lamp in a coniferous-locust tree wood, leg. J. Papp & A. Vojnits (6 males, OPC).

##### *Stenopsyche coreana* Kuwayama, 1930

*Material examined.* **North Korea**, Kangwon Province, Mt. Kumgang-san, Kuryong valley, 14.VI.1991, collected by light trap in the lower part of the valley, leg. L. Ronkay & A. Vojnits (1 male, HNHM). **North Korea**, Kangwon Province, Mt. Kumgang-san, 13.VI.1991, collected at light in the side valley near to Hotel Kumgang, leg. L. Ronkay & A. Vojnits (1 male, OPC). **North Korea**, Kumgang-san (Diamond Mountains), Hotel Kum-gang at village Ontsong, 9.VII.1977, canopied coniferous forest, collecting at Mv lamp in the forest, about 150–200 m S from the hotel leg. O.Gy. Dely & Á. Dely-Draskovits (3 males, OPC). **North Korea**, Kumgang-san (Diamond Mountains), Rükhaam, about 7 km W from Hotel Kum-gang, 11.VII.1977, caught in Malaise-trap erected on a clearing in the forest leg. O. Gy. Dely & Á. Dely-Draskovits (1 male, OPC). **North Korea**, Kangwon Province, Mts. Kumgang san, Hotel Kumgang, 9. VI.1991, collected at light on balcony of the hotel leg. L. Ronkay & A. Vojnits (1 male, OPC). **North Korea**, Province Gang-won, district On-dzong, Kum-gang san, near Hotel Go-song, 250 m, 6.VIII.1975, collected at Mv lamp in a coniferous-locust tree wood, leg. J. Papp & A.

Vojnits (1 male, OPC). **North Korea**, Gang-won Province, Kum-gang san, 10. VI. 1991, collected by light trap, leg. L. Ronkay & A. Vojnits (1 male, OPC).

##### *Stenopsyche marmorata* Navás, 1920

*Material examined.* **North Korea**, Gang-won Province, Mt. Kumgang-san, 28.V.1985. Night collecting at blended light, fed by a Honda generator on the serpentine to Kwinyon-am Rock, leg. A. Vojnits & L. Zombori (1 male, HNHM). **North Korea**, North Pyongan Province, Mt. Myohyang-san, 20.V.1985, cool evening, night collecting at blended light (250 W) on the balcony of the hotel, leg. A. Vojnits & L. Zombori (1 male, HNHM). **North Korea**, North Pyongan Province, Mt. Myohyang-san, Isonnam valley, 23.V.1991. Singled insects in the valley, leg. L. Ronkay & A. Vojnits (1 male, HNHM). **North Korea**, North Khamgen, Chondjin, 3.VI.1991. at light in the O-sang-li valley, about 20 km SW of Chondjin, leg. L. Ronkay & A. Vojnits (14 males, HNHM). **South Korea**, Gyeongsangnam-do, Hadong-gun, Mt. Jirisan, Ssanggyesa valley, parking lot beneath Daesung camp, 270 m, N35°16.523' E127°39.131', 14.IX.2010, leg. D. Murányi *et al.* (1 male, OPC).

##### *Stenopsyche variabilis* Kumanski, 1992

*Material examined.* **North Korea**, North Pyongan Province, Mt. Myohyang-san, 20.V. 1985, cool evening, night collecting at blended light (250 W) on the balcony of the hotel, leg. A. Vojnits & L. Zombori (1 male, HNHM). **North Korea**, North Pyongan Province, Mt. Myohyang-san, Hyangsan, 15.IX.1994, light trap, leg. F. Mészáros & L. Zombori (1 male, HNHM).

#### Family Philopotamidae Stephens, 1829

##### *Dolophilodes mroczkowskii* Botosaneanu, 1970

*Material examined.* **North Korea**, North Pyongan Province, Mt Myohyang-san, Hotel Myohyang-san, 21.V.1985, light, leg. L. Forró & L. Ronkay (1 male, OPC). **North Korea**, North

Pyongan Province, Mt Myohyang-san, Hyangsan valley, near Hwajangam cloister, 21.V.1985, light, leg. L. Ronkay & A. Vojnits (1 male, OPC).

***Kisaura hapirensis Botosaneanui, 1970***

*Material examined.* **North Korea**, Chagang Province, Mt. Myohyang-san, Hotel Myohyang, 13.IX.1980, singled at lamps standing around the hotel, leg. L. Forró & Gy. Topál (1 male, HN HM). **North Korea**, North Pyongan Province, Mt. Myohyang-san, Hotel Myohyang-san, 18.VII.1982, light, leg. L. Forró & L. Ronkay (1 male, OPC). **North Korea**, North Pyongan Province, Mt Myohyang-san, Hotel Myohyang-san, 14.VII.1982, light, leg. L. Forró & L. Ronkay (1 male, HNHM).

***Wormaldia niensis Kobayashi, 1985***

*Material examined.* **North Korea**, North Pyongan Province, Mt. Myohyang-san, Hyangsan, 17.IX.1994, light, trap, leg. F. Mészáros & L. Zombori (1 male, OPC). **South Korea**, Cheju Province, Andok valley, 300 m, 126° 22'E 33° 15'N, 28.IV.1994, light. leg. L. Peregovits, L. Ronkay & A. Vojnits (1 male, HNHM).

**Superfamily Psychomyioidea Walker, 1853**

**Family Ecnomidae Ulmer, 1903**

***Ecnomus tenellus* (Rambur, 1842)**

*Material examined.* **South Korea**, Suweon, near Seoul, 9.VII.1974, leg. P. E. S. Whaley (1 male, OPC).

***Ecnomus yamashironis* Tsuda, 1942**

*Material examined.* **North Korea**, South Pyongan Province, Pyongan, room of Hotel Te-dong on the fifth floor, 29.VII.1975, light, leg. J. Papp & A. Vojnits (27 males, HNHM).

**Family Polycentropodidae Ulmer, 1903**

***Neucentropus mandjuricus* Martynov, 1909**

*Material examined.* **Russia**, Khabarovsk Terr.,

Slavyanka at Amur, 17.VI.1994, light trap, leg. P. Lindskog & A. Nilsson (1 male, SMNH).

***Plectrocnemia ussurica* Oláh & Johanson, sp. nov.**

(Figures 1–3)

*Material examined.* **Holotype: Russia**, Primor-ye, Ussurijsk Reserve, 40 km ENE Ussurijsk, 17–18.VII.1992, light-trap, leg. P. Lindskog & A. Nilsson (1 male, SMNH).

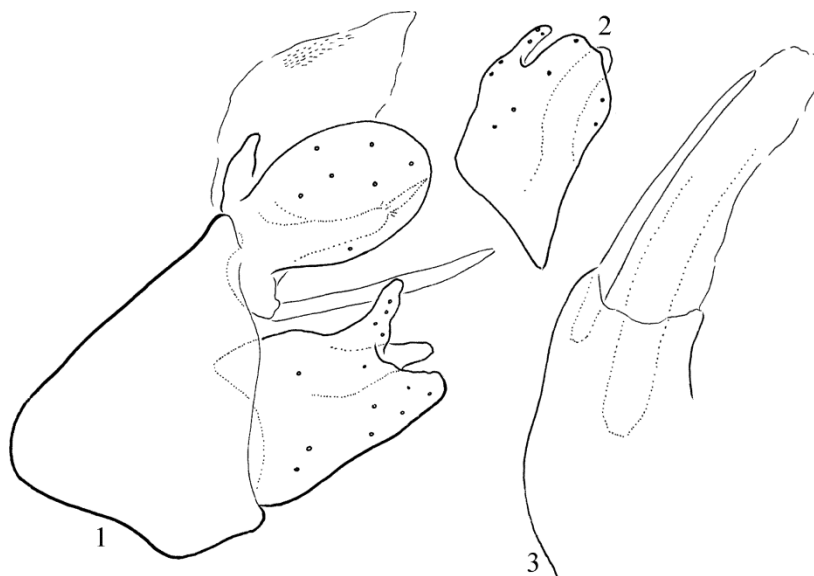
*Diagnosis.* According to the basic genital architecture the new species has resemblance to *P. nagayamai* Schmid and *P. tochimotoi* Schmid, but differs in all the structural details of the paraproctal complex and of the gonopods.

*Description.* Small polycentropodid species with forewing length of 6 mm, segment IX in lateral view subtriangular. Tergite IX and tergite X seems fused, mostly membranous with quadrangular shape in lateral view. Cerci large and ovoid covering most of the paraproctal complex. Paraproctal complex composed of the dorsal and ventral branches without well discernible ventral sclerite. Dorsal branches (lateral process of Ohkawa & Ito 2007) with stout terminal spine nested in the setose apex of the process. The ventral branches (mesoventral process of Ohkawa & Ito 2007) short with a long and stout apical spine, much longer than the apical spine of the dorsal paraproctal branch. Gonopods with well defined lobes of the dorsal and ventrall apical process as well as an inner process. The phallic organ accompanied by a pair of less sclerotized paramere-like processes.

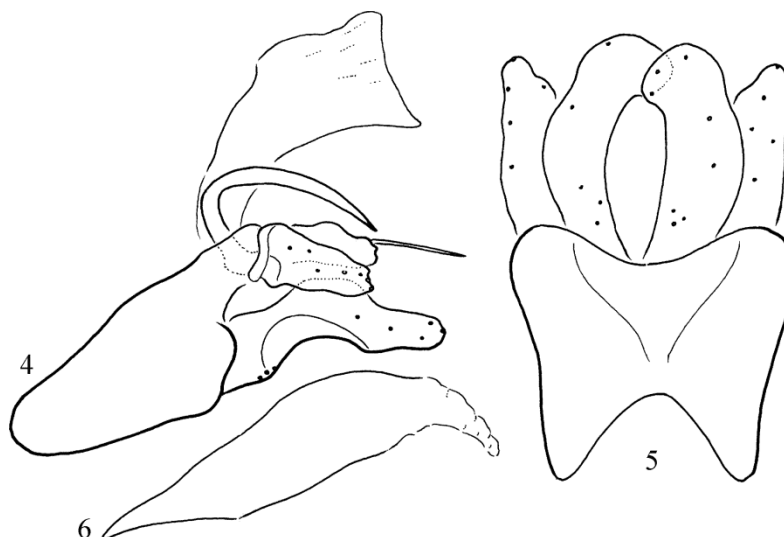
*Etymology.* *ussurica*, named for the region in which the holotype were collected.

***Plectrocnemia wui* (Ulmer, 1932)**

*Material examined.* **South Korea**, Jeju-do, Mt. Hallasan, Yongshil route, 1050 m, edge of Hallasan National Park, 126°30'E 33°21'N, 27.IV.1994, light, leg. L. Peregovits, L. Ronkay & A. Vojnits (1 male, HNHM). **South Korea**, Jeju-do, Andok valley, 300 m, 126°22'E 33°15'N, 28.IV.1994, light, leg. L. Peregovits, L. Ronkay & A. Vojnits (4 males, HNHM).



Figures 1–3. *Plectrocnemia ussurica* Oláh & Johanson, sp. nov. Holotype male: 1 = genitalia in lateral view, 2 = left gonopod in ventral view, 3 = phallic organ in lateral view.



Figures 4–6. *Polyplectropus malickyi* Nozaki, Katsuma & Hattori, 2010. Male: 4 = genitalia in lateral view, 5 = genitalia (segment IX, gonopods, cerci) in ventral view, 6 = phallic organ in lateral view.

***Polyplectropus malickyi* Nozaki, Katsuma & Hattori, 2010**

(Figures 4–6)

*Material examined.* Holotype: **North Korea**, Kumgang-san (=Diamond Mountains), Lake Sam Il, singling and netting on the shore, 10.VII.1977, leg. O.Gy. Dely & A. Dely-Draskovits (1 male, OPC).

*Remarks.* This small polycentropodid species with typical genetal architecture has forewing with almost complete venation, but the venation of hindwing is rather reduced; only forks II and V are present and the discoidal cell is open. *P. malickyi* is an incipient sibling species of *P. unicus* (Hsu & Chen, 1996) described from Taiwan and recorded as well as redescribed from Japan (Nozaki *et al.* 2013); *P. malickyi* Nozaki,

Katsuma & Hattori, 2010 was described from Japan. Our single specimen from North Korea differs from the published drawings of both species by having (1) the dorsal hump on the gonopods flat, sharp flat, not triangular, similarly to the other known Korean specimen recorded and drawn by Park *et al.* (2017); (2) the setose cerci are subquadrangular, not triangular as in *P. malickyi*; (3) the paraproct complex (subphallic sclerite and the spine-like curving process that is the dorsal branch of the paraproct) is differently shaped, (4) the dorsal branch of the paraproct is long and robust, not short and slim. According to Nozaki (personal communication) *P. malickyi* is rather variable. First we have considered this North Korean specimen as a new sibling of the *Polyplectropus unicus* complex. But we have only a single underpigmented male. Without dissections we are unable to discern and compare structural realations. To decide which traits are neutral that is variable being exposed to random processes or adaptive that is stable under various protective mechanisms, we need more specimens from more populations.

#### Family Psychomyiidae Walker, 1852

##### *Metalype uncatissima* (Botosaneanu, 1970)

*Material examined.* **North Korea**, North Khamgen Province, Chondjin, 3.VI.1991, O-sang-li valley, 20 km SW of Chondjin, ligh, leg. L. Ronkay & A. Vojnits (4 males, HNHM).

##### *Psychomyia flavida* species group

The *P. flavida* species group is characterized by the most fused dorsal complex of tergite IX, cercus and paraproct and the most reduced vestiges of coxopodite that is the first segment of gonopods (Schmid 1997).

##### *Psychomyia flavida* new species complex

In the *P. flavida* species group we distinguish the *P. flavida* species complex. In this complex the known species have variously V-shaped plate-like dorsal complex dominating on the genitalia.

However, the most apomorphic derived character of the complex is the presence of a pair of filiform processes discernible as arisen and individualised from the apical ventromesal region of the IX sternite. According to Schmid (1983) this structure represents the coxopodite of the gonopods. In *P. flavida* species group the first segment of the gonopods is frequently indiscernibly fused to sternite IX, therefore the homology of this apomorphic structure remains questionable. *P. composita* Martynov, 1910; *P. coreana* Tsuda, 1942; *P. flavida* Hagen, 1861; *P. tompa* sp. nov.

##### *Psychomyia coreana* (Tsuda, 1942)

(Figures 7–9)

*Psychomyiella coreana* Tsuda, 1942: 230. “Material: 32♂, 24♀, Keizanchin, Nord-Korea, 16.VII.1940, M. Uéno und K. Yamamoto leg.

*Material examined.* **Russia**, Primorye, Ussurijsk Reserve, 40 km ENE Ussurijsk, light-trap, 17–18.VII.1992, leg. P. Lindskog & A. Nilsson (5 males SMNH; 4 males OPC).

*Remarks.* This species was described from North Korea. We have examined specimens collected in Russia, Ussuriland. The holotype was not available for comparison, but the ovoid dorsal profile of the phallic head as the probable speciation trait as well as the lateral shape of the fused tergite IX and cerci and the ventral shape of the setose lobe of the gonopods are well visible on the original drawings of the holotype. The here examined eight specimens has very stable phallic head, but the setose lobe of the gonopods exhibits a range of variations.

##### *Psychomyia flavida* Hagen, 1861

*Psychomyia flavida* Hagen, 1861: 294. “Hab. St Lawrence River, Canada (Osten Sacken); Washington (id.).” Gross habitus description, no genital drawings.

*Psychomyia pulchella* Banks, 1899: 217. “Fort Collins, Colorado (Baker).” Gross habitus description, no genital drawings.



*Psychomyia moesta* Banks, 1907: 131. "One female from Colorado (No. 2133), probably from Ft. Collins or Denver." Gross habitus description, and gross genital drawings.

*Remarks.* Ross (1938) has synonymised *P. pulchella* Banks, and Schmid (1965, 1983) has synonymised *P. composita* Martynov as well as *P. moesta* Banks with *P. flavida*. Schmid has treated *P. flavida* as a widely distributed species inhabiting Siberia, Mongolia and almost the entire North-American continent. Malicky (2013) has considered even *P. coreana* Tsuda as a possible synonym of *P. flavida*. We believe that the North American *P. flavida* populations need a detailed comparative study. The published drawings (Ross 1938, Schmid 1983) may represent independent species.

***Psychomyia tompa* Oláh & Johanson, sp. nov.**

(Figures 10–12)

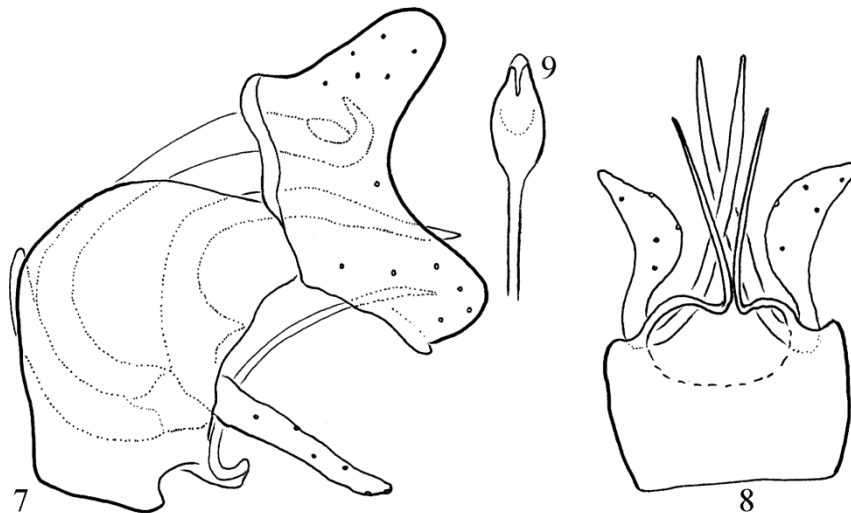
*Material examined.* Holotype, **Russia**, Khabarovsk Terr., Bolshekhkhehtsirsk Reserve, on light, 21.VI.1993, leg. P. Lindskog & A. Nilsson (1 male, SMNH). Paratype, same as holotype (1 female SMNH, 1 male OPC).

*Diagnosis.* This species belongs to the *P.*

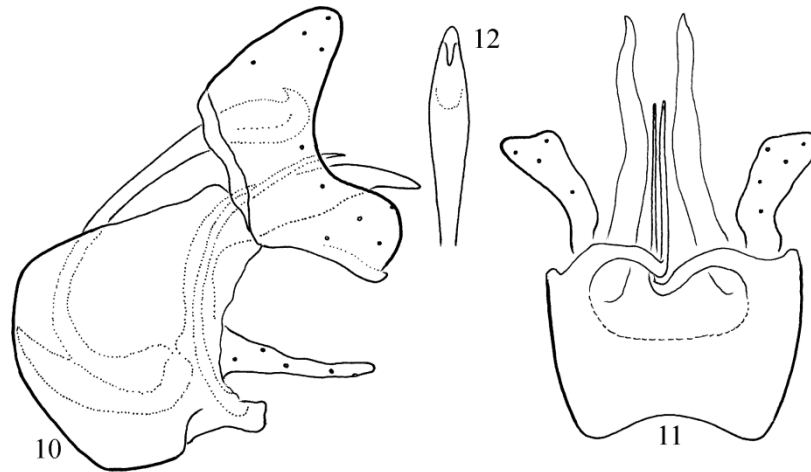
*flavida* species group and *P. flavida* species complex, but differs from all the known species by having blunt and truncate setose lobe of the gonopod and the probable speciation trait, the phallic head is differently formed.

*Description.* Medium-sized species. Forwing 4 mm. Sternum IX subrectangular in lateral view, tergum IX fused to cerci and paraproct forming a V-shaped large plate. Probable vestigium of tergite IX discernible anterad and the probable vestigium of paraproct discernible ventrad. Gonopods composed of the setose lobe and the heavily sclerotized unsetose spine-like process. The setose lobe horizontally flattened, digitate in lateral view with blunt truncated apex in ventral view. The heavily sclerotized spine-like process of the gonopod irregularly robust both in lateral and ventral view. The pair of filiform processes very thin. Phallic organ forms an upward and posterad curving sclerotized tube-like phallosome with swollen apex ending in a small upward and anterad curving spine. The phallic tube supported on its ventral third by a more sclerotized elongated plate fused to the basement of the phallic organ.

*Etymology.* *tompa*, blunt in Hungarian with reference to the blunt and truncate apex of the setose lobe of the gonopods in ventral view.



Figures 7–9. *Psychomyia coreana* (Tsuda, 1942). Male: 7 = genitalia in lateral view, 8 = genitalia in ventral view, 9 = phallic head in dorsal view.



Figures 10–12. *Psychomyia tompa* Oláh & Johanson sp. nov. Holotype male: 10 = genitalia in lateral view, 11 = genitalia in ventral view, 12 = phallic head in dorsal view.

***Psychomyia forcipata* Martynov, 1934**

*Material examined.* **North Korea**, North Pyongan Province, Mt. Myohyang-san, Hyangsan, 15.IX.1994, light trap, leg. F. Mészáros & L. Zombori (1 male, HNHM). **North Korea**, North Pyongan Province, Mt. Myohyang-san, Hyangsan valley near Hwajangam cloister, 27.V.1991, light, leg. L. Ronkay & A. Vojnits (1 male, HNHM).

***Psychomyia minima* (Martynov, 1910)**

*Material examined.* **North Korea**, South Pyongan Province, Pyongan, room of Hotel Te-dong on the fifth floor, 30.VII.1975, light, leg. J. Papp & A. Vojnits (1 male, HNHM). **North Korea**, South Pyongan Province, Pyongan, room of Hotel Te-dong on the fifth floor, 29.VII.1975, light, leg. J. Papp & A. Vojnits (1 male, HNHM). **North Korea**, Mt. Pektusan, wooded environs of the Sam-zi-yan hotel, 18.VII.1977, Malaise-trap on the road to Explosion Lake, leg. O.Gy. Dely & Á. Dely-Draskovits (1 male, OPC). **North Korea**, Pyongyang City, Pyongyang, light on the window of Hotel Tae Dong, 19.IX.1979, leg. H. Steinmann & T. Vásárhelyi (1 male, HNHM). **North Korea**, Pyongyang City, Pyongyang, Garden of Hotel Pyongyang, 21.IX.1978, light, leg. A. Vojnits & L. Zombori (3 males, HNHM).

***Psychomyia myohyangsanica* (Kumanski, 1992)**

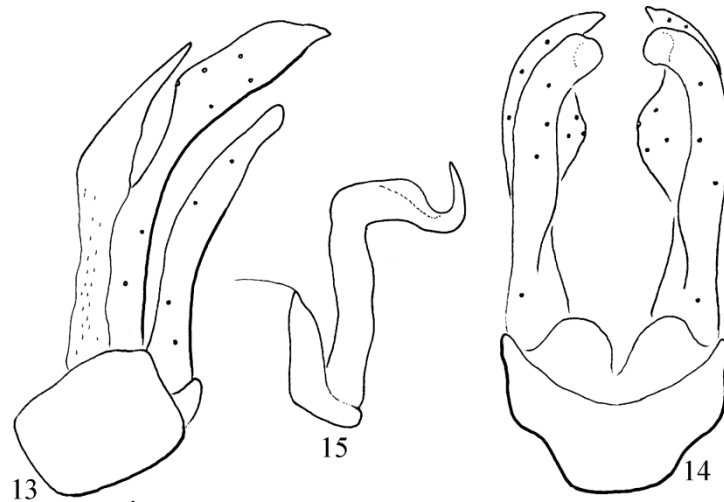
*Material examined.* **North Korea**, South Pyongan Province, Pyongan, room of Hotel Te-dong on the fifth floor, 29.VII.1975, light, leg. J. Papp & A. Vojnits (1 male, HNHM). **North Korea**, South Pyongan Province, Pyongan, room of Hotel Te-dong on the fifth floor, 30.VII.1975, light, leg. J. Papp & A. Vojnits (2 males, HNHM).

***Psychomyia vandor* Oláh & Johanson, sp. nov.**

(Figures 13–15)

*Material examined.* *Holotype*, **Russia**, Primorje, Ussurijsk Reserve, 40 km ENE Ussurijsk, light-trap, 17–18.VII.1992, leg. P. Lindskog & A. Nilsson (1 male SMNH). *Paratype*, same as holotype (2 males SMNH, 3 males OPC).

*Diagnosis.* This small species belongs to species complex having comparably similar sized cercus and gonopod and phallic organ with similar lateral profile: *P. anakdelapan* Malicky, 1995 from China (Sichuan), and *P. kumara* Schmid, 1997, *P. levanidovae* Schmid, 1997, *P. schefferae* Schmid, 1997, *P. scottae* Schmid, 1997 from India. Most close to *P. kumara*, but differs by having long tergite IX, gonopod apex rounded, not bilobed, phallobase small.



Figures 13–15. *Psychomyia vandor* Oláh & Johanson, sp. nov. Holotype male: 13 = genitalia in lateral view, 14 = genitalia in ventral view, 15 = phallic organ in lateral view.

**Description.** Small species. Forewing 3 mm. Sternum IX small rectangular in lateral view, tergum elongated tapering apicad and partially sculptured laterad with microtrichiae. Cerci elongated, mesad humping and tipped with dark pigmented terminal spine. Gonopod with short coxopodite and elongated harpago with blunt rounded mesad turning apex.

**Etymology.** *vandor*, wanderer/migrant in Hungarian with reference to the distribution of the species far from its known relatives those are populating India and China (Sichuan).

#### ***Tinodes furcatus* Li & Morse, 1997**

**Material examined.** **South Korea**, Jeju-do, Andok valley, 300 m, 126°22'E, 33°15'N, 28.IV.1994, light, leg. L. Peregovits, L. Ronkay & A. Vojnits (7 males, HNHM).

#### ***Tinodes higashiyamanus* Tsuda, 1942**

**Material examined.** **North Korea**, Kumgang-san (=Diamond Mountains), Lake Sam Il, singling and netting on the shore, 10.VII.1977, leg. O.Gy. Dely & Á. Dely-Draskovits (1 male OPC).

**Remark.** This species is new to the Korean Peninsula.

### **Superfamily Hydropsychoidea Curtis, 1835**

#### **Family Hydropsychidae Curtis, 1835**

#### **Subfamily Arctopsychinae Martynov, 1924**

##### ***Arctopsyche palpata* Martynov, 1934**

**Material examined.** **North Korea**, North Pyongan Province, Mt. Myohyang-san, pathway Isonnam, 11.X.1988, shifted from the litter of a rocky forest, leg. Z. Korsós & L. Ronkay (8 males, HNHM; 5 males, OPC). **Russia**, Primorye, Khasan District, 3 km W Ryazanovka, light trap, 15.VII.1992, leg. P. Lindskog & A. Nilsson (12 males, 3 females; SMNH). **Russia**, Primorye, Khasan District, 3 km W Ryazanovka, light trap, 11-12.VII.1992, leg. P. Lindskog & A. Nilsson (15 males, SMNH; 6 males, OPC).

#### **Subfamily Hydropsychinae Curtis, 1835**

##### ***Cheumatopsyche infascia* Martynov, 1934**

**Material examined.** **North Korea**, North Pyongan Province, Mt. Myohyang-san, pathway Isonnam, 11.X.1988, shifted from the litter of a rocky forest, leg. Z. Korsós & L. Ronkay (1 male, HNHM). **North Korea**, North Pyongan Province: Mt. Myohyang-san, Hotel Myohyang-san, 18.

VII.1982, light, leg. A. Vojnits & L. Zombori (4 males, HNHM).

***Cheumatopsyche tanidai* Oláh & Johanson, 2008**

*Material examined.* **South Korea**, Jeju-do, Andok valley, 300 m, 126°22'E, 33°15'N, 28.IV.1994, light, leg. L. Peregovits, L. Ronkay & A. Vojnits (2 males HNHM).

***Hydropsyche kozhantschikovi* Martynov, 1924**

*Material examined.* **North Korea**, Chagang Province, Mt. Myohyang-san, River Chongchong-gang valley, netting, 12.IX.1980, leg. L. Forró & Gy. Topál (1 male, OPC). **South Korea**, Gangwon-do, Inje, Mt. Daeamsan 574 m, 10.IX.2013, leg. Li Xuankun (5 males DPP-HIST, 5 males, OPC).

***Hydropsyche orientalis* Martynov, 1934**

*Material examined.* **North Korea**, Kangwon Province, Mt. Kumgang-san, 24.IX.1979. At light on the terrace of Hotel Kumgang, leg. H. Steinmann & T. Vásárhelyi (1 male, HNHM). **North Korea**, North Pyongan Province, Mt. Myohyang-san, Hyangsan, 16.IX.1994, light, trap, leg. F. Mészáros & L. Zombori (1 male, OPC).

***Hydropsyche valvata* Martynov, 1927**

*Material examined.* **South Korea**, Gangwon-do, Inje, Mt. Daeamsan 574 m, 10.IX.2013, leg. Li Xuankun (6 males, DPP-HIST; 5 males, OPC).

***Potamyia chinensis* (Ulmer, 1915)**

*Material examined.* **North Korea**, Province South Pyongan, Pyongan, Pyongan Hotel garden at lamp, 3.VIII.1971, light, leg. J. Papp & S. Horvátovich (1 male, HNHM). **North Korea**, Mt. Pektusan, wooded environs of the Sam-zi-yan hotel, 18.VII.1977, Malaise-trap on the road to Explosion Lake, leg. O.Gy. Dely & Á. Dely-Draskovits (6 males HNHM, 3 males OPC). **North Korea**, Chagang Province, Mt. Myohyang-san, River Chongchong-gang valley, netting, 12.IX.1980, leg. L. Forró & Gy. Topál (4 males, OPC). **North Korea**, Pyongyang City, Garden of Hotel

Pyongyang, 21.IX.1978, singled, leg. A. Vojnits & L. Zombori (49 males, 9 females HNHM). **South Korea**, Jeollanam-do, Gurye, Mt. Baekunsan 620 m, 7.IX.2013, leg. Li Xuankun (3 males OPC). **South Korea**, Gangwon-do, Inje, Mt. Daeamsan 574 m, 10.IX.2013, leg. Li Xuankun (6 males OPC).

***Potamyia czezanovskii* (Martynov, 1910)**

*Material examined.* **North Korea**, Kangwon Province, Mt. Kumgang-san, 11.X.1978, light, leg. A. Vojnits & L. Zombori (1 male, HNHM).

**Subfamily Macronematinae Ulmer, 1905**

***Amphipsyche proluta* McLachlan, 1872**

*Material examined.* **Russia**, Khabarovsk Terr., Slavyanka, 5 km E of Troitskoye, bog margin in dec. forest, 18-19.VI.1993, light trap, leg. P. Lindskog & A. Nilsson (1 male, 1 female, SMNH; 1 male, OPC). **Russia**, Khabarovsk Terr., Slavyanka at Amur, 17.VI.1994, light trap, leg. P. Lindskog & A. Nilsson (5 males, SMNH; 2 male, OPC).

***Macrostemum radiatum* (McLachlan, 1872)**

*Material examined.* **North Korea**, North Pyongan Province: Mt. Myohyang-san, 22.V.1985, collected by light on the balcony of the hotel, leg. A. Vojnits & L. Zombori (1 male, HNHM). **North Korea**, Pyongyang City, Pyongyang, Garden of Hotel Pyongyang, 21.IX.1978, singled, leg. A. Vojnits & L. Zombori (1 male, HNHM). **North Korea**, Mt. Pektusan, wooden environs of the Sam-zi-yan hotel, 19.VII.1977, light, leg. O. Gy. Dely & Á. Dely-Draskovits (2 males, HNHM). **Russia**, West Altai, River Charish Sentelek, 22-23.VII.1993, light, leg. Z. Varga, (4 males, 4 females; OPC). **Russia**, Khabarovsk Terr., Slavyanka at Amur, 17.VI.1994, light trap, leg. P. Lindskog & A. Nilsson (1 male, SMNH; 2 males, OPC). **Russia**, Khabarovsk Terr. Slavyanka, 5 km E Troitskoye Boat to Khabarovsk, 19.VI.1993, leg. B. Viklund (2 males, SMNH). **Russia**, Primorye, Khasau Distri., 5 km W Zanadvoronka, Amba R. light trap, 10. VII. 1992, light trap, leg. P. Lindskog & A. Nilsson (1 male, SMNH).

## Suborder Spicipalpia

### Superfamily Rhyacophiloidea Stephens, 1836

#### Family Rhyacophilidae Stephens, 1836

##### *Rhyacophila angulata* Martynov, 1910

*Material examined.* **North Korea**, North Pyongan Province, Mt. Myohyang-san, 22.V.1985, warm, sunny afternoon, collecting along the bank of the River Hyangsan-chon, mostly singling, leg. A. Vojnits & L. Zombori (3 males, HNHM). **North Korea**, Kangwon Province, Mt. Kumgang-san, 27.V.1985, very cool evening, night collecting at blended light, fed by a Honda generator at Kumgang-mun Gate, leg. A. Vojnits & L. Zombori (1 male, HNHM). **North Korea**, Chagang Province, Mt. Myohyang-san, Hotel Myohyang, 13.IX.1980, singled in the vicinity of the hotel, mainly at lamps standing around the hotel, leg. L. Forró & Gy. Topál (3 males, HNHM). **North Korea**, Kangwon Province: Mt. Kumgang-san, Kuryong valley 14.VI.1991, collected by light trap in the lower part of the valley, leg. A. Vojnits & L. Zombori (1 male, HNHM). **North Korea**, North Khangem Province: Chondjin, 4.VI.1991, collected by light trap in a brook valley SE of Puryong, about 40 km NE of Chondjin, leg. L. Ronkay & A. Vojnits (1 male, OPC). **North Korea**, North Pyongan Province: Mt. Myohyang-san, Issonam valley, 23.V.1991, collected by light trap, leg. A. Vojnits & L. Zombori (3 males, OPC). **Russia**, Primorye, Ussurijsk Reserve, 40 km ENE Ussurijsk, light-trap, 17–18.VII.1992, leg. P. Lindskog & A. Nilsson (1 male, SMNH).

##### *Rhyacophila confissa* Botosaneanu, 1970

*Material examined.* **North Korea**, North Pyongan Province, Mt. Myohyang-san, 21.V.1985, blue sky with some white clouds, warm afternoon. Swept along road-side by the River Hyangsan-chon, leg. A. Vojnits & L. Zombori (2 males, OPC). **North Korea**, North Pyongan Province, Mt. Myohyang-san, 21.V.1985, cool evening. Night collecting at blended light in the

balcony of the hotel, leg. A. Vojnits & L. Zombori (14 males 3 females, OPC). **North Korea**, North Pyongan Province, Mt. Myohyang-san, 22.V.1985, warm, sunny afternoon, collecting along the bank of the River Hyangsan-chon, mostly singling, leg. A. Vojnits & L. Zombori (3 males, OPC). **North Korea**, North Pyongan Province, Mt. Myohyang-san, 22.V.1985, night collecting at blended light in the balcony of the hotel, leg. A. Vojnits & L. Zombori (1 male, OPC).

##### *Rhyacophila coreana* Tsuda, 1940

*Material examined.* **North Korea**, Kangwon Province, Mt. Kumgang-san, Orjong-li, 22.X.1987, collected at light around the Hotel Kumgang-san, leg. Z. Korsós & L. Ronkay (1 male, OPC). **North Korea**, Kangwon Province, Mt. Kumgang-san, 18.IX.1980, singled along the foot-path to Kuryong Falls, leg. L. Forró & Gy. Topál (1 male, HNHM).

##### *Rhyacophila impar* Martynov, 1914

*Material examined.* **North Korea**, North Pyongan Province, Mt. Myohyang-san, 21.V.1985, night collecting at blended light (250 W) on the balcony of the hotel, leg. A. Vojnits & L. Zombori (8 males, 2 females; HNHM). **North Korea**, North Pyongan Province, Mt. Myohyang-san, Hotel Myohyang, 24.V.1991, collected by light trap at the hotel, leg. A. Vojnits & L. Zombori (2 males, OPC).

##### *Rhyacophila kumgangsanicum* Kumanski, 1990

*Material examined.* **South Korea**, Kangwon, Yangyang, Jeombong Mt. 495 m, 11.IX.2013, leg. Li Xuankun (3 males, OPC).

##### *Rhyacophila lata* Martynov, 1917

*Material examined.* **North Korea**, Chagang Province, Mt. Myohyang-san, Hotel Myohyang, 13.IX.1980, singled in the vicinity of the hotel, mainly at lamps standing around the hotel, leg. L. Forró & Gy. Topál (1 male, HNHM, 1 male, OPC). **North Korea**, North Pyongan Province: Mt.

Myohyang-san, Hyangsan, 15.IX.1994, light trap, leg. F. Mészáros & L. Zombori (3 males, 5 females; HNHM). **Russia**, Primorye, Ussurijsk Reserve, 40 km ENE Ussurijsk, light-trap, 17–18.VII.1992, leg. P. Lindskog & A. Nilsson (5 males, SMNH, 3 males, OPC). **Russia**, Primorye, Khasan District, 3 km W Ryazanovka, light trap, 11–12.VII.1992, leg. P. Lindskog & A. Nilsson (1 male, SMNH). **Russia**, Primorye, Khasan District, 3 km W Ryazanovka, light trap, 15.VII.1992, leg. P. Lindskog & A. Nilsson (2 males, 1 female, SMNH).

***Rhyacophila manuleata* Martynov, 1934**

*Material examined.* **North Korea**, North Khamgen Province, Chondjin, 3.VI.1991. Singled at daytime and at light in the O-sang-li valley, about 20 km SW of Chondjin, leg. L. Ronkay & A. Vojnits (1 male, OPC).

***Rhyacophila maritima* Levanidova, 1977**

*Material examined.* **South Korea**, Kangwon, Yangyang, Jeombong Mt. 495 m, 11.IX.2013, leg. Li Xuankun (2 males, OPC). **South Korea**, Kangwon, Inje, Daeam Mt. 494 m, 10.IX.2013, leg. Li Xuankun (3 males, OPC).

***Rhyacophila mjohjangsanica* Botosaneanu, 1970**

*Material examined.* **North Korea**, Chagang Province, Mt. Myohyang-san, Hotel Myohyang, 13.IX.1980, singled in the vicinity of the hotel, mainly at lamps standing around the hotel, leg. L. Forró & Gy. Topál (7 males, HNHM, 2 males, OPC). **North Korea**, North Pyongan Province, Mt. Myohyang-san, Hyangsan, 17.IX.1994, light trap, leg. F. Mészáros & L. Zombori (1 male, OPC).

***Rhyacophila narvae* Navás, 1926**

*Material examined.* **North Korea**, North Pyongan Province, Mt. Myohyang-san, 20.V.1985, Night collecting at blended light in the balcony of the hotel, leg. A. Vojnits & L. Zombori (5 males, OPC). **North Korea**, North

Pyongan Province, Mt. Myohyang-san, 21.V.1985, night collecting at blended light in the balcony of the hotel, leg. A. Vojnits & L. Zombori (3 males, 9 females, OPC). **North Korea**, Kangwon Province, Mt. Kumgang-san, 26.V.1985, collecting at blended light fed by Honda generator some 100 m from the rest house Oe-Kumgan, in a mixed forest, leg. A. Vojnits & L. Zombori (1 male, 1 female, HNHM).

***Rhyacophila retracta* Martynov, 1914**

*Material examined.* **North Korea**, North Khamgen Province, Chondjin, 3.VI.1991, singled in daytime and at light in the O-sang-li valley, about 20 km SW of Chondjin, leg. L. Ronkay & A. Vojnits (5 males, HNHM, 2 males, OPC). **North Korea**, North Pyongan Province, Mt. Myohyang-san, Isonnam valley, 23.V.1991, collected by light trap in the valley, leg. L. Ronkay & A. Vojnits (1 male, OPC). **North Korea**, Pyongyang City, 30.VI.1991, beating the flowers of an ornamental labiate plant in a small park near the Potonggang Hotel, leg. F. Mészáros & L. Zombori (2 males, HNHM). **North Korea**, North Pyongan Province, Mt. Myohyang-san, Hotel Myohyang, 23.V.1991, collected by light around the hotel, leg. L. Ronkay & A. Vojnits (1 male, HNHM).

***Rhyacophila riedeliana* Botosaneanu, 1970**

*Material examined.* **North Korea**, North Khamgen Province, Chondjin, 4.VI.1991, collected by light trap in a brook valley SE of Puryong, about 40 km NE of Chondjin, leg. L. Ronkay & A. Vojnits (1 male, OPC).

***Rhyacophila soldani* Mey, 1989**

*Material examined.* **South Korea**, Gangwon-do, Inje-gun, Inje, sidebrook of Naerincheon river, 38°04.021'N, 128°11.468'E, 200 m, 8.IX.2010, leg. D. Murányi *et al.* (1 male, OPC).

***Rhyacophila vicina* Botosaneanu, 1970**

*Material examined.* **North Korea**, Kangwon Province, Mt. Kumgang-san, 28.V.1985, night

collecting at blended on the serpentine to Kwinyon-am Rock, leg. A. Vojnits & L. Zombori (2 males, HNHM). North Korea, North Pyongan Province, Mt. Myohyang-san, 22.V.1985, pathway to Bulyongdae temple (about 1000 m), collecting by sweeping net, night collecting at blended light (250 W) on the balcony of the hotel, leg. A. Vojnits & L. Zombori (1male, HNHM). North Korea, North Khangem Province, Chondjin, 4.VI.1991, collected by light trap in a brook valley SE of Puryong, about 40 km NE of Chondjin, leg. L. Ronkay & A. Vojnits (2 males, HNHM). North Korea, Pyongang City, Pyongang, 30.VI.1991, beating the flowers of an ornamental labiate plant in a small park near the Potonggang Hotel, leg. F. Mészáros & L. Zombori (2 males, HNHM).

#### Family Hydrobiosidae Ulmer, 1905

##### *Apilochorema sutshanum* Martynov, 1934

*Material examined.* **North Korea**, Kangwon Province, Mt. Kumgang-san, Onjong-ri, 23.X.1987, light, leg. Z. Korsós & L. Ronkay (1 male, HNHM). **Russia**, Ussuriysk District, Anisimovka, ligh trap, 20.VII.1992, leg. P. Lindskog & A. Nilsson (1 male, SMNH, 1 male, OPC).

#### Superfamily Glossosomatoidea Wallengren, 1891

##### Family Glossosomatidae Wallengren, 1891

##### Subfamily Agapetinae Martynov, 1913

##### *Agapetus sibiricus* Martynov, 1918

*Material examined.* **North Korea**, North Pyongan Province, Mt. Myohyang-san, pathway Isonnam, 8.X.1988, singled along stream Hyangsan, leg. Z. Korsós & L. Ronkay (3 males, HNHM). **Russia**, Ussuriysk District, Anisimovka, ligh trap, 20.VII.1992, leg. P. Lindskog & A. Nilsson (1 male, SMNH). **Russia**, Khabarovsk Terr., Bolshekhkhtsirsk Reserve, on light, 21–25.VI.1993, leg. P. Lindskog & A. Nilsson (1 male, SMNH).

##### *Agapetus hieianus* new species complex

This species complex is characterized by the elongated fused complex of segment X and paraproct and also by the extremely elongated and usually laterad turning long cerci. In *Agapetus* genus the paraproct or its vestige is always present and represented by some form of sclerite located usually on the ventrum of the complex (Nielsen 1957). The paraproct component of this complex is present just as a completely fused more sclerotized ventrolateral structure on both sides, an independent ventral pair of processes, most frequently in the form of bi- or tripartite anterad turning whip-like structure. In the *hieianus* species complex the paraproct vestiges are shifted to terminal position of segment X in the form of various spines of different shapes present in different numbers. Terminally shifted remnants of paraproct are present in several other species, but they have lost or very abbreviated cerci: *adejensis*, *armatus*, *beredensis*, *delicatulus*, *fuscipes*, and *hadimensis*. In the *A. hieianus* new species complex all members have very characteristic long and laterad arching cerci: *budoens*, *excisus*, *inaequispinosus*, *hamatus*, *hieianus*, *vas-tag* sp. nov. and *vekon* sp. nov.

##### *Agapetus vastag* Oláh & Johanson, sp. nov.

(Figures 16–18)

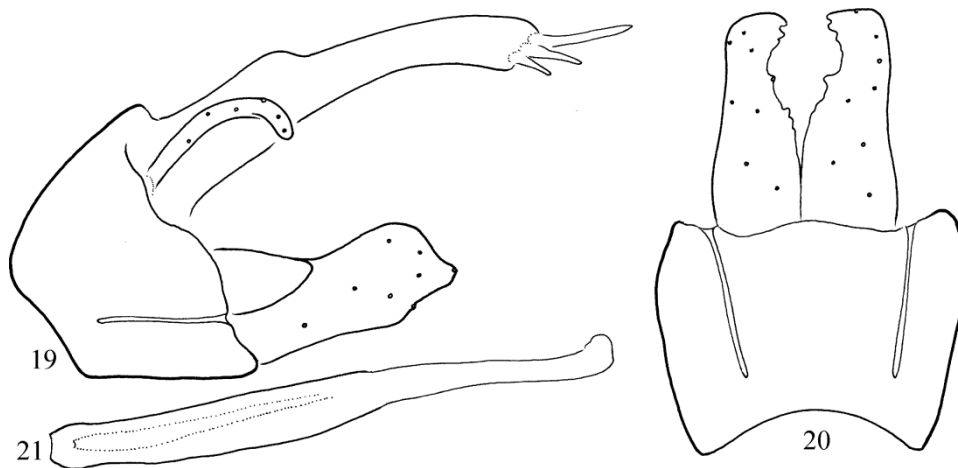
*Material examined.* **Holotype**, **Russia**, Ussuriysk District, Anisimovka, ligh trap, 20.VII.1992, leg. P. Lindskog & A. Nilsson (1 male, SMNH). *Paratypes*, same as holotype (2 males, 2 females, SMNH, 1 male, 1 female, OPC).

*Diagnosis.* Most close to *A. inaequispinosus* described from Mongolia, but differs by having more complex apical spine pattern of the vestigial paraproct as well as the gonopods are completely differently shaped both in lateral and ventral views. More elongated in lateral view, not triangular and with more elaborated teeth pattern in ventral view.

*Description.* Small light brown animal with forewing length of 3 mm. Large involuted cuti-



Figures 16–18. *Agapetus vastag* Oláh & Johanson, sp. nov. Holotype male: 16 = genitalia in lateral view, 17 = genitalia in ventral view, 18 = phallic organ in lateral view.



Figures 19–21. *Agapetus vekon* Oláh & Johanson, sp. nov. Holotype male: 19 = genitalia in lateral view, 20 = genitalia in ventral view, 21 = phallic organ in lateral view.

cular sacculous gland in sternite V present and blister-like protuberance on the dorsal margin of sternite V discernible detached from the sternal ridge. Ventral mesoapical process on sternite VI long with rounded apex. Segment IX subtriangular in lateral and quadrangular in ventral view. The complex of segment X and paraproct stout elongated, slightly S-shaped with particular patterned apical spines. Cluster of apicodorsal

spines longer, apicoventral spines smaller. Cerci long and laterad turning. Gonopods with mesad turning pointed apex in ventral view. Phallic organ simple rod-shaped without any pronounced structural modification.

*Etymology.* *vastag*, thick in Hungarian with reference to the stout complex of the fused segment X and paraproct.



***Agapetus vekon* Olah & Johanson, sp. nov.**

(Figures 19–21)

*Material examined.* **Holotype**, **Russia**, Primorye, Ussurijsk Reserve, 40 km ENE Ussurijsk, light-trap, 17–18.VII.1992, leg. P. Lindskog & A. Nilsson (1 male, SMNH). *Paratypes*, same as holotype: (9 males, 35 females, SNHM, 3 males, 9 females, OPC).

*Diagnosis.* Close to *A. vastag* sp. nov. but differs by having the body of segment X and paraproct complex low and slender, not high and robust; the spine pattern of the apicad shifted paraproct reduced, less developed comprising only a few spines; the shape of the gonopods differently formed both in lateral and ventral view.

*Description.* Small light brown animal with forewing length of 3 mm. Large involuted cuticular sacculous gland in sternite V present and blister-like protuberance on the dorsal margin of sternite V discernible detached from the sternal ridge. Ventral mesoapical process on sternite VI long with rounded apex. Segment IX trapesoid in lateral and subquadrangular in ventral view. The complex of segment X and paraproct slender elongated, with a slightly higher basal half and with particular patterned apical spines. Three apical spines present and unequal in length. Cerci long and laterad turning. Gonopods characterized with mesad turning apex with irregular teeth in ventral view. Phallic organ simple rod-shaped without any pronounced structural modification.

The much elongated slender complex of segment X and paraproct differs from all the known members of the species complex.

*Etymology.* *vekon*, thin in Hungarian with reference to the elongated slender and slim complex of the fused segment X and paraproct.

**Subfamily Glossosomatinae Wallengren, 1891**

***Glossosoma altaicum* (Martynov, 1914)**

*Material examined.* **North Korea**, North Pyongan Province, Mt. Myohyang-san, pathway Isonnam, 11.X.1988, shifted from the litter of a

rocky forest, leg. Z. Korsós & L. Ronkay (2 males, HNHM). **North Korea**, North Pyongan Province, Mt. Myohyang-san, Hyangsan, 17.IX.1994, light trap, leg. F. Mészáros & L. Zombori (1 male, OPC). **Russia**, Central Altai, 20 km S of Ongoday, 3.VIII.1993, light, leg. Z. Varga (1 male, 1 female, OPC). **Russia**, Ussuriysk District, Anisimovka, 20.VII.1992, light trap, leg. P. Lindskog & A. Nilsson (1 male, 1 female, SMNH).

***Glossosoma intermedium* (Klapálek, 1892)**

*Material examined.* **Russia**, Khabarovsk Terr., Bolshekhkhtsirsk Reserve, on light, 24.VI.1993, leg. P. Lindskog & A. Nilsson (1 male, 3 females, SMNH).

***Glossosoma ussuricum* (Martynov, 1914)**

*Material examined.* **North Korea**, Kangwon Province, Mt. Kumgang-san, 11.X.1978, 50 m from the rest-house in the forest, light, leg. A. Vojnits & L. Zombori (1 male, HNHM). **North Korea**, Kangwon Province, Mt. Kumgang-san, 12.X.1978, light, leg. A. Vojnits & L. Zombori (2 males, HNHM). **North Korea**, Kangwon Province, Mt. Kumgang-san, Oe-Kumgang, 25.IX.1994, light trap, leg. F. Mészáros & L. Zombori (1 male, 1 female, HNHM). **North Korea**, Kangwon Province, Mt. Kumgang-san, 12.X.1978, light, leg. A. Vojnits & L. Zombori (2 males, HNHM). **North Korea**, Kangwon Province, Mt. Kumgang-san, Onjong-ri, 24.X.1987, light, leg. Z. Korsós & L. Ronkay (6 males, HNHM). **Russia**, Primorye, Ussurijsk Reserve, 40 km ENE Ussurijsk, light-trap, 17–18.VII.1992, leg. P. Lindskog & A. Nilsson (1 male, 20 females, SMNH).

**Suborder Integripalpia**

**Infraorder Plenitentoria**

**Superfamily Phryganeoidea Leach, 1815**

**Family Phryganeidae Leach, 1815**

***Semblis atrata* (Gmelin, 1789)**

*Material examined.* **North Korea**, North Khamgen Province, Chondjin, brook valley SE of

Puryong, 40 km NE of Chondjin, 4.VI.1991, light trap, leg. L. Ronkay & A. Vojnits (1 male, HNHM).

#### Family Phryganopsychidae Wiggins, 1959

##### *Phryganopsyche latipennis* (Banks, 1906)

*Material examined.* **South Korea**, Gangwon-do, vicinity of Chuncheon, Chuncheon-Dam, 400 m, steep rocky slope with mixed forest, 24.X.1993, light, leg. L. Peregovits & L. Ronkay (1 male, HNHM). **South Korea**, Jeju-do, Mt. Hallasan, Yongshil route, 1050 m, edge of Mt. Hallasan National Park, 126°30'E, 33°21'N, 27.IV.1994, light, leg. L. Peregovits, L. Ronkay & A. Vojnits (4 males, HNHM). **South Korea**, Jeju-do, Mt. Hallasan, Yongshil route, 1050 m, edge of Mt. Hallasan National Park, 126°30'E, 33°21'N, 30.IV.1994, light, leg. L. Peregovits, L. Ronkay & A. Vojnits (3 males, 1 female; HNHM).

#### Superfamily Limnephiloidea Kolenati, 1848

##### Family Lepidostomatidae Ulmer, 1903

##### *Lepidostoma albardanum* (Ulmer, 1906)

*Material examined.* **North Korea**, Kangwon Province, Mt. Kumgang-san, side valley near Hotel Kumgang, 13.VI.1991, light, leg. L. Ronkay & A. Vojnits (3 males, HNHM, 2 males, OPC). **North Korea**, Kangwon Province, Mt. Kumgang-san, 19.IX.1980, at light on the terrace of Hotel Kumgang, leg. L. Forró & Gy. Topál (1 male, HNHM). **South Korea**, Gangwon-do, Yangyang, Mt. Jeombongsan 495 m, 11.IX.2013, leg. Li Xuankun (3 males, DPP-HIST, 2 males, OPC).

##### *Lepidostoma elongatum* (Martynov, 1935)

*Material examined.* **North Korea**, North Pyongan Province, Mt. Myohyang-san, Hotel Myohyang-san, 10.X.1987, light, leg. Z. Korsós & L. Ronkay (1 male, 1 female, HNHM). **North Korea**, Chagang Province, Mt. Myohyang-san, Hotel Myohyang, 13.IX.1980, singled in the vi-

cinity of the hotel, mainly at lamps standing around the hotel, leg. L. Forró & Gy. Topál (15 males, HNHM, 4 males, OPC). **North Korea**, Kangwon Province, Mt. Kumgang-san, 19.IX.1980, at light on the terrace of Hotel Kumgang, leg. L. Forró & Gy. Topál (2 males, HNHM). **South Korea**, Gangwon-do, Inje, Mt. Daeamsan 574 m, 10.IX.2013, leg. Li Xuankun (5 males, DPP-HIST, 9 males, OPC).

##### *Lepidostoma hirtum* (Fabricius, 1775)

*Material examined.* **North Korea**, Kangwon Province, Mt. Kumgang-san, 12.X.1978, light, leg. A. Vojnits & L. Zombori (1 male, HNHM). **North Korea**, North Pyongan Province, Mt. Myohyang-san, Hyangsan, 17.IX.1994, light trap, leg. F. Mészáros & L. Zombori (1 male, OPC).

##### *Lepidostoma orientale* (Tsuda, 1942)

*Material examined.* **North Korea**, Kangwon Province, Mt. Kumgang-san, 19.IX.1980, at light on the terrace of Hotel Kumgang, leg. L. Forró & Gy. Topál (1 male, OPC).

##### *Lepidostoma sinuatum* (Martynov, 1935)

*Material examined.* **North Korea**, Kangwon Province, Mt. Kumgang-san, 24.IX.1979, at light on the terrace of Hotel Kumgang, leg. H. Steinmann & T. Vásárhelyi (1 male, OPC). **North Korea**, Kangwon Province, Mt. Kumgang-san, 12.X.1978, light, leg. A. Vojnits & L. Zombori (1 male, HNHM).

#### Family Goeridae Ulmer, 1903

##### *Goera japonica* Banks, 1906

*Material examined.* **Kazakhstan**, Province Almaty, valley of River Ili, 20 km NNW of Kapchugay, 77°00'E, 44°00'N, 550 m, 31.VIII.1997, leg. A. Orosz (5 males, HNHM). **South Korea**, Jeju-do, Andok valley, 300 m, 126°22'E, 33°15'N, 28.IV.1994, light, leg. L. Peregovits, L. Ronkay & A. Vojnits (16 males, 11 females, HNHM).

*Remarks.* The ventrolateral processes of segment X are branched, phallic organ without setal lines, dorsal profile of the phallic organ parallel-sided. We have examined specimens of the nominate species of the *G. japonica* species complex from extreme peripheries (Kazakhstan, South Korea) and found the speciation traits of the ventrolateral process of segment X and the phallic organ very stable. The neutral, non-adaptive traits, like the ventromesal process of sternite IX are highly variable in the examined populations of Kazakhstan and South Korea.

***Goera horni* Navás, 1926**

*Material examined.* **North Korea**, North Pyongan Province, Mt. Myohyang-san, Hotel Myohyang-san, 18.VII.1982, light, leg. L. Forró & L. Ronkay (1 male, OPC). **North Korea**, Chagang Province, Mt. Myohyang-san, Hotel Myohyang, 13.IX.1980, singled from lamps standing around hotel, leg. L. Forró & Gy. Topal (9 males, HNHM).

*Remarks.* The ventrolateral processes of segment X are unbranched, its lateral profile is rather robust, the phallic organ with setal lines, the dorsal profile of the phallic organ parallel-sided.

***Goera parvula* Martynov, 1935**

*Material examined.* **North Korea**, North Khamgen Province, Chondjin, brook valley SE of Puryong, 40 km NE of Chondjin, 4.VI.1991, light trap, leg. L. Ronkay & A. Vojnits (6 males, HNHM; 4 males, OPC). **North Korea**, Pyongyang City, 30.VI.1991, beating the flowers of an ornamental labiate plant in a small park near the Potonggang Hotel, leg. F. Mészáros & L. Zombori (6 males, HNHM).

***Goera squamifera* Martynov, 1909**

*Material examined.* **North Korea**, North Hwanghae Province, Lake Sohng-ho, 31.VII.1982, light, leg. L. Forró & L. Ronkay (4 males, HNHM). **North Korea**, Kangwon Province, Mt. Kumgang-san, 11.X.1978, 50 m from the rest-house in the forest, light, leg. Z. Korsós & L. Ronkay (1 male, HNHM).

*Remarks.* The ventrolateral processes of segment X are unbranched, its lateral profile is less robust, the phallic organ without setal lines, the dorsal profile of the phallic organ with subapical broadening.

***Goera tungusensis* Martynov, 1909**

*Material examined.* **Mongolia**, Ulan Bator, 16.VII.1987, light, leg. L. Ronkay (6 males, 3 females, HNHM). **North Korea**, North Pyongan Province, Mt. Myohyang-san, pathway Isonnam, 11.X.1988, shifted from the litter of a rocky forest, leg. Z. Korsós & L. Ronkay (2 males, HNHM, 2 males, OPC).

**Polyphorae group**

**Family Apataniidae Wallengren, 1886**

***Apatania aberrans* (Martynov, 1933)**

*Material examined.* **North Korea**, Kangwon Province, Mt. Kumgang-san, 12.X.1978, light, leg. A. Vojnits & L. Zombori (1 male, HNHM). **North Korea**, Kangwon Province, Mt. Kumgang-san, 11.X.1978, light, leg. A. Vojnits & L. Zombori (1 male, HNHM). **North Korea**, Kangwon Province, Mt. Kumgang-san, Onjong-ri, 22.X.1987, light, leg. Z. Korsós & L. Ronkay (4 males, HNHM). **South Korea**, Jeju-do, Mt. Hallasan, Yongshil route, 1050 m, edge of Mt. Hallasan National Park, 126°30'E, 33°21'N, 27.IV.1994, light, leg. L. Peregovits, L. Ronkay & A. Vojnits (2 males, 1 female; HNHM, 1 male OPC). **South Korea**, Jeju-do, Andok valley, 300 m, 126°22'E, 33°15'N, 28.IV.1994, light, leg. L. Peregovits, L. Ronkay & A. Vojnits (1 male, HNHM). **South Korea**, Jeju-do, Mt. Hallasan, Yongshil route, 1050 m, edge of Mt. Hallasan National Park, 126°30'E, 33°21'N, 30.IV.1994, light, leg. L. Peregovits, L. Ronkay & A. Vojnits (2 males, HNHM).

***Apatania maritima* Ivanov & Levanidova, 1993**

*Material examined.* **North Korea**, Pyongyang City, Mt. Daesong-san, 17.V.1985, light, leg. A.

Vojnits & L. Zombori (4 males, HNHM). **South Korea**, Gangwon-do, vicinity of Chuncheon, Soyang-Dam, 127°50'E, 37°55'N 700 m, 20.X.1993, rocky gorge valley with small brooks, light, leg. L. Peregovits & L. Ronkay (1 male, 1 female, HNHM; 1 male, KGU).

***Apatania sinensis* (Martynov, 1914)**

*Material examined.* **North Korea**, Kangwon Province, Wonsan, Botanical Garden, 15.VII.1991, singled, leg. F. Mészáros & L. Zombori (2 males, HNHM). North Korea, Kangwon Province, Mt. Kumgang-san, Onjong-ri, 23.X.1987, in the vicinity of the hotel, light leg. Z. Korsós & L. Ronkay (1 male, 1 female, HNHM). North Korea, Pyongyang City, Hotel Potonggang, 13.X.1987, at the hotel, light, leg. Z. Korsós & L. Ronkay (6 males, 2 females; HNHM). North Korea, South Hwanghae Province, Haeju, Mt. Suyong-san, deciduous forest on SE slope, 16.VII.1991, singled, leg. F. Mészáros & L. Zombori (4 males, HNHM). North Korea, Kangwon Province, Mt. Kumgang-san, Onjong-ri, 22.X.1987, along river Kumgang, singled, leg. Z. Korsós & L. Ronkay (1 female, HNHM). North Korea, North Pyongan Province, Mt. Myohyang-san, pathway Isonnam, 12.X.1987, along pathway, singled, leg. Z. Korsós & L. Ronkay (1 male, HNHM). North Korea, Pyongyang City, Pyongyang, Hotel Potonggang, 14.X.1987, at the hotel, light, leg. Z. Korsós & L. Ronkay (1 male, 1 female, HNHM). **South Korea**, Gangwon-do, vicinity of Chuncheon, Soyang-Dam, 127°50'E, 37°55'N, 700 m, 20.X.1993, rocky gorge valley with small brooks, light, leg. L. Peregovits & L. Ronkay (2 males, 2 females; HNHM).

***Apatania yenchingensis* Ulmer, 1932**

*Material examined.* **South Korea**, Jeju-do, Andok valley, 300 m, 126°22'E, 33°15'N, 28.IV.1994, light, leg. L. Peregovits, L. Ronkay & A. Vojnits (2 males, HNHM, 1 male, KGU).

*Remark.* This species is new to the Korean Peninsula.

**Family Uenoidae Iwata, 1927**

**Subfamily Thremmatinae Martynov, 1935**

***Neophylax ussuriensis* species group**

Based on phylogenetic analysis of both larval and adult characters Vineyard *et al.* (2005) established 10 species groups including the *N. ussuriensis* species group with the single nominate species. The males of *N. ussuriensis* species group are easily distinguished from all the other species of *Neophylax* by the slightly elongated quadrate shaped posteromedial plate-like projection on sternite IX. The species group is further characterised by the amalgamated and elongated complex of segment X with its internal and inferior branches fused together along their entire length and functions as a dorsal phallic shield during copulation. In most of the *Neophylax* species the internal and inferior branches of segment X is not fused; they are rather well separated; similar fused complex structure occurs at the Nearctic *N. consimilis*. In *N. ussuriensis* species group the plate-like projection on sternite IX and the fused, long horizontal structure of segment X with its branches are combined with the characteristically shaped gonopods; the lateral lobes of the gonopods are vertically directed, slightly arching falcate shaped.

Segment X (XI) deeply inset into the dorsum of segment IX and partially fused with it. The main body of segment X is inconspicuous and fused imperceptibly with segment IX. Moreover, the basic body region of segment X is also poorly discernible from the segmental branches: (1) external branches (cerci); (2) internal branches (internal, dorsal, apical, horizontal branches of paraproct) (3) inferior branches (inferior, ventral, basal, vertical branches of paraproct).

In this species group the fused and elongated complex of segment X is comprised of the following structures: (1) basodorsal membranous region with unregular apical margin, according to Vineyard *et al.* (2005) this is the internal branch of

segment X; the pair of elongated horizontal blade-like structure, the functional dorsal phallic shield formed according to Vineyard *et al.* (2005) by (2) the caudal lobe of cerci (external branches) and (3) the inferior branches.

However, the setose cerci (external branches) are regularly covered with long and dense vestitural setae armed with papillate alveoli. The setaless ventroapical continuation of segment X is rather itself the body of segment X and not the continuation of cerci. We suppose that the elongated fused structure is the fused paraproct formed by the interior and inferior branches. This is indicated by the usual phallic shield function of paraproct and also by the presence of a few modified setae. The composing components of the paraproct are not discernible clearly, but we suppose that the horizontal line of lateral ridge may delineate the fused region of internal and inferior branches. The modified setae are present only on the dorsal half above the line; the ventral region below the line has no setae.

The pattern of this horizontal line, the byproduct of the amalgamation of the internal and inferior branches, has high diagnostic value in combination with the lateral profile of the fused elongated structure. It seems, this is a speciation trait complex in this species group. The elongated structure may have an intimate function in post-mating/prezygotic reproductive isolation by mechanical isolation due to the incompatibility of sexual organs or by cryptic female choice during copulation. In our practice of the traditional gross morphology this subtle shape divergences are usually considered and treated as variation of widely distributed species. However, if these divergences are non-neutral, non-random product of adaptive processes in sexual selection even their subtle shape differences are steady and stable. Their stability is due to the underlying very complex adaptive genomic processes organised and maintained by several integrative as well as protective mechanisms like reduced recombination, linkage disequilibrium, selective sweeps and genetic hitchhiking (Oláh & Oláh 2017). At incipient *Drosophila* species well differentiated by

genetic markers, the empirically almost indiscernible slight divergences in aedeagus curvatures are detectable only by geometric morphometrics. These subtle or tiny divergences are robust enough in sexual signals to produce reproductive isolation. They are not randomly produced in neutral mechanisms. They are produced by a huge network of many quantitative trait loci, by thousand of candidate genes under multiplied organising effects in the cooperative, integrative and protective mechanisms of the epistasis and the pleiotropy (Franco *et al.* 2006, Masly *et al.* 2011, McNeil *et al.* 2011, Schafer *et al.* 2011).

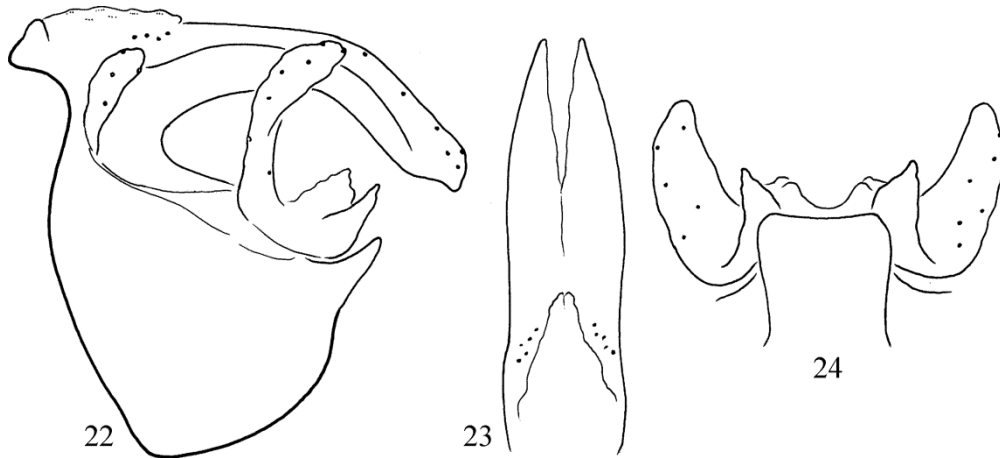
Slight shape divergences in genital arch, aedeagus curvature, and distophallus detectable only by geometric morphometrics have been applied to separate incipient siblings in various *Drosophila* species complexes. Compared to these very tiny genital shape divergences we have detected very great and complex shape divergences in the horizontally elongated blade-like complex among *N. ussuriensis* populations. We consider this highly modified paraproct as a speciation trait of reproductive isolation. Here we describe two new incipient sibling species just by the detection of the divergences in the shape of phallic shield of the fused elongated paraproct. By the description of the two new species the *N. ussuriensis* species group is comprised of three species: *N. goguriensis* sp. nov., *N. sillensis* sp. nov. and *N. ussuriensis*.

***Neophylax goguriensis* Oláh & Park, sp. nov.**

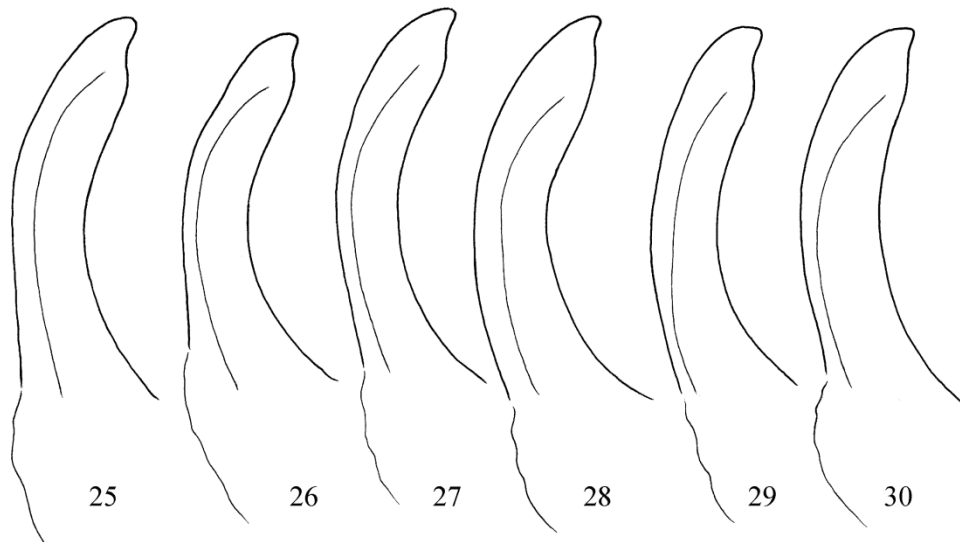
(Figures 22–30)

*Material examined.* **Holotype, North Korea**, North Pyongan Province, Mt. Myohyang-san, Hotel Myohyang-san, 9.11.X.1987, collected at light and with sugar around hotel, leg. Z. Korsós & L. Ronkay (1 male, HNHM). *Paratypes*, same as holotype (1 male, 2 females, HNHM, 2 males, 2 females, OPC, 1 male, 2 females, DPP-HIST, 1 male, 2 female, KGU).

*Diagnosis.* Species delineation is based on the shape divergence of the speciation trait that is the much specialised fused paraproct. The shape of



Figures 22–24. *Neophylax goguriensis* Oláh & Park, sp. nov. Holotype male: 22 = genitalia in lateral view, 23 = segment X complex in dorsal view, 24 = quadratic plate of sternite IX and gonopods in ventral view.



Figures 25–30. *Neophylax goguriensis* Oláh & Park, sp. nov. Paratypes: paraprocts in lateral view.

the speciation trait was examined and drawn at all the six member of the type series. The lateral profile of the fused paraproct is most similar to *N. ussuriensis*, but differs from the nominate species by the aviform apex, that is by the presence of small subapical excision and the pointed apices. This aviform apex seems stable in the examined population. The apical apices of the fused pair of paraproct at *N. ussuriensis* seems different, variously rounded at the single male from North Korea (near to Ussuriland), at three males from

Hokkaido (Japan) and at on all of the published drawings from Russia (Ussuriland) and from Japan.

*Description.* Dark animal with dark brown head and thoracic sclerites. Forewing membrane brown mottled with lighter area, forewing length 12 mm. General habitus, body and genitalia look similar to *N. ussuriensis* (Martynov, 1914) distinguished only by divergences in paraproct structure.

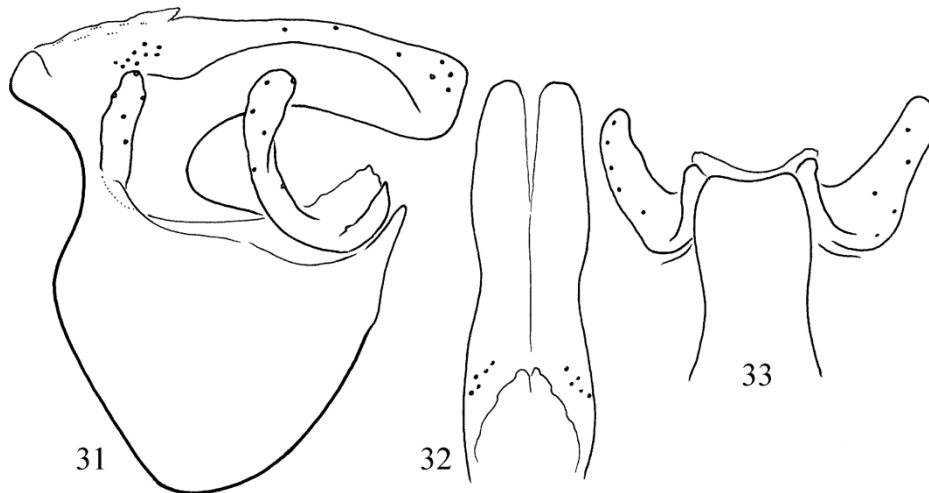
*Etymology.* *goguriensis*, named for the region in which the holotype were collected from 'Goguryeo', the old Dynasty's name in North Korea.

***Neophylax sillensis* Park & Oláh sp. nov.**

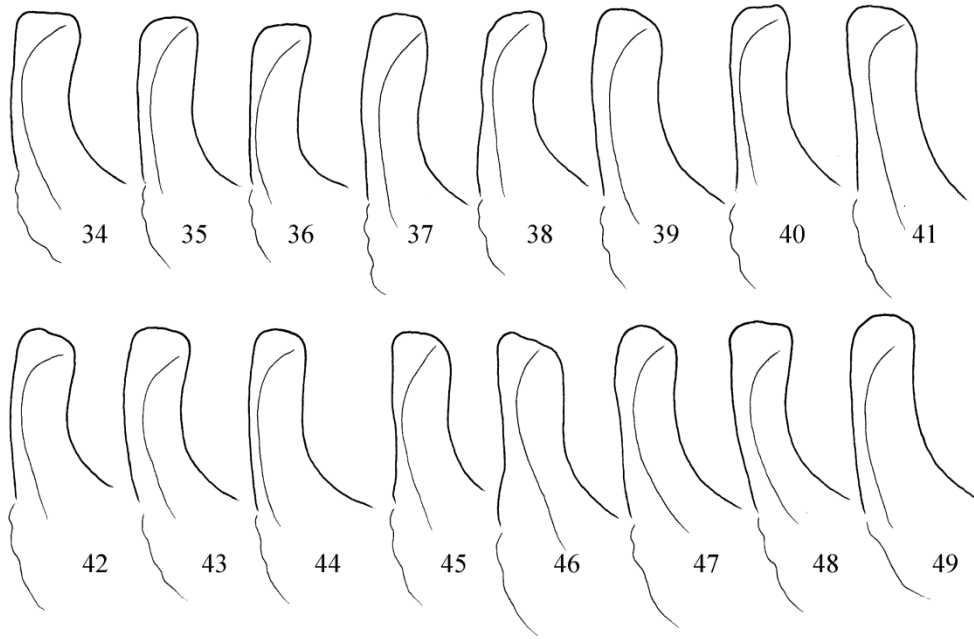
(Figures 31–49)

*Material examined.* **Holotype, South Korea.** Gangwon-do, Yangyang, Mt. Jeombongsan 495 m, 11.IX.2013, leg. Li Xuankun (1 male, OPC). *Paratypes*, same as holotype (2 males, OPC). South Korea. Gangwon-do, Taebaek, Mt. Taebaeksan, Geomryongso 768 m, 12.IX.2013, leg. Li Xuankun (7 males, 2 females, DPP-HIST, 7 males, 3 females, OPC). South Korea, Gangwon-do, Inje, Mt. Daeamsan 574 m, 10.IX.2013, leg. Li Xuankun (3 male, OPC). South Korea, Gangwon-do, vicinity of Chuncheon, Soyang-Dam, 127°50'E, 37°55'N, 700 m, rocky gorge valley with small brooks, 20.X.1993, ligh, leg. L. Peregovits & L. Ronkay (21 males, 6 females, HNHM, 1 male, 1 female, NIBR, 7 males, 3 females, KGU). South Korea, Gangwon-do, Wonju-si, Sungnamro 194-1, Jupocheon Stream, 37°16'42.2"N, 128°05'05.0"E, 400 m, 17.IX.2015, leg. M.S. Kang, (2 male, 1 female, OPC). South Korea, Gangwon-do, Yeongwol-gun, Sangdong-eup, Deokgu-ri, Deokgucheon Stream, 37°06'

08.8"N, 128°47'29.6"E, 450 m, 20.IX.2015, leg. M.S. Kang, (1 male, OPC). South Korea, Gyeongsangnam-do, Milyang-si, Danjang-myeon, Pyochungsa Temple, 35°35'16.53"N, 128°59'47.70"E, 386 m, 18.X.2016, leg. S.J. Park & T Nozaki, (2 males, 2 females, OPC). South Korea, Jeollanam-do, Gwangyang-si, Daab-myeon, Geumcheon-ri, Seomjin River, 35°09'30.4"N, 127°39'28.8"E, 50 m, 7.X.2015, leg. M.S. Kang (1 female, OPC). South Korea, Jeollanam-do, Gwangyang-si, Bonggang-myeon, Joryung-ri, Gwangyangseocheon Stream, 35°05'27.2"N, 127°34'16.6"E, 360 m, 21.X.2015, leg. M. S. Kang, (1male, OPC). South Korea, Jeollanam-do, Suncheon-si, Juam-myeon, Daegwang-ri, Daegwangcheon Stream, 35°03'19.0"N, 127°12'30.8"E, 150 m, 29.X. 2016, leg. M.S. Kang, (1 male, 1 female; (OPC). South Korea, Gyeonggi-do, Yeosu-si, Geumsa-myeon, Jurok-ri, Geumsacheon Stream, 37°21'40.7"N, 127°27'23.5"E, 300 m, 9.X.2016, leg. M.S. Kang, (1 female, OPC). South Korea, Gyeongsangbuk-do, Yeongju-si, Punggi-eup, Samga-ri, Geumgyecheon Stream, 36°55'24.2"N, 128°30'05.2"E, 400 m, 6.X.2015, leg. M.S. Kang, (1 male, 2 females, OPC). South Korea, Gyeonggi-do, Gapyeong, Jomurakgol rd. 37°59.247' N, 127°26.760'E, 360 m, 4.XI.2016, light trap, leg. J. Babics & B. Tóth (4 males, 1 female, HNHM).



Figures 31–33. *Neophylax sillensis* Park & Oláh, sp. nov. Holotype male: 31 = genitalia in lateral view, 32 = segment X complex in dorsal view, 33 = quadratic plate of sternite IX and gonopods in ventral view.



Figures 34–49. *Neophylax sillensis* Park & Oláh, sp. nov. Paratypes: paraprocts in lateral view.

**Diagnosis.** Species delineation is based exclusively on the shape divergence of the speciation trait that is the much specialised fused paraproct. The shape of the speciation trait was examined and drawn at 16 members of the type series from 11 populations: the stability of the shape was remarkably high. The lateral profile of the fused paraproct is most specialised, differing from both *N. ussuriensis* and from *N. gogoriensis* sp. nov. Contrary to the rounded apex of *N. ussuriensis* and to the aviform apex of *N. gogoriensis* sp. nov. the apex of the fused paraproct is truncate at *N. sillensis* sp. nov. Moreover, the fused paraproct is more robust, high and short, not low and long.

**Description.** Dark animal with dark brown head and thoracic sclerites. Forewing membrane brown mottled with lighter area, forewing length between 10–15 mm. General habitus, body and genitalia look similar to *N. ussuriensis* (Martynov, 1914) distinguished only by divergences in paraproct structure.

**Remarks.** We have recorded pronounced range of variation in the forewing length from the same populations: between 10–15 mm for males. *N.*

*relictus* (Martynov, 1935) also exhibits rather large range of variability in body size; the forewing length ranged between 13–18 mm among specimens from the same region.

**Etymology.** *sillensis*, named for the region in which the holotype were collected from 'Silla', the old Dynasty's name in South Korea.

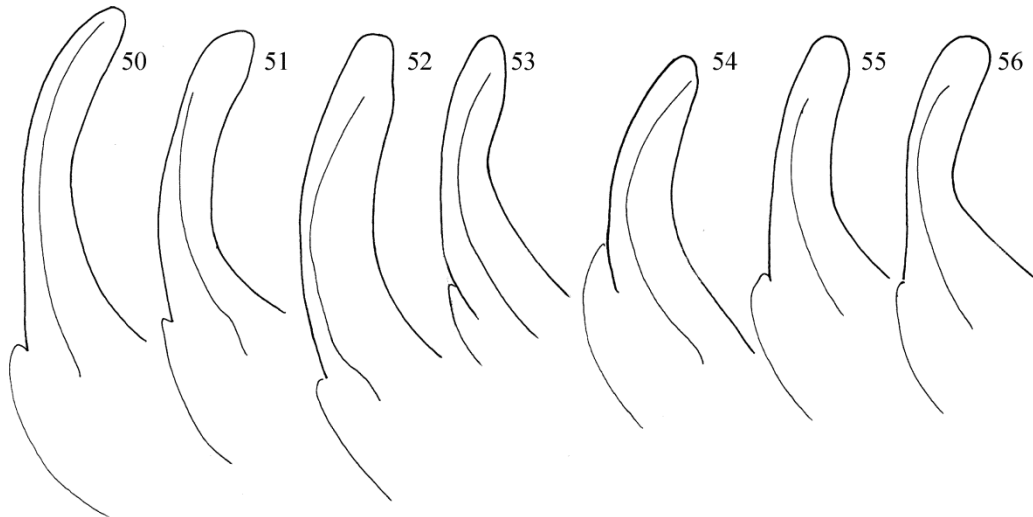
#### *Neophylax ussuriensis* (Martynov, 1914)

(Figures 50–56)

**Material examined.** **Japan**, Hokkaido, Shinchishine-bashi, Icyani-gawa, Shibetsu-cho, 7.X. 1995, leg. T. Ito & A. Ohkawa (2 males, OPC). **Japan**, Hokkaido, Kamikawa, Horokanai-cho, Shumarinai, 44°17'42"N, 142°07'35"E, 24.IX. 2015, light, leg. T. Ito (1 male, 2 females, OPC). **North Korea**, Ryanggang Province, Mupo, Tuman-gang, 1000 m, 29.VI.1988, singling from vegetation, leg. O. Merk & Gy. Szél (1 male, HNHM).

**Remarks.** The apical apices of the fused pair of paraproct at *N. ussuriensis* is variously rounded at the single male from North Korea (near to Ussuriland), at three males from Hokkaido (Ja





Figures 50–56. *Neophylax ussuriensis* (Martynov, 1914). Paraprocts in lateral view.

pan) and at all of the published drawings from Russia (Ussuriland) and from Japan.

***Neophylax relictus* (Martynov, 1935)**

*Material examined.* **North Korea**, Ryanggang Province, Samjiyon, 4.VI.1985, night collecting at blended light (250W), fed by a Honda generator in a *Picea* stand at an altitude of about 2100 m, leg. A. Vojnits & L. Zombori (2 males, HNHM, 1 male, OPC; 1 male, KGU).

*Remark.* This species is new to the Korean Peninsula.

**Family Limnephilidae Kolenati, 1848**

**Subfamily Dicosmoecinae Schmid, 1955**

**Tribe Dicosmoecini McLachlan, 1875**

***Dicosmoecus* McLachlan, 1875**

The taxonomy of *Dicosmoecus* genus remained uncertain despite significant early progresses (Flint 1966, Wiggins & Richardson 1982, Ito & Nagayasu 1991). Two species groups have been distinguished (Wiggins & Richardson 1982): *palatus* and *atripes*. The delination of these groups is based on larval as well as on male and

female adult characters. Two male genital characters have been selected to distinguish the two species group: (1) the length and shape of the dorsal branch of the paraproct (internal process of segment X) and the shape of the paramere. The *D. palatus* species group mostly with Eastern Palaearctic distribution has short and broad dorsal branch of the paraproct and the paramere slender, long and sigmoid in lateral view. The *D. atripes* species group with Western Nearctic distribution has long and slender dorsal branch of the paraproct and the paramere is short, thick and flattened.

In this genus the paraproct seems to function as the typical neutral traits exposed to stochastic processes of the effective population size, gene flow, gene drift combined with recombination. Therefore, dicosmoecine paraproct seems to be an unreliable character in contemporary divergences. Our three new species are distributed in the eastern Palaearctic region, they have long, slender, digitate and sigmoid paramere, but the dorsal branches of paraproct are long and slender, not short and broad or triangular. Being neutral, non-adaptive trait the shape of dorsal branch of the paraproct seems not stable, at least the holotype of *D. jozankeanus* has short dorsal branch (Wiggins & Richardson 1982) and the holotype of *Kogurea ezoensis*, synonymised with *D. jozankeanus*, has

long dorsal branches (Ito & Nagayasu 1991). Here we rely on the finding of Flint (1966) that stable differences exist between *Dicosmoecus* species especially in the paramere spine patterns and in the structure of the basal ridge of the gonopod. However, the stability of paramere spine pattern is still uncertain. The recorded variabilities (Flint 1966, Wiggins & Richardson 1982, Ito & Nagayasu 1991) need further studies on larger series of specimens from several populations in order to detect the background mechanisms of the recorded variabilities: (1) fluctuating asymmetry reflecting developmental instability caused by external and internal effects; (2) stochasticity of neutral traits exposed to random population processes; (3) reinforcement by ecological and reproductive character displacement against unfit hybrid offspring. Here we have examined larger series of *D. coreanus* sp. nov. We have found the paramere spine pattern very stable both in the North and South Korean populations. We distinguish and delineate our three new species mostly by the fine structure of the parameres and the basal ridges of gonopods. Besides, the possible speciation traits of parameres and basal ridges on gonopods we have found some noticeable divergences also in some periphallid structures.

***Dicosmoecus coreanus* Oláh & Park, sp. nov.**

(Figures 57–64)

*Material examined.* **Holotype, South Korea.** Gangwon-do, Taebaek, Mt. Taebaeksan, Geomryongso 768 m, 12.IX.2013, leg. Li Xuankun (1 males, OPC). *Allotype*, same as holotype (1 female, OPC). *Paratypes*, same as holotype (1 male, 1 female, NIBR, 12 males, 2 females, DPP-HIST, 8 males, 2 females, OPC, 8 males, 1 female, KGU). South Korea, Gangwon-do, Pyeongchang-gun, Mitán-myeon, Chang-ri, Changri-cheon Stream, 37°20'44.8"N, 128°30'19.7"E, 400 m, 8.X.2017, leg. M.S. Kang, (1 male, 1 female, OPC). **North Korea,** North Pyongan Province, Mt. Myohyang-san, Hyangsan, sweeping the very sparse underwood vegetation in the forest around the hotel, 15.IX.1994, leg. F. Mészáros & L. Zombori (2 males, HNHM). North Korea, North Pyongan Province, Mt. Myohyang-san, Hyangsan,

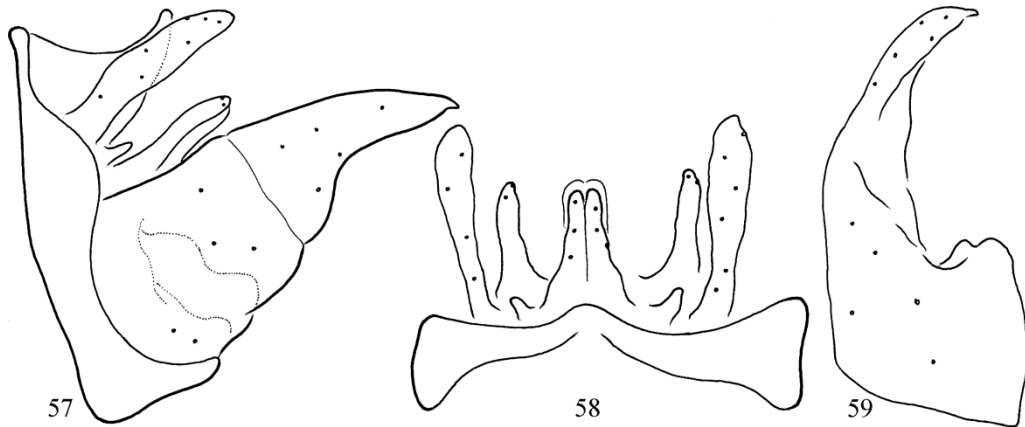
light trap, 16.IX.1994, leg. F. Mészáros & L. Zombori (1 male, HNHM). North Korea, North Pyongan Province, Mt. Myohyang-san, Hyangsan, light trap, 17.IX.1994, leg. F. Mészáros & L. Zombori (2 males, HNHM).

*Diagnosis.* Most close to *D. jozankeanus*, having almost the same structure of the basal ridge on the gonopods. They are contemporary diverged siblings. *D. coreanus* differ clearly by the fine structure of the parameres. Moreover, the new species has rather slim and long dorsal branches of the paraproct and the holotype of *D. jozankeanus* has very short dorsal branches. In the examined populations of the new species the long and slim dorsal branch seems stable, but seems variable in the various drawings of *D. jozankeanus*.

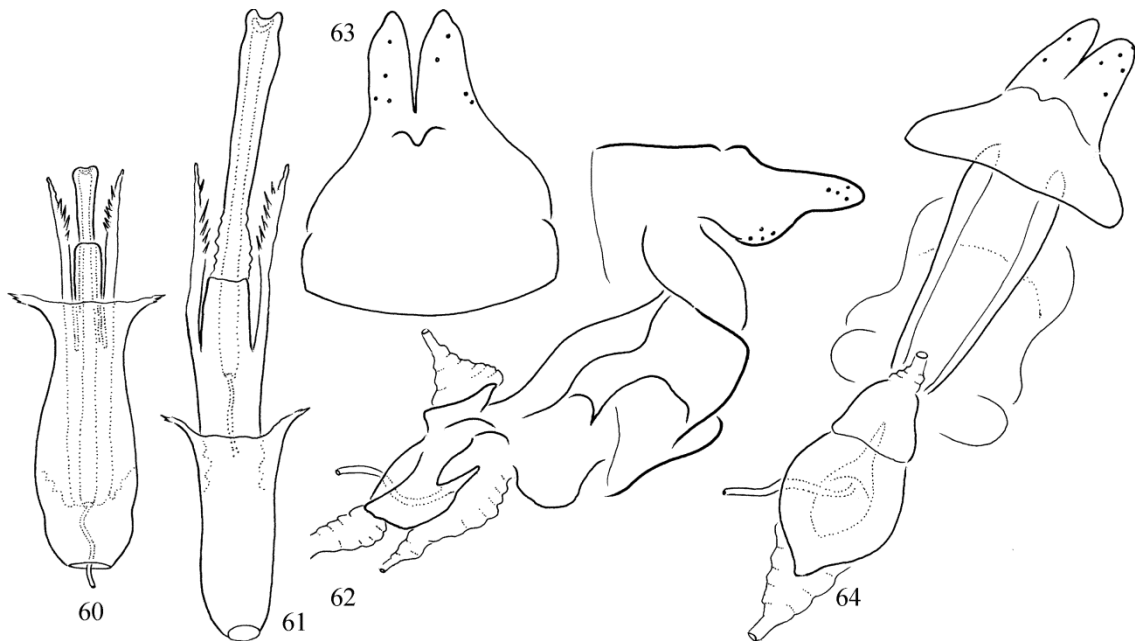
*Description.* Large and dark species with even darker wing neuration. Forewing length 28 mm, spur number 134.

*Male genitalia.* Based on the long and slender paramere shaft, this new species belongs to the *D. palatus* species group, but differs from the three known species (*jozankeanus*, *obscuripennis*, *palatus*) and from the two new species (*juliarum*, *mongolicus*) by the particular apical spine pattern of the parameres: a single setal organising centre resulted in the gradual pectinate apical cluster of spines. Fluctuating asymmetry, an indication of developmental instability between the left and right parameres both in the number and in the position of spines present. However, the fluctuating asymmetry remains in the limits of gradual pectinate pattern.

*Female genitalia.* The gross structure of the female genitalia similar to the female of *D. jozankeanus*, including the dorsal profile of the fused tergite IX and segment X, the setose sternite IX, supragenital plate of segment X (upper vulvar lip), median lobe of the vulvar scale (lower vulvar lip). Similarly we have found the bilobed apices of segment X variable both in dorsal and lateral view. We have examined and drawn in details the fine structure of the vaginal sclerite complex, but there is no other species with known vaginal sclerite complex to compare. Among the nine



**Figures 57–59.** *Dicosmoecus coreanus* Oláh & Park, sp. nov. Holotype male: 57 = genitalia in lateral view, 58 = genitalia in dorsal view, 59 = left gonopod in ventral view.



**Figures 60–64.** *Dicosmoecus coreanus* Oláh & Park, sp. nov. Holotype male: 60 = retracted phallic organ in dorsal view, 61 = erected phallic organ in dorsal view. Allotype female: 62 = genitalia with the vaginal sclerite complex in lateral view, 63 = tergite IX and segment X in dorsal view, 64 = tergite IX and segment X in slightly distorted dorsal view with the vaginal sclerite complex.

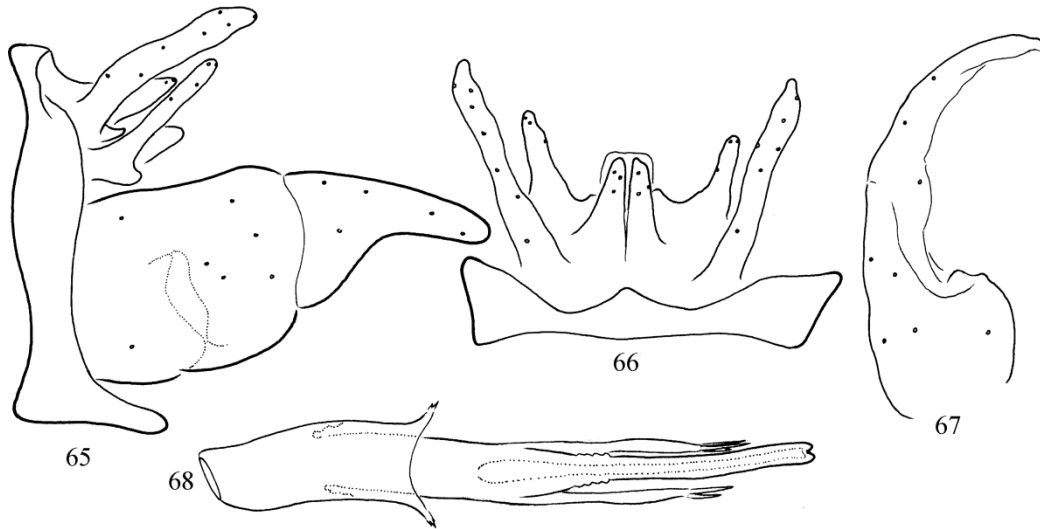
structural elements of the vaginal sclerite complex (Oláh *et al.* 2014) the dorsal and ventral articulations extremely produced, like in many of the females of the limnophiloid Polyphorae.

*Etymology.* *coreanus*, named for the country in which the holotype were collected.

***Dicosmoecus juliarum* Oláh, sp. nov.**

(Figures 65–68)

*Material examined.* Holotype, **Russia**. Central Altai, 20 km S of Ongoday, 50°46'00.51"N 86°09'56.86"E, 950–1000 m, 3.VIII.1993, leg. Z. Varga (1 male, OPC).



Figures 65–68. *Dicosmoecus juliarum* Oláh, sp. nov. Holotype male: 65 = genitalia in lateral view, 66 = genitalia in dorsal view, 67 = left gonopod in ventral view, 68 = erected phallic organ in dorsal view.

**Diagnosis.** Most close to *D. obscuripennis*, but dorsal branch of the paraproct (internal process of segment X) long digitiform, not short broad and triangular. *D. obscuripennis* has basal spine on the parameres produced by the second setal organising centre. A single, apical setal organising centre producing 2–3 apical spines on the very tip of the paramere; no basal setal organising centre producing any spines on the basal region.

**Description.** Forewing length 23 mm, spur number 134. Parameres sigmoid in lateral view, slightly constricted midway in dorsal view. The parameres of the holotype, the single representative of the species exhibit fluctuating asymmetry: two apical spines on the tip of the left paramere and three apical spines present on the tip of the right paramere.

**Etymology.** *juliarum*, named to acknowledge permanent background support provided to our studies by the wives of the collector (Julia) and the wife of the first author (Julia).

***Dicosmoecus mongolicus* Oláh, sp. nov.**

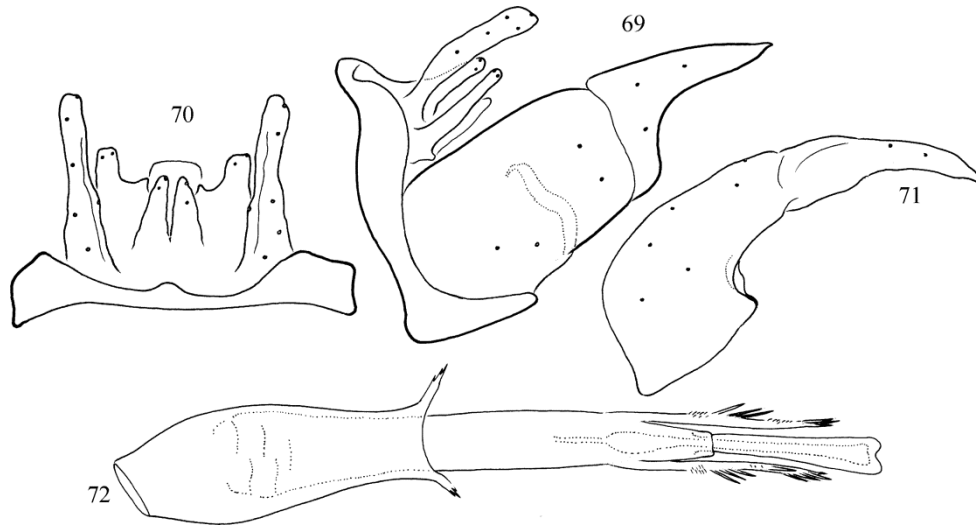
(Figures 69–72)

**Material examined.** Holotype, **Mongolia**. Gobi Altai, Aj Bopgd Uul, 44°34'16.83"N, 95°21'39.21"E, 1950–2000 m, 4.VIII.1988, leg. Z. Varga (1 male, OPC).

**Diagnosis.** Based on the long and slender paramere shaft, this new species belongs to the *D. palatus* species group, but differs from the three known species (*jozankeanus*, *obscuripennis*, *palatus*) and from the two new species (*coreanus* sp. nov., *juliarum* sp. nov.) by the diverse spine pattern of the parameres. *D. jozankeanus* has parameres with two spine clusters, but without any microtrichia; *D. mongolicus* has very low basal ridge on the gonopods, the second possible speciation trait of the genus. This basal ridge very high at the *D. jozankeanus* holotype. Moreover, *D. mongolicus* has particularly patterned ventral branch of the paraproct (inferior process of segment X) with truncated apices and quadrangular basal region in dorsal view.

**Description.** Forewing length 23 mm, spur number 134. There are on the paramere an apical and a middle cluster of spines and there are two areas covered with microtrichia of innervated trichomes, microbristles without sensorial functions, just basad of the apical and middle clusters of spines. Again there is a fluctuating asymmetry between the left and right parameres in the number and position of both the spines and the microtrichia.

**Etymology.** *mongolicus*, named for the country in which the holotype were collected.



Figures 69–72. *Dicosmoecus mongolicus* Oláh, sp. nov. Holotype male: 69 = genitalia in lateral view, 70 = genitalia in dorsal view, 71 = left gonopod in ventral view, 72 = erected phallic organ in dorsal view.

### Tribe Nothopsychini Banks, 1906

#### *Ecclisomyia kamtshatica* (Martynov, 1914)

*Material examined.* North Korea. Kangwon province, Mt Kumgang-san, Oe-Kumgang, sweeping vegetation in the forest around the hotel, 24.IX.1994, leg. M. Mészáros & L. Zombori (3 females, HNHM).

#### *Nothopsyche bilobata* Park & Bae, 2000

(Figures 73–80)

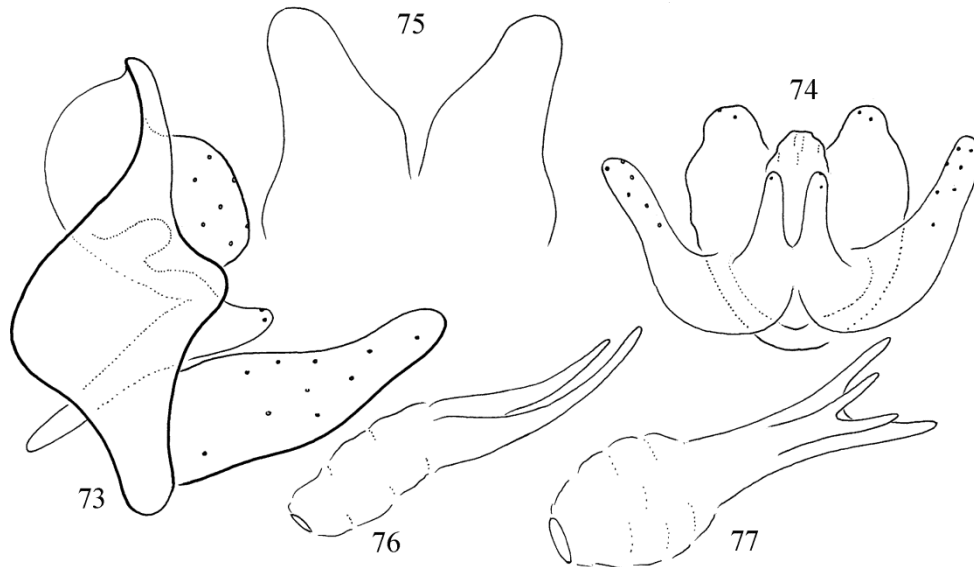
*Nothopsyche bilobata* Park & Bae, 2000: 18–129. “Male adult of *Nothopsyche bilobata* is similar to that of *N. pallipes* Banks, but can be distinguish by the blunt internal branches of abdominal segment X, weakly pointed inferior appendages, and shape of phallus.”

*Material examined.* North Korea. Pyongan Province, Mt Myohyang-san, 8.X.1987, collected at light at Hotel Myohyang-san, leg. Z. Korsós & L. Ronkay (1 male, HNHM). Pyongan Province, Mt. Myohyang-san, 10.X.1987, collected at light around the Hotel Myohyang-san, leg. Z. Korsós & L. Ronkay (1 female, HNHM). Pyongan Province, Mt. Myohyang-san, 11.X.1987, collected at lampshade at Hotel Myohyang-san, leg. Z. Korsós &

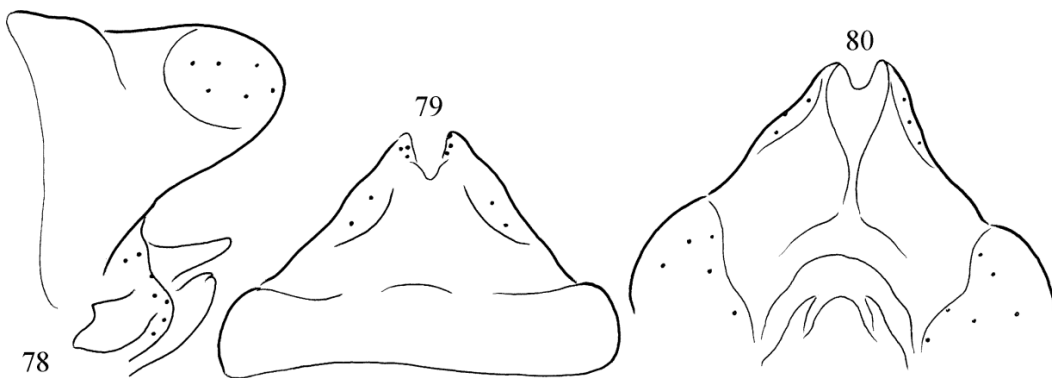
L. Ronkay (1 male, OPC). North Hwanghae Province, Sinpyong, Pyonghwa-ri, 15.X.1978, singled around the quest-house from green vegetation, leg. A. Vojnits & L. Zombori (1 male, KGU).

*Additional diagnosis.* Our specimens from North Korea have resemblance to *Nothopsyche bilobata* but with some differences, at least according to comparison with the original drawings. Here we describe our specimens with draws for a further more detailed comparison. Body colour is light brown of animals held in alcohol over 30 years. Forewing length is 10 mm without any pattern. Tibial spur number is 022 at male and 122 at female. First segment of the female maxillary palp is very short.

*Male genitalia.* Segment IX short ventrad, long pleurad and very short dorsad. The superanal complex is composed of segment X concave dorsad and bulging ventrad, of the vertically elongated rounded setose pair of cerci (external branches), of the short digitate dorsal branches of paraproct (internal, inner), and of the less pigmented bilobed ventral branches of paraproct (inferior, lower). The bilobed ventral branches of paraproct continuing anterad into a semi-circular sclerotized band. The gonopods (inferior appen-



Figures 73–77. *Nothopsyche bilobata* Park & Bae, 2000. Male: 73 = genitalia in lateral view; 74 = genitalia in dorsal view; 75 = gonopods in ventral view; 76 = phallic organ in lateral view; 77 = phallic organ in dorsal view.



Figures 78–80. *Nothopsyche bilobata* Park & Bae, 2000. Female: 78 = genitalia in lateral view; 79 = genitalia in dorsal view; 80 = genitalia in ventral view.

dages of segment IX) are elongated and slightly sigmoid in lateral view. Both the aedeagus and parameres sclerotized apicad and deeply excised bifid.

*Female genitalia.* Segment X triangular in dorsal view with deep apical excision and rounded in lateral view. Entrance of vulva that is the vaginal opening is housed on segment IX, not between segments VIII and IX. Ventral setose lobes of segment IX located laterad, besides of the vaginal opening, not above. The lower vaginal lip,

the vulvar scale discernibly trilobate, forms a semi tubular cavity with the upper vaginal lip that is with the semi-circular supragenital plate. Lateral lobes of the vulvar scale thin, median lobe robust. Vaginal sclerite complex elongated rounded in dorsal view.

#### *Nothopsyche ruficollis* (Ulmer, 1905)

*Material examined.* South Korea. Jeju-do, Mt. Hallasan National Park, 126°00'E 33°15'N, 1000

m, 27.X.1993, mixed deciduous forest, light leg. L. Peregovits & L. Ronkay (3 males, 1 female; HNHM).

**Family Pseudostenophylacinae Schmid, 1955**

***Pseudostenophylax riedeli* Botosaneanu, 1970**

*Material examined.* **North Korea.** Kangwon Province, Mt. Kumgang-san, 27.V.1985, night collecting at blended light (250W), fed by a Honda generator at Kumgang-mun Gate, leg. A. Vojnits & L. Zombori (1 male, HNHM). Kangwon Province, Mt. Kumgang-san, 28.V.1985, night collecting at blended light (250W), fed by a Honda generator on the serpentine to Kwinyon-am Rock, leg. A. Vojnits & L. Zombori (1 male, HNHM). Kangwon Province, Mt. Kumgang-san, Manmulsang Rocks, 750 m, 12.VI.1991, collected by light trap at the beginning of the pathway to Manmulsang Rocks, leg. L. Ronkay, A. Vojnits & L. Zombori (1 male, HNHM).

***Pseudostenophylax amurensis* (McLachlan, 1880)**

*Material examined.* **North Korea.** North Khangem Province, Chondjin, 5.VI.1991, collected in a hilly forest clearing in the vicinity of Kumgang, 15 km NW of Chondjin, leg. L. Ronkay & A. Vojnits (3 males, HNHM; 2 males, OPC).

**Subfamily Limnephilinae Kolenati, 1848**

**Tribe Chilostigmini Schmid, 1955**

***Brachypsyche schmidi* Choe, Kumanski & Woo, 1999**

*Material examined.* **South Korea.** Gyeonggi-do, Gapyeong-gun, Buk-myeon, Jomurakgol rd.: 37°59'24.7"N 127°26'76.0"E 360 m, 4.XI.2016, light trap, leg. J. Babics & B. Tóth (1 male, HNHM).

**Tribe Limnephilini Kolenati, 1848**

***Asynarchus iteratus* McLachlan, 1880**

*Material examined.* **Mongolia.** Gorkhi-Terelj National Park, 20.VII–15.VIII.1986, leg. Z. Varga (4 males, OPC).

***Asynarchus mongolicus* Oláh, sp. nov.**

(Figures 81–83)

*Material examined.* **Holotype, Mongolia.** Gorkhi-Terelj National Park, 47°58'58.81"N 107°27'07.10"E, 1550–1600 m, 20.VII–15.VIII.1986, leg. Z. Varga (1 male, OPC).

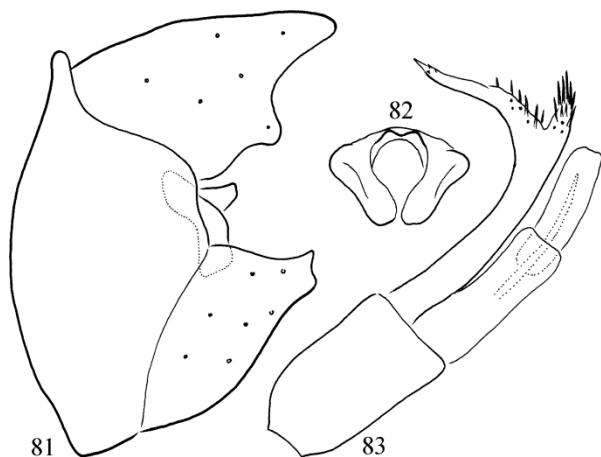
*Diagnosis.* The new species is most close to *A. lapponicus*, but differs by having differently shaped lateral profiles both of the cerci and gonopods as well as easily distinguished by the diversified fine structure of the parameres.

*Description.* The single male specimen stored in alcohol over thirty years is faded brown. The forewing length is 14 mm. Segment IX very short dorsad longer ventrad, although the demarcation line between segment IX and gonopods is just discernible. The cerci is very large, subtriangular, its ventral lobe located middle and blunt, not pointed. Paraproct reduced in size, its dorsal arm especially small and triangular in lateral view. Gonopod lateral profile characterized with pointed dorsal and very blunt ventral apical lobe. Phallic organ composed of phallosome (phallobase), endothenca, aedeagus, endophallus and parameres. Parameres characterized by an upward and forward turning spine-like dorsal arm and the more setose horizontal ventral arm.

*Etymology.* *mongolicus*. Named for the country in which the holotype were collected.

***Limnephilus fuscovittatus* Matsumura, 1904**

*Material examined.* **Japan.** Tsukanoiri-ike, I-taka-cho, Neito-ku, Nagoya, Aichi, 2.IX.2010, leg. T. Nozaki (2 males, OPC). **North Korea.** Ryanggang Province, Samjiyon, 4.VI.1985, night collecting at blended light (250W), fed by a Honda generator in a Picea stand at an altitude of about 2100 m, leg. A. Vojnits & L. Zombori (2 males, HNHM, 1 male, OPC). Pyongyang City, Pyongyang, Hotel Potonggang, 13.X.1987, singled at light around the hotel, leg. Z. Korsos & L. Ronkay (2 females, HNHM, 1 female, OPC). Pyongyang City, Pyongyang, Ryongak-san, 21.



Figures 81–83. *Asynarchus mongolicus* Oláh sp. nov. Holotype male: 81 = genitalia in lateral view; 82 = paraproct in caudal view; 83 = phallic organ in lateral view.

IX.1994, singled at a lookout place, leg. Z. Mészáros & L. Zombori (1 male, HNHM). North Pyongan Province, Mt Myohyang-san, Hyangsan, 15.IX.1994, light trap, leg. Z. Mészáros & L. Zombori (2 males, HNHM). North Hwanghae Province, Sariwon, Samsal Hotel balcony, 29.IX.1994, light trap, leg. Z. Mészáros & L. Zombori (10 males, 4 females; HNHM). Kangwon Province, Mt Kumgang-san, Oe-Kumgang, 23.IX.1994, sweeping path-side vegetation behind Kumgangs Hotel, leg. Z. Mészáros & L. Zombori (1 male, HNHM).

#### *Limnephilus orientalis* Martynov, 1935

**Material examined.** South Korea. Gyeong-sangnam Province, Hadong-gun, Jiri Mts. Ssang-gyesa valley, parking lot beneath Daesung camp, 270 m, 35°16.523'N 127°39.131'E, 14.IX.2010, leg. D. Murányi et al. (1 female, OPC).

#### *Limnephilus quadratus* Martynov, 1914

**Material examined.** North Korea. Ryang-gang, Chann-Pay plateau, Sam-zí-yan, 1700 m, 27.VIII.1971, netting on lake shore, leg. J. Papp & S. Horvatovich (2 males, HNHM; 1 male, KGU).

**Remark.** This species is new to the Korean Peninsula.

#### *Nemotaulius brevilinea* (McLachlan, 1871)

**Material examined.** North Korea. Kangwon Province, Mt. Kumgang-san, 26.V.1985, cool night. Collecting at blended light, fed by a Honda generator, some 100 m from the rest house Oe-Kumgang, in a mixed forest, leg. A. Vojnits & L. Zombori (1 male, HNHM).

#### *Nemotaulius coreanus* Oláh, 1985

(Figures 84–88)

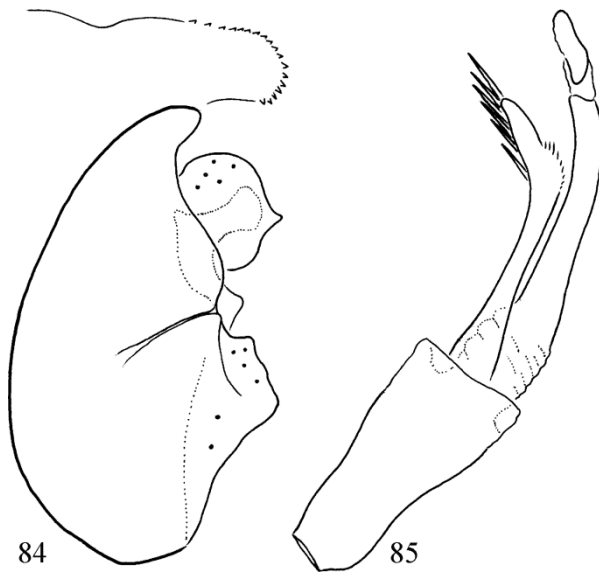
*Nemotaulius coreanus* Oláh, 1985: 137–139. “Superior appendages (cerci) clearly ovoid with a well-developed triangular projection at submiddle position on the apical margin. Other peculiar feature of the superior appendages is an enlarged circular strongly sclerotized black area occupying the larger lower half of the appendages including also the triangular projection. Intermediate appendages (paraproct) not visible in lateral view due to this heavily sclerotized black circle on the superior appendages. In lateral aspect the heavily sclerotized distal ending of intermediate appendages broad, clavate or rather with a renal configuration.” “This is a distinct large and very decorative new caddisfly species allied to *N. admorsus* McLachlan, 1866 distributed in Japan, Sakhalin, Ussuri and Kurile Islands. Differs from *admorsus* in its forewing pattern with rounded apico-posterior angle which is very very pointed in *admorsus*. Second and third joints of maxillary palpi equal, second longer in *admorsus*. Superior and intermediate appendages differently formed.”

*Glyphotaelius admorsus* McLachlan, 1866? (sp.?) Martynov 1914: 177–179. A single male specimen was described from lower Ussuriland with question mark as similar to the Japanese *Glyphotaelius admorsus* McLachlan. However, Martynov listed significant differences: (1) in lateral view the appendices praeanales (cerci) without tooth at *G. admorsus*, but the specimen from Ussuriland has a tooth-like outgrowth on the apical margin, (2) in lateral view the internal branch (paraproct) is band-like with conical apex at *G. admorsus*, but with diverging, broad apex at the specimen from Ussuriland. Misidentification!

*Nemotaulius admorsus* (McLachlan, 1866). Kumanski 1991: 20–21: species new to Korea. Misidentification!

*Nemotaulius admorsus* (McLachlan, 1866). Choe et al. 1999: 33–35. “superior appendages (cerci) with





**Figures 84–85.** *Nemotaulius coreanus* Oláh, 1985. Holotype male: 84 = genitalia in lateral view; 85 = phallic organ in lateral view.

triangular projection in the middle of the apical margin and with strongly sclerotized black area on the inner surface. Upper lobe of each intermediate appendage blunt, not visible laterally, because of the sclerotized portion of superior appendages.” Misidentification!

*Material examined.* **Male holotype.** **North Korea.** Mt Pektusan, before Sam-zi-yan Hotel, lakeshore, wooded environment, collecting at Mv lamp, 20.VII.1977, (1 male, HNHM). **South Korea.** Gyeongsangnam-do, Hadong-gun, Mt. Jirisan, Ssanggyesa Valley, parking lot beneath Daesung camp, 270 m, 35°16.523'N 127°39.131'E, 14.IX.2010, leg. D. Murányi et al. (1 female, OPC). South Korea, Jeollabuk-do, Wanjugun, Soyang-myeon, Hwasim-ri, Soyangcheon Stream, 35°49'56.3"N 127°16'53.6"E 100 m, 21.IX.2016, leg. M. S. Kang (1 male, KGU). South Korea, Gyeongsangbuk-do, Cheongdo-gun, Unmun-myeon, Ojin-ri, Ojin-1 Bridge, 35°42'13.9"N 128°58'19.3"E 170 m, 30.VIII.2015, leg. S. J. Park, (1 male, OPC). South Korea, Gangwon-do, Yanggu-gun, Nam-myeon, Gaojak-ri, Gwangchi valley, 38°08'19.6"N: 128°04'09.6"E 500 m, 08.IX.2016, leg. M. S. Kang, (1 female, OPC). South Korea, Gyeongsangnam-do, Danjang-myeon, Milyang-si, Pyochungsa Temple,

35°35'16.53"N 128°59'47.70"E 386 m, 29.VIII.2015, leg. S.J. Park, (1 female, KGU).

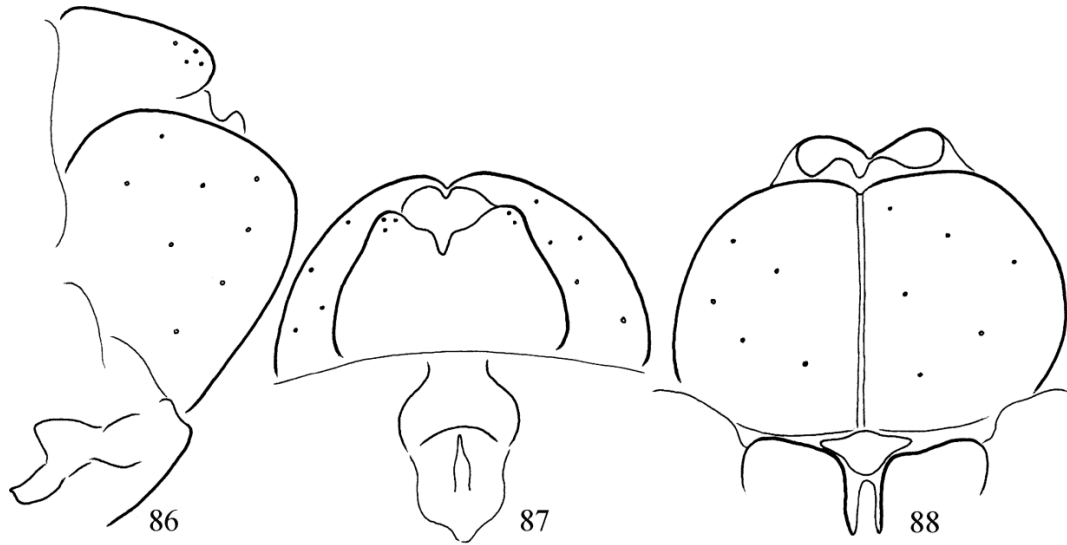
*Remarks.* The Japanese species of *Nemotaulius admorsus* has cerci (preanal appendages) without dental projection on the apical margin. Contrary, all the examined specimens of *Nemotaulius coreanus* from North and South Korea as well as, at least according to Martynov's original description and drawings, specimen from Ussuriland have characteristic dental projection on the apical margin of the cerci. The other periphallic organ the paraproct (intermediate appendages) is band-like with conical apex at *N. admorsus* and capitate or rather clavate at *N. coreanus* that is with broadening apex in lateral view. The fine structure of the parameres is even more diverged in the two species. *N. admorsus* has paramere apex with long setae both on the dorsal and ventral margin in lateral view. *N. coreanus* has long setae only on the dorsum of the paramere apex; the ventral setae

on the apex are located only subapical and represent completely different type of sensory structure, they are very short and fine. Until we have no more material it seems that *N. admorsus* lives only in Japan, at least all the specimens collected and examined until now from the continent have the specific characters of *N. coreanus*.

#### Stenophylacini Schmid, 1955

##### *Hydatophylax formosus* Schmid, 1965

*Material examined.* **North Korea.** Kangwon Province, Mt. Kumgang-san, 22.X.1987, collected at light around the Hotel Kumgang-san, leg. Z. Korsós & L. Ronkay (1 male, OPC). Kangwon Province, Mt. Kumgang-san, Hotel Kumgang, 17.IX.1980, collected at light around the Hotel Kumgang-san, leg. L. Forró & Gy. Topál (3 males, HNHM). Kangwon Province, Mt. Kumgang-san, Hotel Kumgang, 28.IX.1979, singled and netted on and in the water of the brook Kuryong, leg. H. Steinmann & T. Vásárhelyi (1 male, HNHM). Kangwon Province, Mt. Kumgang-san, 18.IX. 1980, singled along the foot-path



Figures 86–88. *Nemotauius coreanus* Oláh, 1985. Female: 86 = genitalia in lateral view; 87 = genitalia in dorsal view with dorsal profila of the vaginal sclerite; 88 = genitalia in ventral view.

to Kuryong Falls, leg. L. Forró & Gy. Topál (1 male, HNHM). Pyongyang City, Pyongyang, Garden of Hotel Pyongyang, 24.IX.1978, collected by aspirator around lampshade, leg. A. Vojnits & L. Zombori (1 male, HNHM). **South Korea.** Gangwon-do, Yangyang, Mt. Jeombongsan 495 m, 11.IX.2013, leg. Li Xuankun (6 males, 1 female, DPP-HIST; 6 males, 2 females, OPC). Gangwon-do, Yangyang, Mt. Seoraksan, Hangye-ryeong pass, brook in deciduous forest, 875 m, 38°05.481'N 128°24.267'E, 9.IX.2010, leg. D. Murányi *et al.* (1 male, OPC). Gangwon-do, Yangyang, Mt. Seoraksan, Osaek-Oncheon, N branch of Osaekcheon stream, 365 m, 38°04.814'N 128°26.943'E, 9.IX.2010, leg. D. Murányi *et al.* (2 males, 1 female; OPC). South Korea, Gangwon-do, Yangyang, Mt. Seoraksan, Osaek-Oncheon, parking lot at entrance to Yongso falls, 520 m, 38°05.180'N 128°26.021'E, 8.IX.2010, leg. D. Murányi *et al.* (10 males, OPC).

***Hydatophylax grammicus* (McLachlan, 1880)**

*Material examined.* **North Korea.** North Pyongan Province, Mt. Myohyang-san, 20.V.1985, night collecting at blended light (250W), in the balcony of the hotel, leg. A. Vojnits & L.

Zombori (2 males, HNHM). North Pyongan Province, Mt. Myohyang-san, 21.V.1985, night collecting at blended light (250W), in the balcony of the hotel, leg. A. Vojnits & L. Zombori (3 males, HNHM). North Pyongan Province, Mt. Myohyang-san, 22.V.1985, night collecting at blended light (250W), in the balcony of the hotel, leg. A. Vojnits & L. Zombori (2 males, HNHM). North Pyongan Province, Mt. Myohyang-san, 22.V.1985, night collecting at blended light (250W), by using Honda generator, some three km of the hotel, by the river Hyangsan-chon, leg. A. Vojnits & L. Zombori (2 males, HNHM). North Pyongan Province, Mt. Myohyang-san, Hotel Myohyang, 25.V.1991, collected by light in a mixed forest near to the hotel, leg. L. Ronkay & A. Vojnits (2 males, HNHM). North Korea, North Pyongan Province, Mt. Myohyang-san, Isonnam valley, 23.V.1991, collected by light at a white sheet illuminated by a 160 W mixed lamp, leg. L. Ronkay & A. Vojnits (2 males, OPC). North Korea, North Pyongan Province, Mt. Myohyang-san, Hotel Myohyang, 23.V.1991, collected by light around the hotel, leg. L. Ronkay & A. Vojnits (1 male, HNHM). North Pyongan Province, Mt. Myohyang-san, Hotel Myohyang, 24.V.1991, collected by light at the hotel, leg. L. Ronkay & A. Vojnits (2 males, HNHM). North

Pyongan Province, Mt. Myohyang-san, Hotel Myohyang, 26.V.1991, singled from a mixed deciduous forest SE from the hotel, leg. L. Ronkay & A. Vojnits (1 male, HNHM).

***Hydatophylax magnus* (Martynov, 1914)**

*Material examined.* **North Korea.** North Pyongan Province, Mt. Myohyang-san, 8.X.1987, collected at light at Hotel Myohyang-san, leg. Z. Korsós & L. Ronkay (2 males, HNHM). North Pyongan Province, Mt. Myohyang-san, Hotel Myohyang-san, 11.X.1987, collected at light on lampshade at the hotel, leg. Z. Korsós & L. Ronkay (1 male, OPC). North Hwanghae Province, Sinpyong, Pyonghwa-ri, 15.X.1978, singled around the quest-house from green vegetation, leg. A. Vojnits & L. Zombori (1 male, OPC). **South Korea.** Chungcheongbuk-do, Mt. Cheonwangbong 587 m, 8.IX.2013, leg. Li Xuankun (1 male, 1 female, DPP-HIST; 1 male, 1 female, OPC). South Korea, Jeollanam-do, Gurye-gun, Mt. Jiri, Nogodan, rocky stream in deciduous forest, 1280 m, 35°17.738'N 127°31.430'E, 15.IX.2010, leg. D. Murányi *et al.* (1 male, OPC). Gyeongsangnam-do, Sancheong-gun, Mt. Jiri, Ogeok valley, N branch of Yupyeong, forest edge, 655 m, 35°22.848'N 127°47.103'E, 16.IX.2010, leg. D. Murányi *et al.* (9 males, 5 females; OPC). South Korea, Jeollabuk-do, Muju-gun, Mt. Deokyu, Sugyeongdae, clearing edge above a road, 640 m, 35°53.888'N 127°46.378'E, 16.IX.2010, leg. D. Murányi *et al.* (2 males, OPC). Gyeongsangnam-do, Hadong-gun, Mt. Jiri, Ssanggyesa valley, parking lot beneath Daesung camp, 270 m, 35°16.523'N 127°39.131'E, 14.IX.2010, leg. D. Murányi *et al.* (9 males, 5 females; OPC). Jeollanam-do, Gurye-gun, Mt. Baekun 620 m, 7.IX.2013, leg. Li Xuankun (16 males, 5 females; OPC). South Korea, Gyeongsangnam-do, Mt. Deokyu, near Geochang, Galgye-ri, 35°47.792'N 127°49.169', 443 m, 28.X.2016, light tr., leg. J. Babics & B. Tóth (8 males, 1 female, HNHM).

***Hydatophylax nigrovittatus* Schmid, 1950**

*Material examined.* **North Korea.** North Pyongan Province, Mt. Myohyang-san, 21.V.1985, cool night. Night collecting at blended light (250W), in the balcony of the hotel, leg. A.

Vojnits & L. Zombori (2 males, HNHM). North Pyongan Province, Mt. Myohyang-san, 22.V.1985, warm, sunny afternoon. Collecting along the bank of the river Hyangsan-chon, mostly singling, leg. A. Vojnits & L. Zombori (1 female, HNHM). North Pyongan Province, Mt. Myohyang-san, Hotel Myohyang, 23.V.1991, collected by light around the hotel, leg. L. Ronkay & A. Vojnits (1 male, HNHM). **South Korea.** Gyeongsangbuk-do, Mt. Bohyonsan, Experimental Station between Wolmae and Mt. Bohyonsan, 36°09'N 129°00'E, 800 m, 23.IV.1994, light, leg. L. Peregovits, L. Ronkay & A. Vojnits (4 males, HNHM).

***Hydatophylax soldatovi* (Martynov, 1914)**

*Material examined.* **North Korea.** Mt. Pektusan, wooded environs of the Sam-zi-yan hotel, 19.VII.1977, Collecting at Mv lamp, leg. O.Gy. Dely & Á. Dely-Draskovits (2 males, HNHM). Mt. Pektusan, wooded environs of the Sam-zi-yan hotel, 18.VII.1977, collecting at Mv lamp, leg. O.Gy. Dely & Á. Dely-Draskovits (2 males, HNHM; 1 male, OPC; 1 male, KGU).

*Remark.* This species is new to the Korean Peninsula.

**Superfamily Leptoceroidea Leach in Brewster, 1815**

**Family Leptoceridae Leach in Brewster, 1815**

***Athripsodes ceracleoides* Kumanski, 1991**

*Material examined.* **North Korea.** Pyongyang City, Pyongyang, Garden of the Hotel Pyongyang, 21.IX.1978, singled around lampshade, leg. A. Vojnits & L. Zombori (1 male, HNHM).

***Ceraclea albimacula* (Rambur, 1842)**

*Material examined.* **North Korea.** Pyongyang City, Pyongyang, Garden of the Hotel Pyongyang, 28.VII.1982, singled around lampshade, leg. L. Forró & L. Ronkay (3 males, HNHM). Ryanggang Province, Samjiyon, 5.VI.1985. mixed *Larix*

- *Betula* forest along the road Paekdu-san, 15 km from the hotel, light leg. A. Vojnits & L. Zombori (1 male, HNHM).

***Ceraclea annulicornis* (Stephens, 1836)**

*Material examined.* **Russia.** Khabarovsk Terr., Slavyanka at Amur, 17.VI.1994, light trap, leg. P. Lindskog & A. Nilsson (15 males, SMNH; 8 males, OPC).

***Ceraclea lobulata* (Martynov, 1935)**

*Material examined.* **North Korea.** Ryanggang Province, Samjiyon, 5.VI.1985, mixed *Larix* - *Betula* forest along the road Paekdu-san, 15 km from the hotel, light leg. A. Vojnits & L. Zombori (2 males, HNHM). **Russia.** West Altai, R. Charish Sentelak, 22–23.VII.1993, light, leg. Z. Varga (3 males, OPC).

***Ceraclea mitis* (Tsuda, 1942)**

*Material examined.* **North Korea.** North Pyongan Province, Mt Myohyang-san, Hotel Myohyang-san, 22.V.1985, light, leg. A. Vojnits & L. Zombori (11 males, 41 females; OPC).

***Ceraclea morsei* Kumanski, 1991**

*Material examined.* **North Korea.** Pyongyang City, Pyongyang, Hotel Tae Dong, 20.IX.1979, light, leg. H. Steinmann & T. Vásárhelyi (1 male, OPC).

***Ceraclea shuotsuensis* (Tsuda, 1942)**

*Material examined.* **North Korea.** North Pyongan Province, Mt. Myohyang-san, pathway Isonnam, 11.X.1988, shifted from the litter of a rocky forest, leg. Z. Korsós & L. Ronkay (3 males, HNHM). North Pyongan Province, Mt. Myohyang-san, Hotel Myohyang-san, 11.X.1988, collected on lampshade at the hotel, leg. Z. Korsós & L. Ronkay (2 males, HNHM). North Korea, Mt. Pektusan, wooded environs of Sam-zi-yan Hotel, 18.VII.1977, at small lake, light leg. Z. Korsós & L. Ronkay (2 males, HNHM).

***Ceraclea sibirica* (Ulmer, 1906)**

*Material examined.* **North Korea.** North Pyongan Province, Mt. Myohyang-san, pathway Isonnam, 11.X.1988, shifted from the litter of a rocky forest, leg. Z. Korsós & L. Ronkay (2 males, HNHM). North Pyongan Province, Mt. Myohyang-san, Hotel Myohyang-san, 11.X.1988, collected on lampshade at the hotel, leg. Z. Korsós & L. Ronkay (1 male, HNHM). **Russia.** West Altai, R. Charish Sentelak, 22–23.VII.1993, light, leg. Z. Varga (4 males, OPC).

***Oecetis dilata* Yang & Morse, 2000**

*Material examined.* **North Korea,** Kangwon Province, Mt. Kumgang-san, side valley near Hotel Kumgang, 13.VI.1991, light, leg. L. Ronkay & A. Vojnits (1 male, HNHM).

***Oecetis kumanskii* Yang & Morse, 2000 stat. nov.**

*Oecetis testacea orientalis* Kumanski, 1991: 52–53. Holotype: “Kumgang Mts., the foothills, near the hotel Go-song and Ondzong village (ca. 50 m alt.), stony stream, the hyporhithral-epipotamon zone. 18–20.VIII.1982, (leg. Beron & Popov, at light).” “Discussion: The only information about the presence of this species in the easternmost regions of the Palearctic goes back to Kuwayama (1930), the occurrence of *Oe. testacea* in Japan been evidently not recognised by any other author. On the other hand, this species has not been established out of Europe and it was a sort of surprise to be found in Korea as well. Besides chorologically, the two subspecies are readily recognizable after the above mentioned genital features.”

*Oecetis testacea kumanskii* Yang & Morse, 2000: 135. “Since the identity is unknown, the name *Oecetis orientalis* Navas, 1921, from “Tonking” (Vietnam), is a NOMEN DUBIUM. Nevertheless, Navas’s name is an available name. Therefore, the species *Oecetis orientalis* Tsuda, 1942b, is a homonym (Fischer, 1966) that was renamed *Oecetis tsudai* Fischer, 1970. Because of the “coordinate status” of names in the species group, the subspecies *Oecetis testacea orientalis* Kumanski, 1991, also is a homonym that should be renamed. Therefore, we rename this subspecies *Oecetis testacea kumanskii* Yang and Morse, NEW NAME.”

*Oecetis kumanskii* Yang & Morse 2000. Based on the significant divergences both in the male and female genital fine structure as well as on our theoretical considerations (Oláh *et al.* 2018) we raise the taxonomic status of this taxon to species. **Stat. nov.**

*Material examined.* **North Korea.** Pyongyang City, Pyongyang, 15.IX.1979, at light of a 160 W MV bulb in the window of Hotel Tae Dong, leg. H. Steinmann & T. Vásárhelyi (1 male, HNHM). North Korea, Chagang Province, Mt Myohyangsan, Hotel Myohyang, 13.IX.1980, singled at lamps standing around the hotel, leg. L. Forró & Gy. Topál (3 males, HNHM).

#### ***Oecetis nigropunctata* Ulmer, 1908**

*Material examined.* **North Korea.** North Pyongan Province, Mt. Myohyang-san, pathway Isonnam, 8.X.1988, singled along stream Hyangsan, leg. Z. Korsós & L. Ronkay (1 male, HNHM). South Hwanghae Province, Haeju, Mt. Suyong-san, deciduous forest on SE slope, 31.VII.1982, light, leg. L. Forró & L. Ronkay (1 male, HNHM).

#### ***Mystacides dentata* Martynov, 1924**

*Material examined.* **North Korea.** North Pyongan Province, Mt. Myohyang-san, Hyangsan, 15.IX.1994, light trap, leg. F. Mészáros & L. Zombori (1 male, 1 female; HNHM).

#### ***Setodes pulcher* Martynov, 1910**

*Material examined.* **North Korea.** Chagang Province, Mt Myohyang-san, Hotel Myohyangsan, 14.VII.1982, light, leg. L. Forró & L. Ronkay (3 males, 3 females; HNHM).

#### **Family Odontoceridae Wallengren, 1891**

##### ***Psilotreta falcu* Botosaneanu, 1970**

*Psilotreta falcu* Botosaneanu, 1970: 314–316. “Holotype ♂ et allotype ♀ choisis parmi les exemplaires de st. 7.” “Station 7. Province Hamgjong-pukto: rivière Poro-čhon à 2 km. environ au NO de Kjongšong. 4.VI. 965, leg. M. Mroczkowski et A. Riedel.”

*Psilotreta pyonga* Oláh, 1985: 140–141.

*Psilotreta pyonga* Oláh, 1985: Parker & Wiggins 1987: 48. *Psilotreta pyonga* is closely related to *P. falcu*, if not conspecific.

*Psilotreta pyonga* Oláh, 1985: Oláh & Johanson 2010: 101, holotype and new material re-examined and stated formally that *P. pyonga* is a junior synonym of *P. falcu*.

*Material examined.* Holotype of *P. pyonga*. “Korea, Prov. North Pyongan, Mt. Myohyangsan, Hotel Myohyang-san, 14.VII.1982, leg. Forró et Ronkay.” **North Korea.** Kangwon Province, Mt. Kumgang-San, 28.V.1985, light, leg. A. Vojnits & L. Zombori (1 male, 2 females; NHMB). North Korea, Kangwon Province, Mt. Kumgang-San, 13.VI.1991, light, leg. L. Ronkay & A. Vojnits (1 male, (NHMB).

*Remarks.* Distinguished from *P. locumtenens* by longer and robust paraproct, by the well-developed ventroapical lobe on the coxopodite of the gonopod and by the short and hooked paramere.

##### ***Psilotreta kerka* Oláh, sp. nov.**

(Figures 89–91)

*Material examined.* Holotype, **North Korea.** North Khamgen Province, Chondjin, 2.VI.1991, O-sang-li valley, 20 km SW of Chondjin, singled and netted, leg. L. Ronkay & A. Vojnits (1 male, HNHM).

*Diagnosis.* This species with 11 mm forewing length is most close to *P. falcu*, but differs by the shape of the paraproct and the paramere. The curving spine of the paraproct is forming a complete circle and the narrowing tip is directed vertically downward, not posterad; as a result the tip of the paraproct is not visible in dorsal view. The paraproct is more robust compared to the paraproct of the *P. falcu*. The pair of parameres is longer, more robust and its tip is not forming an apical hook.

*Description.* General habitus, body and genitalia characters are similar to *P. falcu* Botosaneanu, 1970 differs discernibly by the divergences of paraproct and paramere.

*Etymology.* *kerka*, rounded or circle in Hungarian with reference to the lateral shape of the paraproct forming an almost complete circle.

***Psilotreta locumtenens* Botosaneanu, 1970**

*Material examined.* **North Korea.** Pyongyang City, Ryongak-san, 8.VI.1985, leg. A. Vojnits & L. Zombori (1 male, HNHM). North Korea, Kangwon Province, Mt. Kumgang-san, side valley near Hotel Kumgang, 13.VI.1991, light, leg. L. Ronkay & A. Vojnits (1 male, HNHM).

*Remarks.* Distinguished from *P. falcula* by short and fine paraproct, by less developed ventroapical lobe on the coxopodite of the gonopod and by long and straight paramere.

**Family Molannidae Wallengren, 1891**

***Molanna moesta* Banks, 1906**

*Material examined.* **North Korea.** Kangwon Province, Mt. Kumgang-san, side valley near Hotel Kumgang, 13.VI.1991, light, leg. L. Ronkay & A. Vojnits (1 male, HNHM). **South Korea.** Cheju Province, Andok valley, 300 m, 126°22'E 33°15' N, 28.IV.1994, light, leg. L. Peregovits, L. Ronkay & A. Vojnits (3 males, HNHM). North Korea, Pyongyang City, Daesong-san, 31.V. 1985, light leg. A. Vojnits & L. Zombori (1 male, HNHM).

***Molanna submarginalis* McLachlan, 1872**

*Material examined.* **North Korea.** Ryanggang, Chann-Pay plateau, Sam-zi-yan, 1700 m, 27.VIII.1971, netting on lake shore, leg. J. Papp & S. Horvatovich (3 males, HNHM).

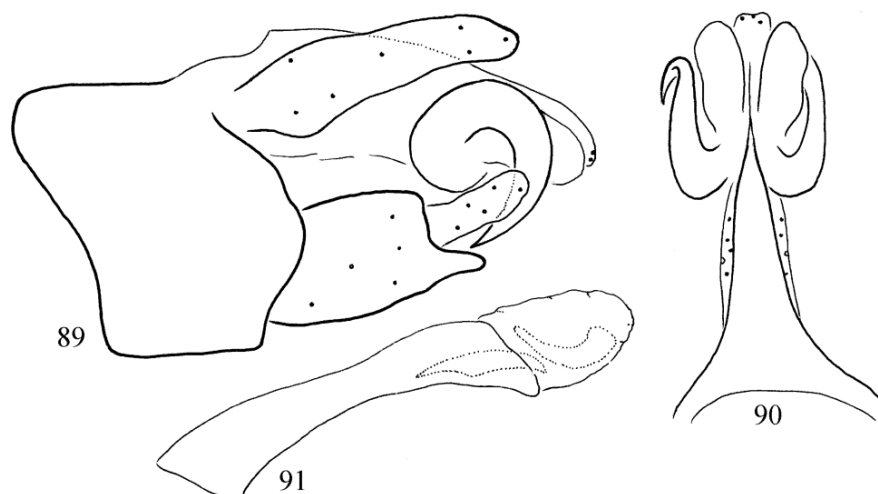
**Superfamily Sericostomatoidea Stephens, 1836**

**Family Sericostomatidae Stephens, 1836**

***Gumaga orientalis* (Martynov, 1935)**

*Material examined.* **North Korea.** North Pyongan Province, Mt. Myohyang-san, 21.V.1985, light, leg. A. Vojnits & L. Zombori (3 males, HNHM). North Korea, North Pyongan Province, Mt. Myohyang-san, 27.V.1991, light in Hyangsan valley near Hwajangam cloister, leg. L. Ronkay & A. Vojnits (4 males, HNHM; 3 males, OPC).

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**Figures 89–91.** *Psilotreta kerka* Oláh, sp. nov. Holotype male: 89 = genitalia in lateral view; 90 = genitalia in dorsal view; 91 = phallic organ in lateral view.

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## Review of the earthworm biodiversity of Turkey and its neighbouring countries (Clitellata, Megadrili)

M. MISIRLIOĞLU<sup>1</sup>, H. VALCHOVSKI<sup>2</sup>, & M. STOJANOVIĆ<sup>3</sup>

<sup>1</sup>*Mete Mısırlıoğlu, Eskişehir Osmangazi University, Faculty of Science and Letters, Department of Biology, 26480 Eskişehir, Turkey. E-mail: metem@ogu.edu.tr*

<sup>2</sup>*Hristo Valchovski, Department of Soil Microbiology, Institute of Soil Science, Agrotechnologies and Plant Protection “N. Poushkarov”, 7 Shosse Bankya Str., 1080 Sofia, Bulgaria.*

<sup>3</sup>*Mirjana Stojanović, University of Kragujevac, Faculty of Science, Institute of Biology and Ecology, Kragujevac, Serbia.*

**Abstract.** This paper presents the combined list of earthworms from Turkey and its neighbouring countries: Syria, Iran, Georgia, Armenia, Azerbaijan, Cyprus, Greece and Bulgaria. Turkey has one of the richest earthworm biodiversities among the Eurasian countries. Its interesting geographic position on the conjunction of three continents (Asia, Europe and Africa) and the close proximity of three different biodiversity hotspots (Caucasus, Mediterranean and Iran-Anatolia) are the primary influence on the large number species as well as the different climatic conditions and major biogeographical barriers in the country. Till now 83 species and subspecies has been recorded and the earthworms of Turkey is characterized by the highest rate of endemism in the region (30 taxa = 36.14%). Taking into account the whole dataset (autochthonous + peregrine species) Turkish earthworms shows strong similarity to the fauna of Georgia (34 taxa = 40.96%) and Greece (32 taxa = 38.55%).

**Keywords.** Biodiversity, earthworms, clitellata, megadrili, fauna of Turkey.

### INTRODUCTION

Turkey is a vast country (783 356 km<sup>2</sup>) composed of two lands located in two different continents. The waterway consisting of Bosphorus, the Sea of Marmara, and the Dardanelles Strait divides the European part (called East Thrace and constitutes 3% of the country) from the Asian one (called Anatolia and constitutes 97% of the country). Besides the three seas – Mediterranean, Aegean and Black Sea – surrounding the country, it has eight bordering neighbour countries: Bulgaria, Greece, Syria, Iraq, Iran, Azerbaijan, Armenia and Georgia (Figure 1).

Seven geographic regions distinguished by different climatic conditions and large barriers such as the Anatolian Diagonal, Taurus and North Anatolian mountains and the waterways mentioned above play an important role in contributing to the various species compositions. In addition to this,

its closeness to three biodiversity hotspots – the Mediterranean, Caucasus and Iran-Anatolia – has a major effect on its rich biodiversity (Mısırlıoğlu 2017a, 2017b, Mısırlıoğlu *et al.* 2017).

Earthworm research in Turkey was started by Rosa at the end of the nineteenth century with the first earthworm record of *Allolobophora syriaca* Rosa, 1893 from Samsun, North Anatolia. After that, only a few studies (Rosa 1905, Pop 1943, Omodeo 1952, 1955, Zicsi 1973, 1981, 1985) which are based on sporadic collections which have been carried out over ninety years.

The research published by Omodeo & Rota (1989, 1991) are the most comprehensive studies on Turkish fauna in the whole of the 20<sup>th</sup> century. They identified several taxa and reported new records for the country in two separate papers (Csuzdi *et al.* 2006, Mısırlıoğlu 2017, Szederjesi & Mısırlıoğlu 2017).



**Figure 1.** The number of earthworm taxa in Turkey and adjacent countries reported in the literature.

Since then Csuzdi *et al.* (2006) combined all Turkish faunistic results in an annotated checklist. It was the most important step to understanding the whole earthworm fauna of Turkey and followed by considerable faunistic research containing new taxa and new records (*e.g.* Csuzdi *et al.* 2007, Szederjesi *et al.* 2014a, Szederjesi & Mısırlıoğlu 2017, Mısırlıoğlu 2018)

As a result of this research, Turkey is the richest country in terms of earthworm taxa in the region. Although there are still large unsampled areas in the country, more than 80 earthworm taxa have been recorded so far and most probably the number will be in the hundreds in the future (Mısırlıoğlu 2017b, Reynolds & Mısırlıoğlu 2018).

The aim of this the paper is to summarise current knowledge on the earthworm fauna of Turkey and its neighbouring countries.

## MATERIAL AND METHODS

The data treated herein comes from the incorporation of all available literature records concerning the distribution of earthworms in Turkey and its neighbouring countries, except for Iraq, for which there is no confident knowledge on species

occurrence. The valid taxa names are given according to the online database of Csuzdi (2012).

The species listed are assigned to the following zoogeographic categories: Peregrine, Atlanto-Mediterranean, Circum-Mediterranean, Trans-Aegean, Moesian, Illyric, Balkanic-Alpine and different groups of endemics (distributed in the Balkans, Anatolia, Caucasus, Caucaso-Anatolian or Levantine-Anatolian or Balkanic-Anatolian areas) (Zicsi 1973, Csuzdi & Zicsi 2003, Csuzdi *et al.* 2006, Kvavadze 1985, Mısırlıoğlu 2017a, 2017b, Perel 1979, 1997, Stojanović *et al.* 2012, Stojanović & Milutinović 2013, Stojanović *et al.* 2013, Trakić *et al.* 2016, Reynolds and Mısırlıoğlu 2018).

Faunistic similarity was computed with PAST 3.2 software package (Hammer *et al.* 2001) using Jaccard index which expresses similarity in the lists of species of two country areas as follows  $C = j / (a + b - j)$  where  $a$  and  $b$  are the number of species in area A and B, respectively, and  $j$  is the common number of species found in both areas. The maximum value (1, 100%) is reached when the species lists are identical for two areas, the minimum value (zero) when the lists are completely different.

## RESULTS

The list of earthworm taxa recorded in Turkey and in neighbouring countries comprises 164 species and subspecies (Appendix 1), of which 153 (in 18 genera) belong to family Lumbricidae, one species belong to Criodrilidae, and ten species are from the families Acanthodrilidae (three species in two genera), Megascolecidae (five species in three genera) and Ocnerodrilidae (two species in two genera).

Presence of some species in Turkey is uncertain, probably due to misidentification. Omodeo & Rota (1989) reported the Alpine species *Aporrectodea smaragdina* (Rosa, 1892) from Turkey without detailed description. However, according to Csuzdi et al. (2006) because of the absence the characteristic green colour of the specimens, they were probably belonging to *Allolobophora brunnecephala* and not the Central-European *Ap. smaragdina*.

On the other hand, Omodeo & Rota (1991) mentioned the presence of species *Allolobophora bellicosa* (Ude, 1922) (synonym *Perelia nematogena*) in Turkey. However, Csuzdi et al. (2006) consider that the short description of this species is also more similar to *Allolobophora brunnecephala*. Other authors (Pavliček et al 2010, Szederjesi 2017b) have accepted this view.

The presence of *Dendrobaena samarigera* in Turkey is mentioned in the papers of Csuzdi et al (2006), Pavliček et al. (2010) and Szederjesi (2017b). However, in Csuzdi et al. (2006) authors express their suspicion in the presence of this species in Turkey due to the incomplete description of the juvenile specimen found in Turkey by Omodeo (1952). Therefore the presence of this species in Turkey requires confirmation (Csuzdi et al 2006; Szederjesi 2017b).

## DISCUSSION

So far, eighty-three taxa have been registered from Turkey, a greater number than for the 7

neighbouring countries (Mısırlioğlu 2017b, 2018, Reynolds & Mısırlioğlu 2018).

The earthworm fauna of Turkey is characterized also by the highest rate of endemism. According to Csuzdi et al. (2006), the country has a distinctive specialized earthworm fauna. The largest number of Turkish endemics belong to the Anatolian endemics (30 taxa) with 13 taxa from the genus *Dendrobaena* and seven taxa from *Healyella* genus.

Out of 31 *Dendrobaena* species and subspecies registered in Turkey, 13 taxa belong to Anatolian endemics, 12 taxa are Caucaso-Anatolian, five are Levantine-Anatolian and one taxon is Balkanic-Anatolian. Therefore, 41.93 % of *Dendrobaena* species and subspecies are endemics for this region of Turkey (Omodeo and Rota 2008, Szederjesi et al. 2014a). Besides, *Dendrobaena orientalis orientalis*, *D. semitica*, *D. haueri*, *D. samarigera*, *Healyella syriaca*, *Perelia galileana* are Levantine-Anatolian species which were registered both in Anatolia and the Levant and indicate the connection between two regions.

Some of the species which belong to the genera *Spermophorodrilus* or *Perelia* could not disperse over the Taurus Mountains. For example, *Perelia galileana* was found in Israel and Hatay Province of Turkey (Csuzdi & Pavliček 2005, Pavliček et al. 2006, Csuzdi et al. 2007, Mısırlioğlu et al. 2008).

The second largest portion of the endemic group belongs to genera *Spermophorodrilus* and *Healyella*. The genus *Healyella* and *Spermophorodrilus* species are almost all endemic to the country. *Healyella* is distributed throughout Anatolia and Middle East. Of the nine *Healyella* species, eight are registered in Turkey, and only two species, *He. syriaca* and *He. jordanis* are recorded outside of Turkey (Pavliček et al. 2003, Mısırlioğlu & Stojanovic 2018). Only *He. syriaca*, occupies a broader area, (Anatolia, Iran, Syria, Lebanon and Israel). Eight *Healyella* species are registered in the central part of Northern Anatolia which represents the distri-

bution centre of the genus (Omodeo & Rota 1999). Caucaso-Anatolian endemic Turkish earthworms are distributed mainly in the North-Eastern region of the country (Csuzdi *et al.* 2006). Besides, five *Dendrobaena* endemics show clear Levantine connection: *D. orientalis*, *D. hauseri*, *D. samarigera* (if present), *D. semitica* and *D. szalokii* (Appendix 1).

There are several endemic groups that are present in a large area of Turkey and neighbouring countries. The greatest number is the Anatolian endemics which represent 28.30% (30 taxa) of the total endemic lumbricid species. Then follow Balkanic endemics (29 taxa = 27.35%), Caucasian endemics (23 taxa = 21.69%), Caucaso-Anatolian (9 taxa = 8.49%), Levantine-Anatolian (7 taxa = 6.6%), Iranian endemics (3 taxa = 2.83%), Levantine and Balkanic-Anatolian with two taxa each (1.88%) and one Cypriot endemic.

The zoogeographical composition of the earthworm fauna in the whole study area appears as follows: Endemics (106 taxa = 64.63%), Peregrine (29 taxa = 17.68%), Trans-Aegean (7 taxa = 4.26%), Central-European (5 taxa = 3.04%), and Circum-Mediterranean (4 taxa = 2.43%), three taxa for each of Balkanic-Alpine and Caucasian-East-Mediterranean, two taxa for Atlanto-Mediterranean and one taxon for each of Moesian, Illyric and Alpine-East-Mediterranean.

The Caucasus is the center of relatively young genera such as *Allolobophora*, *Eisenia*, *Eiseniella*, *Helodrilus* and *Dendrobaena*. The connection between Transcaucasia and Turkey has been important for speciation especially for the genus *Dendrobaena*. *Dendrobaena alpina armeniaca*, *D. attemsi decipiens*, *D. kurashvilii*, *D. montana*, *D. pentheri*, *D. resslis*, *D. schmidti marinae*, *D. schmidti tellermanica*, *Di. grandis grandis*, *Di. hydrophilicus*, *Di. polysegmenticus* and *Allolobophora brunnecephala* are Caucaso-Anatolian species.

The list of earthworms from Bulgaria represents 49 confirmed species and subspecies. Unfor-

tunately, the fauna of Bulgaria is still incompletely known despite the efforts of the recent investigations (Zicsi & Cszudi 1986, Valchovski & Szederjesi 2016, Valchovski & Mısırlioğlu 2017b, Valchovski 2017), but it appears highly peregrine. Of the 49 species, 17 (34.69%) belong to peregrines. Endemic species follow with 14 taxa = 28.57% (Balkan and large endemics 10 taxa = 20.40%, Bulgarian endemics 4 taxa = 8.16%). Next are the Trans-Aegean (6 taxa = 12.24%), Central European (5 taxa = 10.20%) and Balkanic-Alpine (3 taxa = 6.12%). Mediterranean (3 taxa = 6.12%) and Moesian (1 taxon = 2.04%) are less numerous. Except for the peregrine worms, 9 taxa are registered both in Turkey and Bulgaria. *Allolobophora leoni*, *Aporrectodea dubiosa*, *Aporrectodea handlirschi*, *Aporrectodea jassyensis*, *Dendrobaena attemsi*, *Octodrilus transpadanus* and *Proctodrilus tuberculatus* are Trans-Aegean, while *Murchieona minuscula*, *Octodrilus complanatus* and *Dendrobaena byblica* are Circum-Mediterranean.

Of the 66 earthworm taxa recorded from Greece 57 belong to the family Lumbricidae, one to the Criodrilidae, four to the Megascolecidae, two to the Acanthodrilidae and two to the Ocnodrilidae. Nine species within the family Lumbricidae are strict endemics and 18 taxa are recorded both in Turkey and Greece: 5 Trans-Aegean, 4 Circum-Mediterranean, 3 Caucasus-East Mediterranean, 2 Balkan-Anatolian species, 2 Balkan-Anatolian, one Balkanic-Alpine-East Mediterranean, and one Alpin-East Mediterranean (Szederjesi 2017a, 2017b, Szederjesi *et al.* 2017).

Twenty-one earthworm species (19 lumbricid and two acanthodrilid species) are known from Cyprus so far (Szederjesi 2017a); 11 of them are autochthonous: one Circum-Mediterranean (*Dendrobaena byblica*), one Alpine-East-Mediterranean (*Dendrobaena pantaleonis*), one Levantine (*Dendrobaena semitica*), one Trans-Aegean (*Proctodrilus tuberculatus*), two Caucasian-East Mediterranean (*Helodrilus patriarchalis*, *Dendrobaena pentheri*), and three Circum-Mediterra-

nean (*Eiseniella neapolitana*, *Murchieona minuscula*, *Octodrilus complanatus*) are distributed in Turkey and Cyprus. Among them only *Dendrobaena penteri* shows Anatolian affinity being distributed in the Caucasus region, Anatolia and Cyprus (Szederjesi *et al.* 2016, Szederjesi 2017b).

According to Szederjesi (2017a), the earthworm fauna of Crete comprises 20 species. Out of them nearly 45% are peregrine and nearly 14% are Circum-Mediterranean and only two are Balkanic endemics (*D. byblica olympiaca*, *E. ebneri*). Turkey and Crete have seven species registered on the territory of both lands and none of them are peregrine. Among these species, there are three from Circum-Mediterranean and one each for the Atlanto-Mediterranean, Alpine-East Mediterranean and Caucasian-East Mediterranean and Trans-Aegean categories.

Of the 28 taxa of Iranian earthworms, 24 belong to the family Lumbricidae, three to Acanthodrilidae and one to Megascolecidae. Nine of the lumbricid taxa are endemic (Szederjesi *et al.* 2014b, Latif *et al.* 2016).

Iranian earthworms have more zoogeographic affinities with the Levantine than with the Anatolian fauna; in fact only seven taxa (apart from peregrines) are recorded both in Iran and Turkey: *Aporrectodea jassyensis*, *Dendrobaena byblica*, *D. orientalis*, *D. penteri*, *D. semitica*, *Healyella syriaca*, *Helodrilus patriarchalis*. However, there are large unsampled areas in both countries and high similarity of earthworms between northern Iran, Eastern Turkey and Transcaucasus were observed by Mısırlioğlu *et al.* (2008).

Of the 58 species and subspecies of Georgian earthworms, 54 belong to the Lumbricidae, one to Criodrilidae, two to Acanthodrilidae and one to Megascolecidae (Bakhtadze *et al.* 2003, 2008, Kvavadze 1985, Kvavadze *et al.* 2007). 23 taxa (39.65%) are strict Georgian endemics belonging to the family Lumbricidae, while 18 taxa are peregrine (31.03%). There are seven (12.06%) Trans-Aegean and ten (17.24%) Caucaso-Anatolian and three Caucasian-East-Mediterranean

species. Of the 18 species and subspecies distributed both in Georgia and Turkey the majority belongs to Caucaso-Anatolian, Trans-Aegean, Circum-Mediterranean and Caucasian-East-Mediterranean categories. Caucaso-Anatolian endemics are one of the most important groups. Those are: *Dendrobaena attemsi decipiens*, *D. kurashvili*, *D. schmidtii marinae*, *D. schmidtii tellermanica*, *Dendrodriloides grandis grandis*, *Dendrodriloides hydrophilicus* and *Dendrodriloides polysegmenticus*. All of them belong to genera *Dendrobaena* and *Dendrodriloides* that make this region one of the most important centres of endemism of these genera (Omodeo & Rota 1999, Csuzdi *et al.* 2006). The Caucaso-Anatolian species are distributed particularly in the North-Eastern region of Turkey.

Unfortunately, there is only sporadic data for Armenia and Azerbaijan (Szederjesi 2017b). 11 autochthonous taxa are registered both in Armenia and Turkey and the most important group is formed by Caucaso-Anatolian species (*Allolobophora brunnecephala*, *Dendrobaena alpina armeniaca*, *D. kurashvili*, *D. montana*, *D. schmidtii tellermanica*, *Dendrodriloides grandis grandis*). Two species are Trans-Aegean and Caucasian-East-Mediterranean and one Levantine endemic. A similar situation occurs between Azerbaijan and Turkey with only nine autochthonous shared taxa with four Caucaso-Anatolian species (*Allolobophora brunnecephala*, *Dendrobaena alpina armeniaca*, *D. schmidtii tellermanica*, *Dendrodriloides grandis grandis*) two Trans-Aegean and Caucasian-East-Mediterranean and one Levantine endemic.

Based on sporadic investigations in Syria (Kvavadze 1985, Omodeo & Rota 1989, Pavlíček *et al.* 2003), there exists 14 taxa with only two species, *Dendrobaena semitica* and *Healyella syriaca*, distributed both on the territory of Syria and Turkey.

Unfortunately, there are no confident earthworm records from Iraq. It is expected that the Upper Mesopotamia and the eastern part of Turkey could show similarities with the earthworm fauna of Iraq especially in its Northern part.

It is interesting that in the neighbouring Trans-Caucasian area, there is a noticeable high proportion of earthworm endemics: in Georgia (46.56%), Azerbaijan (41.37%) and Armenia (45.16%).

The earthworm fauna of Turkey including Peregrines has high percentage similarities with the faunas of Greece (32 taxa = 38.55%) and Georgia (34 taxa = 40.96%). Then follow Bulgaria (22 taxa=26.50%), Armenia (21 taxa = 25.30%), Azerbaijan (20 taxa = 24.09%), Iran (19 taxa = 22.89%), Cyprus (17 taxa = 20.48%), Crete (15 taxa = 18.07%), and Syria (12 taxa = 14.45%).

Conversely, our data shows the degree of endemism for Turkey and its neighbouring countries as extremely high, exceeding 64.63%. Summing up the endemics, the Trans-Anatolian and Mediterranean taxa, 73.17% of the total lumbricid fauna of this complex area shows strong autochthonous character.

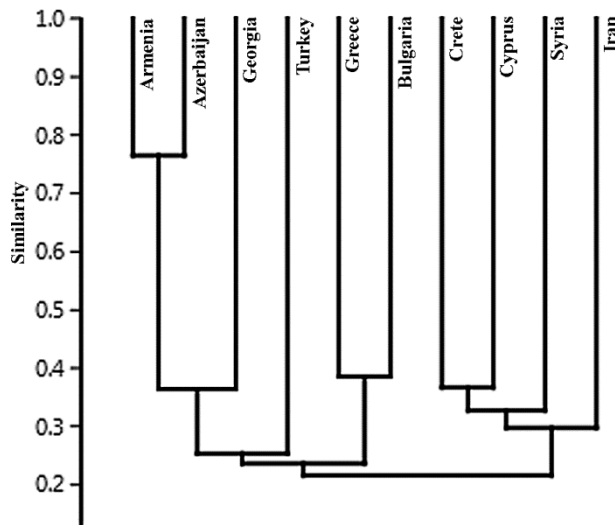
Jaccard index indicates a higher overall earthworm similarity between the area of Turkey and the area of Georgia ( $C_j = 31.78\%$ ) and Greece ( $C_j = 27.35\%$ ), than between Turkey and the rest neighbouring countries (Table 1.). However, it

should be taken into account that the values of Jaccard index (and all the above comparisons) are influenced by the differences in the level of knowledge on earthworm diversity in the compared areas and by the differences in the size of the compared areas.

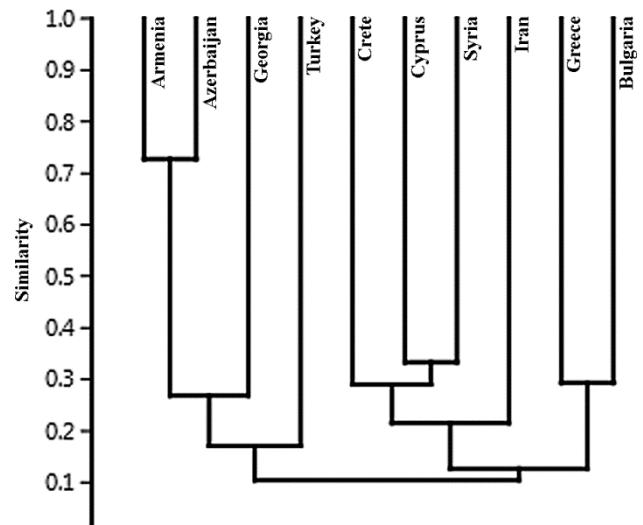
If we take into account only the autochthonous species the highest similarities can be found among Turkey and Georgia ( $C_j = 22.35\%$ ), Greece ( $C_j = 16.3$ ) and Armenia ( $C_j = 15.07\%$ ) which highlights the two main regions showing strong influence on the Anatolian earthworm fauna; the Balkan and the Caucasian region. However, the UPGMA dendrograms generated using Jaccard similarity on the full and the autochthonous datasets (Figs. 2–3) unanimously place Turkey into the cluster composed of the Caucasian countries. The other main clusters consist of Bulgaria together with Greece and an other Iran, Syria and the Mediterranean Islands. It is worth noting that using the autochthonous dataset Syria and Cyprus form a sister-clade with high similarity ( $C_j = 33.33\%$ ); this recalls the theory of Pavlíček & Csuzdi (2008) that the Cypriote earthworm fauna has originated through immigration from the Levantine coast in the Messinian period.

**Table 2.** Jaccard similarity coefficients ( $C_j$ ) comparing Turkey and neighbouring countries (using the whole dataset and peregrines removed).

	$C_j$ (%) for total taxa	$C_j$ (%) for autochthonous taxa
Bulgaria	20	11.63
Greece mainland	27.35	16.30
Cyprus	19.54	11.76
Crete	17.05	7.27
Iran	20.65	10.29
Georgia	31.78	22.35
Syria	14.12	9.09
Armenia	22.58	15.07
Azerbaijan	21.74	13.89



**Figure 2.** Faunistic similarity of Turkey and the neighbouring countries using Jaccard index and UPGMA clustering on the whole dataset.



**Figure 3.** Faunistic similarity of Turkey and the neighbouring countries using Jaccard index and UPGMA clustering on the autochthonous dataset.

Our knowledge about the diversity and distribution of earthworms in Turkey and its neighbouring countries is far from complete; due to the fact that we still have limited data concerning the East and South-East parts of Turkey and some eastern neighbours of Turkey. Thus to compare the faunistic data with these countries is almost impossible. It is reasonable that the eastern part of Turkey will include a large number of endemic species in addition to Oriental and Levantine species. To fill this gap in our knowledge on the earthworm fauna of the studied region more detailed investigations are needed which will result in finding many more new earthworm species in this area.

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**Appendix 1. Earthworms of Turkey and its Neighbouring Countries.**

Species	Turkey	Greece mainland	Bulgaria	Crete	Cyprus	Syria	Iran	Armenia	Azerbaijan	Georgia	Distribution type
<b>Family: LUMBRICIDAE Rafinesque-Schmaltz, 1815</b>											
<i>Allolobophora bulgarica</i> Černosvitov, 1934			*								Balkan endemicism
<i>Allolobophora s.l. brunnecephala</i> Kavadze, 1985	*							*	*		Caucaso-Anatolian
<i>Allolobophora chlorotica</i> (Savigny, 1826)	*	*	*	*					*	*	Peregrine
<i>Allolobophora dofleini</i> (Ude, 1922)		*									Balkan endemicism
<i>Allolobophora immaculata</i> Omodeo & Rota, 1989	*										Anatolian endemicism
<i>Allolobophora kosowensis</i> Karaman, 1968		*									Balkan endemicism
<i>Allolobophora kintrishiana</i> Kavadze 1987										*	Caucasian endemicism
<i>Allolobophora leoni</i> Michaelsen, 1891	*		*							*	Trans-Aegean
<i>Allolobophora mehadiensis</i> (Rosa, 1895)			*								Balkan endemicism
<i>Allolobophora robusta robusta</i> (Rosa, 1895)			*								Balkan endemicism
<i>Allolobophora tuleshkovi</i> (Černosvitov, 1934)			*								Balkan endemicism
<i>Aporrectodea caliginosa caliginosa</i> (Savigny, 1826)	*	*	*	*	*	*	*	*	-	*	Peregrine
<i>Aporrectodea caliginosa trapezoides</i> (Dugès, 1828)	*	*	*	*	*	*	*	*	*	*	Peregrine
<i>Aporrectodea dubiosa</i> (Örley, 1881)	*		*							*	Trans-Aegean
<i>Aporrectodea georgii</i> (Michaelsen, 1890)		*	*	*		*					Atlanto-Mediterranean
<i>Aporrectodea handlirschi</i> (Rosa, 1897)	*	*	*							*	Trans-Aegean
<i>Aporrectodea handlirschi mahnerti</i> (Zicsi, 1973)	*										Anatolian endemicism
<i>Aporrectodea jassyensis</i> (Michaelsen, 1891)	*	*	*	*			*	*	*	*	Trans-Aegean
<i>Aporrectodea longa</i> (Ude, 1885)		*	*				*				Peregrine
<i>Aporrectodea rosea</i> (Savigny, 1826)	*	*	*	*	*		*	*	*	*	Peregrine
<i>Bimastos eiseni</i> (Levinsen, 1884)		*	*				*				Peregrine
<i>Bimastos parvus</i> (Eisen 1874)							*				Peregrine
<i>Bimastos rubidus</i> (Savigny, 1826)	*	*	*		*		*	*	*	*	Peregrine
<i>Cernosvitovia biserialis</i> (Černosvitov, 1937)			*								Balkan endemicism
<i>Cernosvitovia dobrogeana</i> (Pop, 1938)			*								Balkan endemicism
<i>Cernosvitovia muntieniana</i> Zicsi & Pop, 1991			*								Balkan endemicism
<i>Cernosvitovia rebeli</i> (Rosa, 1897)		*	*								Moesian
<i>Cernosvitovia schweigeri</i> (Zicsi, 1973)	*										Anatolian endemicism
<i>Dendrobaena alpina alpina</i> (Rosa, 1884)		*	*	*				*	*	*	?Balkan-Alpine

<i>Dendrobaena alpina armeniaca</i> (Rosa, 1893)	*							*	*		Caucaso-Anatolian
<i>Dendrobaena alpina diplotritheca</i> Kavadze, 1972										*	Caucasian endemism
<i>Dendrobaena attemsi attemsi</i> (Michaelsen, 1902)	*	*	*					*	*	*	Trans-Aegean
<i>Dendrobaena attemsi decipiens</i> (Michaelsen, 1910)	*									*	Caucaso-Anatolian
<i>Dendrobaena balcanica</i> (Černosvitov, 1937)		*	*								Balkan endemism
<i>Dendrobaena bokakotorensis</i> Šapkarev, 1975		*									Balkan endemism
<i>Dendrobaena bruna</i> Omodeo & Rota, 1989	*										Anatolian endemism
<i>Dendrobaena byblica byblica</i> (Rosa, 1893)	*	*	*	*	*	*	*			*	Circum-Mediterranean
<i>Dendrobaena byblica arsiatica</i> Kavadze 1985										*	Caucasian endemism
<i>Dendrobaena byblica olympiaca</i> (Michaelsen, 1902)		*		*							Balkan endemism
<i>Dendrobaena cevdeti</i> Szederjesi, Pavlicek, Coşkun & Csuzdi, 2014	*										Anatolian endemism
<i>Dendrobaena cognettii</i> (Michaelsen, 1903)	*	*									Atlanto-Mediterranean
<i>Dendrobaena epirotica</i> Zicsi & Michalis, 1993		*									Balkan endemism
<i>Dendrobaena faucium</i> (Michaelsen, 1910)										*	Caucasian endemism
<i>Dendrobaena fridericae fridericae</i> Omodeo & Rota, 1989	*										Anatolian endemism
<i>Dendrobaena fridericae uludagi</i> Omodeo & Rota, 1991	*										Anatolian endemism
<i>Dendrobaena jaloniensis</i> Kavadze, 1985										*	Caucasian endemism
<i>Dendrobaena hauseri</i> Zicsi, 1973	*										Levant-Anatolian
<i>Dendrobaena hortensis</i> (Michaelsen, 1890)	*	*	*	*			*	*	*	*	Peregrine
<i>Dendrobaena hrabei</i> (Černosvitov, 1934)		*	*								Balkan endemism
<i>Dendrobaena imeretiana</i> Kavadze, 1992										*	Caucasian endemism
<i>Dendrobaena kelassuriensis</i> Kavadze, 1985										*	Caucasian endemism
<i>Dendrobaena kervillei</i> (Michaelsen, 1910)						*					Levantine endemism
<i>Dendrobaena kurashvili</i> Kavadze 1971	*							*		*	Caucaso-Anatolian
<i>Dendrobaena loebli</i> (Zicsi, 1985)	*	*									Balkan-Anatolian
<i>Dendrobaena mahnerti</i> Zicsi, 1974		*									Balkan endemism
<i>Dendrobaena mahunkai</i> Csuzdi, Pavlíček & Mısırhoğlu 2007	*										Anatolian endemism
<i>Dendrobaena mamişsonica</i> Kavadze, 1984										*	Caucasian endemism
<i>Dendrobaena michalisi</i> Karaman, 1972		*									Balkan endemism
<i>Dendrobaena montana</i> (Michaelsen, 1910)	*							*			Caucaso-Anatolian
<i>Dendrobaena nassonovi adjarica</i> Kavadze 1973										*	Caucasian endemism
<i>Dendrobaena nassonovi nassonovi</i> Kulagin, 1889										*	Caucasian endemism
<i>Dendrobaena nivalis</i> Omodeo & Rota 1989	*										Anatolian endemism

<i>Dendrobaena octaedra</i> (Savigny, 1826)		*	*				*			*	Peregrine
<i>Dendrobaena olympica</i> (Černosvitov, 1938)		*									Balkan endemicism
<i>Dendrobaena omodeoi</i> Csuzdi, Pavliček & Mısırlioğlu, 2007	*										Anatolian endemicism
<i>Dendrobaena orientalis orientalis</i> Černosvitov, 1940	*						*	*	*		Levant-Anatolian
<i>Dendrobaena orientalioides</i> Zicsi, 1985	*										Anatolian endemicism
<i>Dendrobaena pantaleonis</i> (Chinaglia, 1913)		*		*	*						Alpine -East-Mediterranean
<i>Dendrobaena pantaleonis eutypica</i> Omodeo & Rota, 1989	*										Anatolian endemicism
<i>Dendrobaena parabyblica</i> Perel, 1972								*			Levantine endemicism
<i>Dendrobaena pentheri</i> (Rosa, 1905)	*	*			*		*	*	*	*	Caucasian-East-Mediterranean
<i>Dendrobaena persimilis</i> Omodeo & Rota, 1989	*										Anatolian endemicism
<i>Dendrobaena perula</i> Omodeo & Rota, 1989	*										Anatolian endemicism
<i>Dendrobaena pindonensis</i> Zicsi & Michalis, 1993		*									Balkan endemicism
<i>Dendrobaena platyura depressa</i> (Fitzinger, 1833)				*							Central European
<i>Dendrobaena proandra</i> Omodeo & Rota, 1989	*										Anatolian endemicism
<i>Dendrobaena resslii</i> Zicsi, 1973	*										Anatolian endemicism
<i>Dendrobaena retrosella</i> Szederjesi & Csuzdi, 2012		*									Balkan endemicism
<i>Dendrobaena rhodopensis</i> (Černosvitov, 1937)		*	*								Balkan endemicism
<i>Dendrobaena samarigera</i> (Rosa, 1893)	?*										? Levant-Anatolian
<i>Dendrobaena schmidti marinae</i> Kavadze, 1985	*									*	Caucaso-Anatolian
<i>Dendrobaena schmidti surbiensis</i> (Michaelsen 1910)								*	*	*	Caucasian endemicism
<i>Dendrobaena schmidti tellermanica</i> Perel, 1966	*							*	*	*	Caucaso-Anatolian
<i>Dendrobaena semitica</i> (Rosa, 1893)	*				*	*	*				Levant-Anatolian
<i>Dendrobaena swanetiana</i> Kavadze, 1992										*	Caucasian endemicism
<i>Dendrobaena szalokii</i> Szederjesi, Pavlicek, Coşkun & Csuzdi, 2014	*										Levant-Anatolian
<i>Dendrobaena veneta</i> (Rosa, 1884)	*	*	*	*	*	*	*	*	*	*	Peregrine
<i>Dendrobaena verihemiandra</i> Kavadze, 1989										*	Caucasian endemicism
<i>Dendrodriloides ganjiensis</i> (Kavadze 1985)								*	*		Caucasian endemicism
<i>Dendrodriloides grandis grandis</i> (Michaelsen, 1907)	*							*	*	‡	Caucaso-Anatolian
<i>Dendrodriloides grandis perelae</i> (Kavadze 1973)								*		*	Caucasian endemicism
<i>Dendrodriloides hydrophilicus</i> (Kavadze, 1979)	*									*	Caucaso-Anatolian
<i>Dendrodriloides polysegmenticus</i> (Kavadze, 1973)	*									*	Caucaso-Anatolian
<i>Dendrodriloides supsaensis</i> (Kavadze 1985)										*	Caucasian endemicism

<i>Eisenia andrei</i> Bouché, 1972			*					*	*	*	Peregrine
<i>Eisenia ariadne</i> (Michaelsen, 1928)		*									Balkan endemicism
<i>Eisenia colchidica</i> (Perel, 1967)	*	*								*	Caucasian-East-Mediterranean
<i>Eisenia ebneri</i> (Michaelsen, 1914)		*		*							Balkan endemicism
<i>Eisenia fetida</i> (Savigny, 1826)	*	*	*	*	*		*	*	*	*	Peregrine
<i>Eisenia iverica</i> (Kvavadze, 1973)										*	Caucasian endemicism
<i>Eisenia kafaniensis</i> Kvavadze 1985								*	*	*	Caucasian endemicism
<i>Eisenia kattoulasi</i> Zicsi & Michalis, 1981	*	*									Balkan-Anatolian
<i>Eisenia kotschani</i> Szederjesi, Pavliček & Csuzdi 2014	*										Anatolian endemicism
<i>Eisenia lagodechiensis</i> (Michaelsen, 1910)								*	*	*	Caucasian endemicism
<i>Eisenia lucens</i> (Waga, 1857)			*								Central European
<i>Eisenia malekiae</i> Szederjesi, Latif & Csuzdi, 2014							*				Iranian endemicism
<i>Eisenia muganiensis</i> (Michaelsen, 1910)								*	*		Caucasian endemicism
<i>Eisenia omranii</i> Latif, Malek & Csuzdi, 2017							*				Iranian endemicism
<i>Eisenia oreophila</i> Szederjesi & Csuzdi, 2012		*									Balkan endemicism
<i>Eisenia patriciae</i> Szederjesi, Pavliček, Coşkun & Csuzdi, 2014	*										Anatolian endemicism
<i>Eisenia storkani</i> Černosvitov, 1934			*								Balkan endemicism
<i>Eisenia thamarae</i> Kvavadze and Nikolasvili 1983								*	*	*	Caucasian endemicism
<i>Eiseniella neapolitana</i> (Örley, 1885)	*	*			*	*					Circum-Mediterranean
<i>Eiseniella tetraedra</i> (Savigny, 1826)	*	*	*	*	*	*	*	*	*	*	Peregrine
<i>Healyella baloghi</i> (Zicsi, 1981)	*										Anatolian endemicism
<i>Healyella boluana</i> Omodeo & Rota, 1989	*										Anatolian endemicism
<i>Healyella mariae</i> Omodeo & Rota, 1989	*										Anatolian endemicism
<i>Healyella michaelseni</i> Omodeo & Rota, 1989	*										Anatolian endemicism
<i>Healyella naja</i> Omodeo & Rota, 1989	*										Anatolian endemicism
<i>Healyella schweigeri</i> (Zicsi, 1981)	*										Anatolian endemicism
<i>Healyella syriaca</i> (Rosa, 1893)	*					*	*				Levant-Anatolian
<i>Healyella zapparolii</i> Omodeo & Rota, 1989	*										Anatolian endemicism
<i>Helodrilus balcanicus balcanicus</i> (Černosvitov, 1931)		*									Balkan endemicism

<i>Helodrilus cernosvitovianus</i> (Zicsi, 1967)		*									Uncleared type
<i>Helodrilus duhlinkae</i> Zicsi & Csuzdi, 1986			*								Balkan endemicism
<i>Helodrilus oculatus</i> (Hoffmeister, 1845)									*		Caucasian endemicism
<i>Helodrilus patriarchalis</i> (Rosa, 1893)	*	*		*	*	*	*	*	*	*	Caucasian-East Mediterranean
<i>Helodrilus vagneri</i> Mršić, 1991		*									Balkan endemicism
<i>Lumbricus meliboeus</i> Rosa, 1884			*								Balkan-Alpine
<i>Lumbricus polyphemus</i> (Fitzinger, 1833)			*								Central European
<i>Lumbricus rubellus</i> Hoffmeister, 1843	*	*	*	*				*	*	*	Peregrine
<i>Lumbricus terrestris</i> Linnaeus, 1758			*							*	Peregrine
<i>Murchieona minuscula</i> (Rosa, 1896)	*	*	*	*	*						Circum-Mediterranean
<i>Octodrilus complanatus</i> (Dugés, 1828)	*	*	*	*	*	*				*	Circum-Mediterranean
<i>Octodrilus croaticus</i> (Rosa, 1895)		*									Illyric
<i>Octodrilus transpadanus</i> (Rosa, 1884)	*	*	*						*	*	Trans-Aegean
<i>Octolasion cyaneum</i> (Savigny, 1826)	*				*						Peregrine
<i>Octolasion lacteum</i> (Örley, 1881)	*	*	*			*	*	*	*	*	Peregrine
<i>Perelia galileana</i> Csuzdi & Pavlíček, 2005	*										Levant-Anatolian
<i>Perelia hatayica</i> Csuzdi, Pavlíček & Mısırlıoğlu, 2007	*										Anatolian endemicism
<i>Perelia kaznakovi</i> (Michaelsen, 1910)							*		*		Caucasian endemicism
<i>Perelia makrisi</i> Szederjesi, Pavlicek & Csuzdi, 2017					*						Cypriot endemicism
<i>Perelia nematogena</i> (Rosa 1903)					*						Balkan-Alpine
<i>Perelia persiana</i> (Michaelsen, 1900)							*				Iranian endemicism
<i>Perelia phoebea</i> (Cognetti, 1913)		*			*						Balkan endemicism
<i>Proctodrilus antipai</i> (Michaelsen, 1891)		*	*								Central-European
<i>Proctodrilus opisthoductus</i> Zicsi, 1985		*	*								Central-European
<i>Proctodrilus tuberculatus</i> (Černosvitov, 1935)	*	*	*		*					*	Trans-Aegean
<i>Spermophorodrilus antiquus</i> (Černosvitov, 1938)		*	*								Balkan endemicism
<i>Spermophorodrilus simsoni</i> Omodeo & Rota, 1989	*										Anatolian endemicism
<i>Spermophorodrilus vignai</i> Omodeo & Rota, 1989	*										Anatolian endemicism
<i>Trapezonscolex cavazzutii cavazzutii</i> Omodeo, 1988	*										Anatolian endemicism
<i>Trapezonscolex cavazzutii pascuorum</i> Omodeo, 1988	*										Anatolian endemicism
<b>Family: ACANTHODRILIDAE Claus, 1880</b>											
<i>Dichogaster bolau</i> (Michaelsen, 1891)							*				Peregrine
<i>Microscolex dubius</i> (Fletcher, 1887)	*	*		*			*			*	Peregrine
<i>Microscolex phosphoreus</i> (Duges, 1837)	*	*			*		*			*	Peregrine

<b>Family: CRIODRILIDAE</b> Vejdovsky, 1884											
<i>Criodrilus lacuum</i> Hoffmeister, 1845	*	*	*			*				*	Peregrine
<b>Family: MEGASCOLECIDAE</b> Rosa, 1891											
<i>Amyntas corticis</i> (Kinberg, 1867)	*	*					*			*	Peregrine
<i>Amyntas gracilis</i> (Kinberg, 1867)	*	*									Peregrine
<i>Amyntas morrisi</i> (Beddard, 1892)	*										Peregrine
<i>Metaphire californica</i> (Kinberg, 1867)	*	*									Peregrine
<i>Pontodrilus litoralis</i> (Grube, 1855)		*									Peregrine
<b>Family: OCNERODRILIDAE</b> Beddard, 1891											
<i>Eukerria saltensis</i> (Beddard, 1895)		*									Peregrine
<i>Ocnerodrilus occidentalis</i> Eisen, 1878		*									Peregrine
<b>Total Species Number</b>	<b>83</b>	<b>66</b>	<b>49</b>	<b>20</b>	<b>21</b>	<b>14</b>	<b>28</b>	<b>31</b>	<b>29</b>	<b>58</b>	

**Remarks.** *Allolobophora carpathica* Cognetti, 1927 was registered in Bulgaria by Mihailova (1964), but it is a doubtful record for the country. Besides, we did not regard *B. rubidus subrubicundus* as a separate taxon.



## Splitting by adaptive traits in the *Rhyacophila obscura* species group (Trichoptera, Rhyacophilidae)

J. OLÁH<sup>1\*</sup> and O. KISS<sup>2</sup>

<sup>1</sup>János Oláh, Residence postal address: Tarján u. 28, H-4032 Debrecen, Hungary. E-mail: profolah@gmail.com

\*Corresponding author

<sup>2</sup>Ottó Kiss, Residence postal address: Bajcsy Zs. 4, H-3014 Hort, Hungary.

**Abstract.** The discovery of two new sibling species of the *Rhyacophila obscura* species group in the same population from the Fan-Si-Pan Mts. of Vietnam and the detected shape divergences of paraprocts with speciation trait function of reproductive barrier building initiated the survey of the entire species group. Character tree discordances inside the species tree motivated and justified us to survey briefly some aspects of splitting theory and practice. At all levels of taxonomic hierarchy there are genealogical discordances. Every homologous phenomic trait or nucleotide position may have their own true tree-like history. How taxonomists try to create nominal kinds most corresponding to the natural kinds along the iterative fractal splitting. Fractal is the nature's geometry and organises itself by the negentropy of integration and reticulation against the entropy of disintegration. Splitting along fractals and reticulation produces independent adaptive or neutral genealogically discordant trees; therefore, the reality of phylogenetic trees is highly questioned. Pheneticists work with large set of unweighted characters and without real hermeneutic analysis. Applying large number of unweighted adult, larval or molecular characters of independent tree histories and without hermeneutics we kill the reality of splitting. In the genealogy of *Rhyacophila obscura* species group we have applied weighted characters in lineage splitting by the hermeneutics of adaptive/neutral, commonality/generalizability, distribution/area and complexity/simplicity principles. *Rhyacophila obscura*, the ancestral species of the species group has (1) the most robust/complex adaptive epiproct and paraproct, the traits liable to adaptive divergences in reproductive isolation; (2) the most common/general distribution of the adaptive ancestral epiproct in the complex; (3) and the largest distributional area. This ancestral species was diverged to *R. bidens*, to the ancestor of the complex splitted by the reduction of epiproct to a small bilobed structure. The ancestral complex of *R. obscura* and the first splitted complex of *R. bidens* have been further splitted both by contemporary adaptive paraproct reduction and by neutral stochastic shape divergences of segment X and harpagones. During these splitting practices four new species were described: *R. assamensis* sp. nov., *R. atlagos* sp. nov., *R. kurta* sp. nov., *R. sudar* sp. nov.

**Keywords.** Trait tree, species tree, splitting principles, new species.

### INTRODUCTION

Marbled-winged and medium-sized *Rhyacophila* species was collected (population sample of 53 males, 21 females) by Canadian zoologists in the Fan-Si-Pan Mountains of Vietnam, deposited in the Royal Ontario Museum (ROM) and identified as *Rhyacophila bidens* Kimmins (Armitage & Arefina 2003), a widely distributed ancestral taxon of the small *Rhyacophila obscura* species group. Initially, we studied two other male specimens with similar habitus collected by Hungarian zoologists from nearby habitats in the Fan-Si-Pan Mountains of Vietnam and deposited in HHNM. Surprisingly the fine

phenomics of the two specimens was different: we have detected remarkable divergences in the fine structures of their paraprocts. Borrowing and examining with fine phenomics the paraproct structure of 44 specimens from ROM, identified as *R. bidens*, revealed that these specimens represent the same two undescribed species with similarly subtly, but stably diverged paraprocts. The possibility that the detected shape divergences of paraprocts may function as a speciation trait of reproductive barrier building has initiated this study. We planned to examine the shape divergences of paraprocts by focus on fine phenomics, as the initial split criteria for species delimitation in this species group. We put to-

gether, collected or loaned, all the available specimens, including type materials, of the entire species group scattered in various collections.

### Splitting theory and practice

In general the detection of shape divergences in speciation traits requires the application of both the principles and practices of fine phenomics. Its arsenal and essence are not limited just to higher magnification. Most important is that focused due attention must be directed to traits of reproductive structures with subtle and stable divergences. It routinely includes and requires careful empirical practice and hermeneutics on (1) character selection; (2) character analysis; (3) character ranking; (4) screening possible supertraits involved in reproductive isolation; (5) fine cleaning and clearing of genitalia; (6) adequate microscopic resolution; (7) comparative and proper selection of the examination view for trait presentation and drawing; (8) variability range detection for adaptive/neutral distinction. By proper application and further development of fine phenomic there exists a real potential to detect stable shape divergences in the early reproductive barrier building enabling us to delineate incipient sibling phylogenetic species by the initial splitting criteria. This is confirmed here by delineating incipient species by speciation trait of paraprot in the *Rhyacophila obscura* species group. Young species delimited either by virtual neutral sequences or by empirical speciation traits are exposed to traditional debates between splitters of differences and lumpers of similarities. However, not the taxonomists, but the universe itself splits the entities of nature in an iterative fractal mode by integrative organisation (Oláh *et al.* 2018). Taxonomists try establishing nominal kinds, the taxa most corresponding to the natural kinds of this fractal splitting.

*Splitting along fractals.* Anything is fractal if the new outgrowths are proliferating by iteration principle like river networks, plant trees, phylogenetic trees or human vascular system (Oláh *et al.* 2017). Fractal splitting, being iterative, contains and reflects its own semantics, almost self-explanatory. The gross taxonomy, our present nominal

kinds rely upon principle that divergence (splitting the lineages) occurs in nature, in spite of reticulation (melding of lineages). But in nature, reticulation dominates over divergence and integration over selection according to the general organisational system: aggregates of element in interaction (Botnariuc 1967). Both the reticulation and divergence, like the nature itself, are organised in fractal pattern. These iterative mechanisms occur and function along the largest and along the smallest, irreducible cladistic units. Fractal is the nature's geometry and organises itself by the negentropy of integration and reticulation against the entropy of disintegration (Oláh *et al.* 2018).

*Independent spontaneous splitting.* All taxa are a mix in various ratios of ancestral and derived characteristics (Omland *et al.* 2008). These classical entities are composed of quanta and are the results of quantum mechanisms. They are products (1) of einselection (Zurek 2003); (2) of the environment induces decoherence, when entangled particles decohere; (3) of the collapse of wave-packet superposition along a single eigenstate with known eigenvalue. Taxa are products from the probability cloud of gene/trait trees in species trees. It seems that interacting with the environment splits the world along fractal iteration on all level of organisation. Under the permanent external and internal perturbation pressures there is a counteracting comparative balancing power of integrative organisation to sustain structural and functional autonomy in every once-emerged entity. These protective mechanisms may function by reinforcement like inverse barriers in quantum tunnelling, and they are more elaborated for adaptive traits and less effective for neutral traits. As a result neutral traits are more exposed to stochastic pressures of random effects and the single or various packages of combined characters could be randomly and independently ancestral or derived. Nevertheless, the most adapted stochastic splitting is the end product of speciation supervised by the balancing power of the integrative organisation. As a result at all levels of taxonomic hierarchy there are genealogical discordances, every homologous phenomic trait or

nucleotide position may have their own true tree-like history. The reality of dichotomic (or polytomic) phylogenetic trees is highly questioned, they are almost certainly reticulated (Oláh *et al.* 2018).

*Splitting principles.* Characters should not have equal value in phylogenetic analysis. But they usually have! Pheneticists work with large set of unweighted characters and without real hermeneutic analysis. Unweighted splitting, dominates in numerical taxonomy and in molecular sequence processing, remains blind without empirical hermeneutics. The phenetic species concept in taxonomy and phenetic clade construction in systematics do not give adequate importance to apomorphic characters of “evolutionary novelties”. Applying large number of unweighted adult, larval or molecular characters with independent tree histories without hermeneutics we kill the reality of splitting.

*Splitting practices.* In this small species group we apply a simple demonstrative approach to reconstruct the possible splitting histories by empirical phenomics. We decide upon temporal sequences of splitting by character ranking of empirical parsimony in hermeneutics with the help of universal principles (Winther 2009, Schmitt 2016, Oláh *et al.* 2017) of (1) commonality: common equals primitive, character state present in the largest number of taxa is plesiomorphic; (2) generality: hierarchical concept: character state present in the entire group is plesiomorphic relative to alternative character state of a subset of that group; (3) complexity: following Williston (1914), Gregory (1935) and Schmid (1979): complex is plesiomorphic, calculating that complexity could arise, not only by incremental addition but by incremental subtraction (Oláh *et al.* 2014): the reduction in the number of structural parts could be associated with increasing complexity (Esteve-Altava *et al.* 2013); (4) locality or area: larger distributional area is accompanied with plesiomorphy, especially with peripatric siblings; (5) distinction between adaptive and neutral traits: subtle and stable adaptive contemporary divergences. We

use an empirical synthetic method for character definition by combining observed conditions along examined entities gained with analysing character by character or taxa by taxa based on observed ranges of variations obtained from population samples.

### Splitting in *Rhyacophila obscura* group

*Rhyacophila obscura* Martynov, 1927 was described from the region of “12 sources”, 75 km NE from Tashkent, Uzbekistan as related, though not closely, to Siberian species of *R. depressa* Martynov, *R. sibirica* McLachlan and *R. lenae* Martynov (Martynov 1927). In his seminal study on joint treatment of the evolution and classification Ross (1956) has placed *R. obscura* together with *R. bidens* Kimmins, *R. scissa* Morton and *R. scissoides* into the *R. scissa* species group as an offshoot of *R. castanea* stem (Ross 1956). In his canonical study on the entire genus Schmid (1970) has removed *R. obscura* together with *R. bidens* from the *R. scissa* species group and placed them into the newly established *R. obscura* species group in the *R. castanea* stem of *R. philopotamoides* branch together with three new species *R. chenmo*, *R. chungse* and *R. sakyapa*.

Schmid (1970) has recognised that the epiproct (anal sclerite of Schmid) and the harpagones, the second segment of the gonopod split independently in this species group. The combination of these disharmoniously splitted traits has the power to delineate species, but result in different trees. The tree of epiproct shows dissimilar phylogenetic relations compared to gonopod tree. These discordant trait trees obscure lineage sorting. Which trait tree represents the species tree? The discordance created by different phylogenies of the different trait trees were absolved by giving higher ranking value to epiproct splitting. Theoretically he has based and constructed his species tree of the group on the epiproct tree and the gonopod splitting was considered secondary as a result of parallel evolution.

As we have discussed, in spite of the integrative organisation, unknown ratio of traits or trait

aggregates may split independently and spontaneously in random, non-synchronous pattern. We agree with Schmid's construction of phylogeny giving higher splitting value to epiproct, but he has selected this option without any explanation or interpretation. Why he has given higher splitting value to epiproct is not communicated. Our hermeneutics is based upon the ranking/splitting principle of adaptive/neutral distinction. We have given higher importance in lineage splitting to epiproct and paraproct due to their adaptive divergences. The gonopod shape divergences were considered as neutral and random process driven, mostly stochastic product of integrative organisation against external and internal environmental impacts, realised under the random mechanisms of mutation, permutation, transmutation, perturbation, effective population size, gene flow, genetic drift, and recombination. Lineage splitting, the decision about the phylogenetic ranking value of the diverged traits in the *Rhyacophila obscura* species group was implemented by applying our principle of adaptive/neutral trait distinction in combination with the commonality/generality, complexity and locality/area ranking/splitting principles.

*Rhyacophila obscura*, the ancestral species of the species group has (1) the most robust/complex adaptive epiproct and paraproct, the traits liable to adaptive divergences in reproductive isolation; (2) the most common/general distribution of the adaptive ancestral epiproct in the complex; (3) and the largest distributional area. This ancestral species was diverged to *R. bidens*, to the ancestor of the complex splitted by the reduction of epiproct to a small bilobed structure. The ancestral complex of *R. obscura* and the first splitted complex of *R. bidens* have been further splitted both by contemporary adaptive paraproct reduction and by neutral stochastic shape divergences of segment X and harpagones.

*Rhyacophila obscura*, the ancestral complex. This complex has larger distribution area from Iran to Vietnam as compared to the *R. bidens* complex with more limited distributional area from India (Garhwal) to Myanmar. All lineages

have large epiproct and further splits are produced by adaptive paraproct reduction in sexual integration of reproductive barrier building or by random shape divergences in neutral traits of segment X and gonopod.

(1) The nominate species represents the ancestral lineage of the species group with large reniform, subtriangular epiproct and large clavate paraproct and highly bilobed harpago. *R. obscura*: distributed from Iran to Myanmar.

(2) Subtriangular epiproct retained. Contemporary splitting by adaptive paraproct reduction is accompanied by the reduction of the dorsal lobe on the neutral trait of harpagones of gonopod. *R. atlagos* sp. nov. *R. kurta* sp. nov.: both new species diverged in the Fan-Si-Pan Mts. Vietnam.

(3) Subtriangular epiproct and clavate paraproct retained. Splitting is produced by neutral traits of segment X and gonopod. *R. chenmo*: distributed in India (Manipur). *R. sakyapa*: distributed in India (Pauri Garhwal).

*Rhyacophila bidens*, the first splitted complex. This complex is distributed from India (Garhwal) to Myanmar. Its all lineages have small reduced epiproct with bilobed shape and further splits are produced either by adaptive paraproct reduction in sexual integration of reproductive barrier building or by random shape divergences of harpagones.

(1) First ancestral splitting from *R. obscura* by epiproct reduction: *Rhyacophila bidens*.

(2) Contemporary splitting from *R. bidens* by paraproct reduction: *R. sudar* sp. nov.

(3) Splitting by neutral trait of gonopod: *R. chungse*.

(4) Contemporary splitting from *R. chungse* by paraproct reduction accompanied by neutral trait splits in segment X and harpagones: *R. amatulla* sp. nov.

## MATERIALS

To examine the fine structure of the paraproct we have borrowed type materials, holotype and paratypes of *Rhyacophila bidens* Kimmins, 1953 from the Swedish Museum of Natural History, as well as one paratype of *R. bidens* from the Canadian National Collection; paratypes of *R.*

*chenmo* Schmid, 1970, *R. chungse* Schmid, 1970 and *R. sakyapa* Schmid, 1970 from the Canadian National Collection as well as holotype of *R. szaboi* from the Mátra Museum of the Hungarian Natural History Museum. Non-type materials of *R. bidens* were borrowed from Royal Ontario Museum determined by Brian Armitage and from the Canadian National Collection determined by Fernand Schmid. Specimens from Nepal were available from Kiss Private Collection and the two specimens from Vietnam, those initiated this study were received from the Hungarian Natural History Museum.

**Depositories.** Canadian National Collection, Ottawa, Canada (CNC); Kiss Private Collection (KPC); Mátra Museum of the Hungarian Natural History Museum, Gyöngyös, Hungary (MM); Oláh Private Collection, Debrecen, Hungary, under national protection of the Hungarian Natural History Museum (OPC); Royal Ontario Museum, Toronto, Canada (ROM); Swedish Museum of Natural History, Stockholm, Sweden (SMNH)

## TAXONOMY

### *Rhyacophila assamensis* sp. nov.

(Figures 1–4)

*Rhyacophila chungse* Schmid, 1970:152. 5 paratypes: India, Assam, Kameng, from five localities. The holotype is described from India (Manipur). The 5 paratypes from Assam proved to represent a diverged distinct new species. Misidentification!

**Material examined. Holotype.** India, Assam, Kameng Frontier Division, Ankaling, 2100 ft., 12.III.1961, leg. F. Schmid (1 male CNC). **Paratypes.** India, Assam, Kameng Frontier Division, Lungdur, 2800 ft., 16.V.1961, leg. F. Schmid (1 male CNC). India, Assam, Kameng Frontier Division, Lungdur, 2800 ft., 11–12.X.1961, leg. F. Schmid (2 males CNC). India, Assam, Kameng Frontier Division, Bokhar, 2200–2500 ft., 28.V.1961, leg. F. Schmid (1 male CNC). India, Assam, Kameng Frontier Division, Amatulla, 1800 ft., 17.V.1961, leg. F. Schmid (1 male OPC).

**Diagnosis.** A member of the *R. bidens* complex. A new species of the contemporary splitting from *R. chungse* by paraproct reduction accompanied by neutral trait splits in segment X and harpagones. *R. assamensis* sp. nov. is most close to *R. chungse* Schmid, 1970, but differs by having filiform paraproct in caudal view, not the ancestral form of clavate paraproct; epiproct is widely bilobed, not narrow; the neutral trait of segment X tapering triangular, not digitate both in dorsal and ventral view; the neutral trait of harpagones bilobed and the ventral lobe broad, not slender.

**Description.** Male (in alcohol). Body, appendages and wings brown, maxillary palp formula I-II-IV-V-III, forewing length 11 mm; forewing mottled, thyridial spot conspicuous, small hyaline spot visible on the margin of the apical cells.

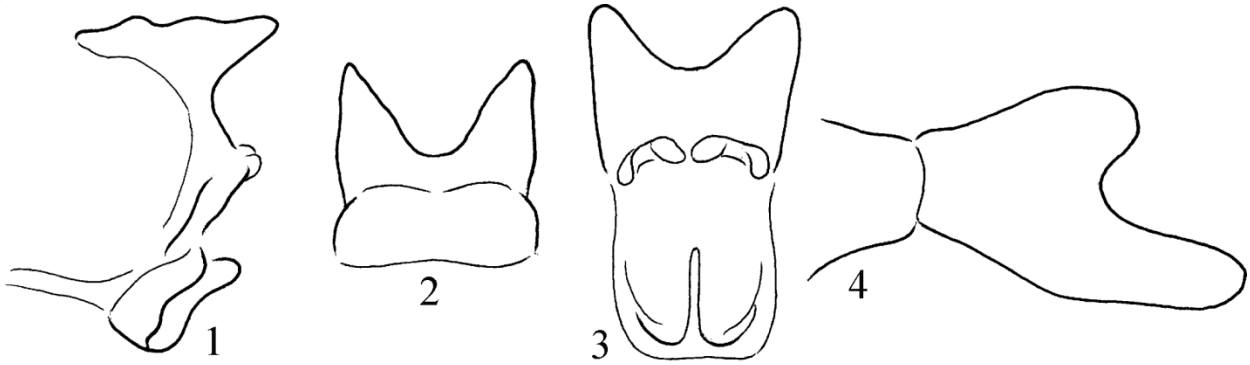
**Male genitalia.** Segment IX is longer dorsad than ventrad. Segment X as long as wide with rounded triangular excision in dorsal view; small bilobed epiproct (anal sclerite) present and the mesal and lateral lobes widely separated; paraproct composed of tergal strap and sclerotized U-shaped apical band with reduced, slim filiform median lobe. Gonopod bisegmented; harpagones bilobed, ventral lobe longer almost as broad as the dorsal lobe. Phallic organ composed of phallobase (short phallosome and most developed endosoma), aedeagus and parameres; parameres stout erectile processes, capitate by short dorsal and long ventral setae; phallosomal tenon and gonopodal tendon well developed; aedeagus with single dorsal and bifid ventral arms.

**Etymology.** Named after the locus typicus.

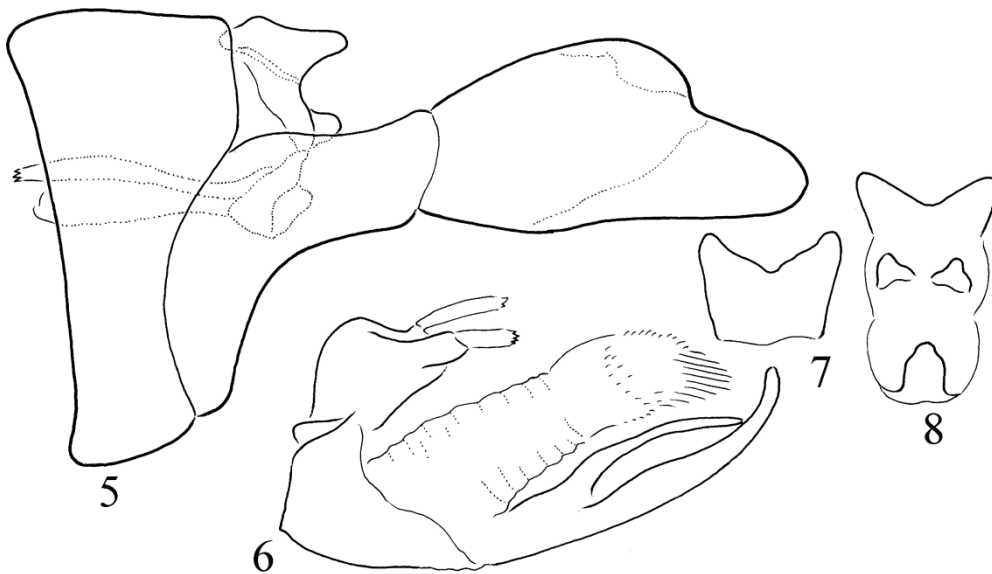
### *Rhyacophila atlagos* sp. nov.

(Figures 5–8)

**Material examined. Holotype.** Vietnam, Lao Cai Province, Fan-Si-Pan Mts, 16km NW Sa Pa, 1800 m, 16.III.1998, light leg. L. Peregovits & T. Vásárhelyi (1 male, HNHM). **Paratypes.** Lao Cai Province, Sapa, large waterfall on rd. from Sapa to Lai Chau, 8.V.1995, UV light, leg. D. Currie, B. HUBLEY & J. SWANN (6 males, ROM; 3 males OPC).



Figures 1–4. *Rhyacophila assamensis* sp. nov. Holotype male: 1 = segment X, epiproct and paraproct in lateral view; 2 = segment X in dorsal view; 3 = segment X, epiproct and paraproct in caudal view; 4 = left harpago in lateral view.



Figures 5–8. *Rhyacophila atlagos* sp. nov. Holotype male: 5 = genitalia in lateral view; 6 = phallic organ in lateral view; 7 = segment X in dorsal view; 8 = segment X, epiproct and paraproct in caudal view.

**Diagnosis.** A member of the *R. obscura* ancestral species complex having the retained subtriangular epiproct present. Contemporary splitting by adaptive paraproct reduction is accompanied by the reduction of the dorsal lobe on the neutral trait of harpagones of gonopod. *R. atlagos* sp. nov. is most close to *R. kurta* sp. nov. but differs by having segment X wider than long; harpagones with less excised, not step-wise apical margin in lateral view; median lobe on paraproctal complex abbreviated to a medium-sized plate, not lost.

**Description.** Male (in alcohol). Body, appendages and wings brown, maxillary palp formula I-II-IV-V-III, forewing length 11 mm; forewing mottled, thyridial spot conspicuous, small hyaline spot visible on the margin of the apical cells.

**Male genitalia.** Segment IX longer dorsad than ventrad. Segment X shorter than wide with short V-shaped excision in dorsal view; subtriangular epiproct (anal sclerite) present; paraproct composed of tergal strap and robust sclerotized U-shaped apical band with medium-sized plate-like median lobe. Gonopod bisegmented; harpago

elongated. Phallic organ composed of phallobase (short phallosome and most developed endosoma), aedeagus and parameres; parameres stout erectile processes, capitate by short dorsal and long ventral setae; phallosomal tenon and gonopodal tendon well developed; aedeagus with single dorsal and bifid ventral arms.

*Etymology.* *atlagos* from “átlagos” average in Hungarian, refers to the average size of the median lobe (lingua at Schmid) of the paraproctal complex (apical band of Schmid).

### ***Rhyacophila bidens* Kimmins, 1953**

*Rhyacophila szaboi* Kiss, 2013: 23–26. **Syn. nov.**

*Material examined. Holotype.* Myanmar, N. E. Burma, Kambaiti, 7000 ft., 30.IV.1934, R. Malaise. The entire holotype is mounted in single permanent slide: 4 wings, abdomen, right gonopod and rest of the body, deposited in SMNH. *Paratypes.* Myanmar, N.E. Burma, Kambaiti, 7000 ft., 12–22.VI.1934, R. Malaise. NHRS-Kajo 000000362, on green label: 8979 E 95+. Pinned intact specimen, abdomen cleared, placed in plastic vial with glycerine, closed with plastic plug, deposited in SMNH. Myanmar: N.E. Burma, Kambaiti, 23.V.1934, Malaise. Pinned specimen, abdomen cleared, mounted in permanent slide, deposited in CNC. *Non-type material.* **India, Manipur**, Chingsao, 14.VI.1960, leg. F. Schmid (1 male, CNC). **India, Assam**, Kameng, Chug, 25–31.VII.1961, leg. F. Schmid (3 males, CNC). **India, Assam**, Kameng, Rupa, 5500 ft. 26.VIII.1961, leg. F. Schmid (1 male, OPC). **India, Assam**, Kameng, Domkho, 8.IX.1961, leg. F. Schmid (2 males, CNC). **India, Assam**, Kameng, Talung Dzong, 6.VI.1961, leg. F. Schmid (2 males, CNC). **India, Assam**, Kameng, Shergaon, 29.VIII.1961, leg. F. Schmid (3 males, CNC). **India, Assam**, Kameng, Rahung, 16.VII.1961, leg. F. Schmid (3 males, CNC). **India, Assam**, Kameng, Bilo La, 10.VI.1961, leg. F. Schmid (2 males, CNC). **India, Assam**, Kameng, Dirang Dzong, 18.VII.1961, leg. F. Schmid (3 males, CNC). **India, Assam**, Kameng, Nyukmadon, 4.VIII.1961, leg. F. Schmid (3 males, CNC). In-

dia, Assam, Kameng, Phutang, 28.IX.1961, leg. F. Schmid (1 male, CNC). **India, Assam**, Kameng, Phutang, 29–30.IX.1961, leg. F. Schmid (1 male, CNC). **India, Assam**, Kameng, Phutang, 1–4.X.1961, leg. F. Schmid (1 male, CNC). **India, Assam**, Kameng, Nakhu, 4.VII.1961, leg. F. Schmid (1 male, CNC). **India, Assam**, Kameng, Kujjalong, 28–30.VI.1961, leg. F. Schmid (1 male, CNC). **India, Assam**, Kameng, Moshing, 6800 ft., 4–7.IX.1961, leg. F. Schmid (1 male, CNC; 1 male, OPC). **India, Assam**, Kameng, Moshing, 6800 ft., 8–10.IX.1961, leg. F. Schmid (1 male, CNC). **India, Sikkim**, Chumtang, 5120 ft, 16–23.VII.1949, leg. F. Schmid (1 male, OPC). **India, Sikkim**, Chateng, 8700 ft, 12.VI.1959, leg. F. Schmid (1 male, CNC). **India, Sikkim**, Shingba, 10400 ft, 30.VI.1959, leg. F. Schmid (1 male, OPC). **India, Sikkim**, Gey, 11650 ft, 18.V.1959, leg. F. Schmid (1 male, CNC). **India, Sikkim**, Zomphuk, 6500 ft, 1.X.1959, leg. F. Schmid (3 males, CNC). **India, Sikkim**, Yugang, 6500 ft, 24.VII.1959, leg. F. Schmid (1 male, CNC; 1 male, OPC). **India, Sikkim**, Zema, 8900 ft, 11.VI.1959, leg. F. Schmid (3 males, CNC). **India, Sikkim**, Teng, 4600 ft, 1.VIII.1959, leg. F. Schmid (1 male, CNC; 1 male, OPC). **India, Sikkim**, Lachung, 8610 ft, 2.–13.VII.1959, leg. F. Schmid (3 males, CNC). **India, Sikkim**, Selep, 7000 ft, 27.VII.1959, leg. F. Schmid (2 males, CNC). **India, Sikkim**, Lathong, 6500 ft, 26.VII.1959, leg. F. Schmid (2 males, CNC). **India, Sikkim**, Namnasa, 10000 ft, 26.VII.1959, leg. F. Schmid (2 males, CNC). **India, Sikkim**, Yoksam, 5600 ft, 30.IX.1959, leg. F. Schmid (3 males, CNC). **Nepal**, *Holotype* of *Rhyacophila szaboi* Kiss, 2013. Mt. Kalinchok, 5 km W of Bigu, 27° 62'N, 86°03'E, 2000 m, by light trapping, 3.VII.1997, leg. M. Hreblay & K. Csák (deposited in the Mátra Muzeum, Gyöngyös, Hungary). *Paratypes* of *Rhyacophila szaboi* Kiss, 2013. Mt. Kalinchok, 5 km W of Bigu, 27°62'N, 86°03'E, 2000 m, by light trapping, 3.VII.1997, leg. M. Hreblay & K. Csák (2 males, OPC). **Nepal**, Ktm. Godavari, 6000', 14–15.VII.1967, Can. Nepal Exped. (5 males, CNC). **Nepal**, Ganesh Himal, 1 km N of Nesim, 28°08'N, 85°17'E, 2600 m, 11.III.1996, leg. L. Bodi & Gy. Makranczy (1 male, OPC). **Nepal**, East Nepal, Surke Danda, 4

km NE of Suketar, Lalik Kharka, 2350 m, 9.VI.1997, leg. M. Hreblay & L. Szécshenyi (1 male, OPC). Nepal, Mt. Kalinchok, 2 km N of Tarebhir, 2600 m, 2.VII.1997, leg. M. Hreblay & K. Csák (2 males, OPC).

*Distribution.* Myanmar, India (Garhwal, Manipur, Assam, Sikkim), Nepal

***Rhyacophila chenmo* Schmid, 1970**

*Material examined. Paratypes.* **India**, Manipur, Sirohi Kashong, 7000 pds, petit torrent, 11–13.VII.1960, leg. F. Schmid (1 male, CNC).

***Rhyacophila chungse* Schmid, 1970**

*Material examined. Paratypes.* **India**, Manipur, Chingsao, 5400 ft., 13.VI.1960, leg. F. Schmid (1 male, CNC). India, Manipur, Chingsao, 3800 ft., 14.VI.1960, leg. F. Schmid (2 males, CNC; 1 male OPC). India, Manipur, Langdang, 5300 ft., 5.VI.1960, leg. F. Schmid (1 male, CNC). India, Manipur, Sirohi Kashong, 6000 ft., 9.VI.1960, leg. F. Schmid (1 male, CNC). India, Manipur, Loni, 4500–5500 ft., 16.VI.1960, leg. F. Schmid (1 male, CNC).

***Rhyacophila kurta* sp. nov.**

(Figures 9–12)

*Rhyacophila bidens* Kimmins, 1953. Armitage & Arefina 2003: 114–116. Among the examined 44 male paratypes we have found 35 *R. kurta* sp. nov. and 9 *R. atlagos* sp. nov. specimens. The drawings are probably from a specimen of *R. kurta*. Misidentification!

*Material examined. Holotype.* **Vietnam**, Lao Cai Province, Fan-Si-Pan Mts, 3km NW Cat Cat, 2000m, 4.VII.1997, light leg. G. Kósa (1 male, HNHM). *Paratypes.* Lao Cai Province, Sapa, large waterfall on rd. from Sapa to Lai Chau, 8.V.1995, UV light, leg. D. Currie, B. Hubley & J. Swann (26 males, ROM; 9 males, OPC).

*Diagnosis.* A member of the *R. obscura* ancestral species complex having the retained sub-

triangular epiproct present. Contemporary splitting by adaptive almost complete paraproct reduction is accompanied by the reduction of the dorsal lobe on the neutral trait of harpagones of gonopod. *R. kurta* sp. nov. is most close to *R. atlagos* sp. nov. but differs by having segment X longer than wide; harpagones with more excised, stepwise apical margin in lateral view; median lobe on paraproctal complex abbreviated, almost lost, not a medium-sized plate.

*Description.* Male (in alcohol). Body, appendages and wings brown, maxillary palp formula I-II-IV-V-III, forewing length 11 mm; forewing mottled, thyridial spot conspicuous, small hyaline spot visible on the margin of the apical cells.

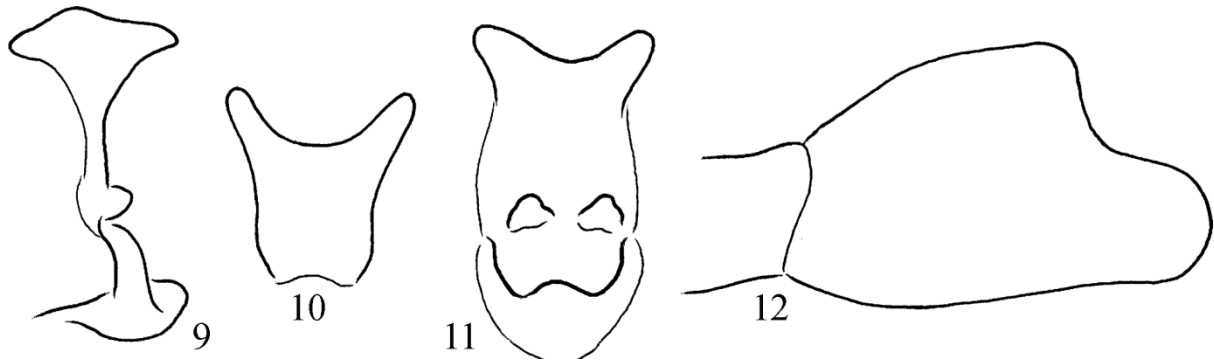
*Male genitalia.* Segment IX longer dorsad than ventrad. Segment X longer than wide with rounded excision in dorsal view; small triangular epiproct (anal sclerite) present; paraproct composed of tergal strap and robust sclerotized U-shaped apical band with abbreviated median lobe. Gonopod bisegmented; harpago short with stepwise apical margin. Phallic organ composed of phallobase (short phallosome and most developed endosoma), aedeagus and parameres; parameres stout erectile processes, capitate by short dorsal and long ventral setae; phallosomal tenon and gonopodal tendon well developed; aedeagus with single dorsal and bifid ventral arms.

*Etymology.* *kurta* from “kurta” short in Hungarian, refers to the abbreviated very short mesal lobe (lingua at Schmid) of the paraproctal complex (apical band of Schmid).

***Rhyacophila obscura* Martynov, 1927**

*Material examined.* **Afghanistan**, Hindukush, Salangtal, Ejan, 2050 m, 11.X.1952, leg. J. Klapperich (1 male, OPC). **Kazakhstan**, Zhaliskiy Alatau Mts. 15 km S of Issyk, Issyk lake, 1710 m, 6.X.2002, leg. B. Benedek & T. Csóvári (1 male, 1 female, OPC). Province Almaty, Almatinsky Zapovednik, Issyk valley, 1800–2000 m, 77°30'E, 43°15'N, UV light trap, 20–21.VII.1997, leg. A. Orosz (1 male, HNHM). **Myanmar**, Burma, Mishmi Hills, Lohit River, 16.III.1935, leg. M. Steele





Figures 9–12. *Rhyacophila kurta* sp. nov. Holotype male: 9 = segment X, epiproct and paraproct in lateral view; 10 = segment X in dorsal view; 11 = segment X, epiproct and paraproct in caudal view; 12 left harpago in lateral view.

(1 male, OPC). **Nepal**, East Nepal, Deorali Danda, 1 km N of Yamphudin, 1850 m, 12.V.1997, leg. M. Hreblay & L. Szécshenyi (1 male, OPC). **Pakistan**, Sost, 2800 m, 16.VI.1992, light leg. G. Csorba & M. Hreblay (1 male, OPC). Pakistan, Hindukush Mts. 5 km E. of Shandur Pass, 3750 m, 21.VIII.2001, leg. B. Benedek & G. Ronkay (1 male, HNHM). Pakistan, Karakoram Mts, Chapurson y. near Rhaminji, 2500 m, 27.VIII.2001, leg. B. Benedek & G. Ronkay (1 male, HNHM). Pakistan, Kashmir, Bubin, lower, 17.VIII.2001, leg. B. Benedek & G. Ronkay (5 males, HNHM). Pakistan, Kashmir, Deosai Mts. Bubin 3150 m, 13.VIII.2001, leg. B. Benedek & G. Ronkay (1 male, HNHM).

*Remarks.* Widely distributed species reported from Iran, Pakistan, China (Xinjiang), Nepal, Bhutan, Kazakhstan, India (Himachal Pradesh) and here we report it from Afghanistan and Myanmar.

#### ***Rhyacophila sakyapa* Schmid, 1970**

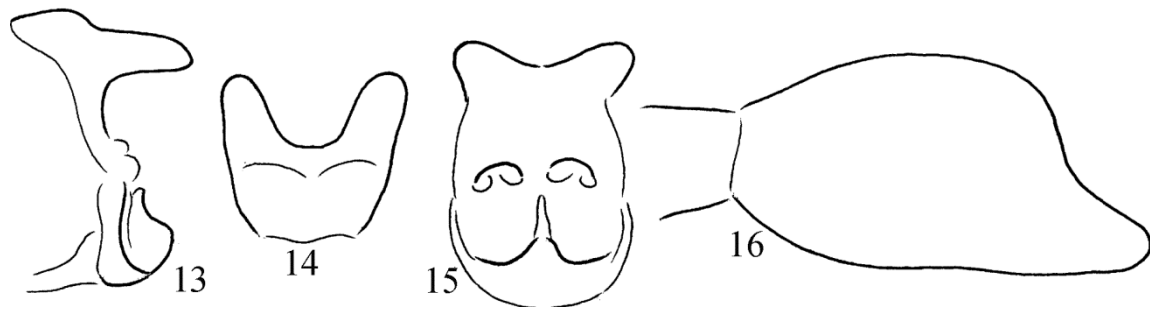
*Material examined. Paratypes.* **India**, Pauri Garhwal, Ukhal, 16.V.1958, leg. F. Schmid (1 male, CNC). India, Pauri Garhwal, Ukhal, 12.V.1958, leg. F. Schmid (1 male, CNC). India, Pauri Garhwal, Binaik Chatti, 1–2.VII.1958, leg. F. Schmid (1 male, CNC). India, Pauri Garhwal, Tarsali, 6–7.V.1958, leg. F. Schmid (2 males, CNC; 1 male, OPC).

#### ***Rhyacophila sudar* sp. nov.**

(Figures 13–16)

*Material examined. Holotype.* **India**, Pauri Garhwal, Akhrotkoti, 5700–6500 ft., 17–18.V.1958, leg. F. Schmid, identified as *R. bidens* by Schmid, (1 male, CNC). *Paratypes*, same as holotype (1 male, CNC; 1 male, OPC). **India**, Sikkim, Uttare, 6950 ft., 5.IV.1959, leg. F. Schmid (2 males, CNC; 1 male OPC). India, Sikkim, Ramtang, 5780 ft., 24.VI.1959, leg. F. Schmid (3 males CNC). India, Sikkim, Dentham, 4500 ft., 4.IV.1959, leg. F. Schmid (1 male CNC). India, Sikkim, Sirwani, 1150 ft., 1.V.1959, leg. F. Schmid (1 male CNC). India, Sikkim, Nanga, 5000 ft., 11.V.1959, leg. F. Schmid (2 males CNC). India, **Assam**, Kameng, Chug, 14.IV.1961, leg. F. Schmid (2 males, CNC; 1 male, OPC).

*Diagnosis.* Having small bilobed epiproct *R. sudar* sp. nov. is a member of the *R. bidens* complex. A new species of the contemporary splitting from *R. bidens* by adaptive paraproct reduction accompanied by neutral trait splits in segment X and harpagones. *R. sudar* sp. nov. is most close to *R. bidens* Kimmins, 1953, but differs by having highly reduced filiform and abbreviated paraproct in caudal view, not the ancestral form of clavate paraproct of *R. bidens*; the neutral trait of segment X rather digitiform both in dorsal and ventral view, not tapering triangular; the neutral trait of harpagones with lower and longer dorsum.



Figures 13–16. *Rhyacophila sudar* sp. nov. Holotype male: 13 = segment X, epiproct and paraproct in lateral view; 14 = segment X in dorsal view; 15 = segment X, epiproct and paraproct in caudal view; 16 = left harpago in lateral view.

**Description.** Male (in alcohol). Body, appendages and wings brown, maxillary palp formula I-II-IV-V-III, forewing length 11 mm; forewing mottled, thyridial spot conspicuous, small hyaline spot visible on the margin of the apical cells.

**Male genitalia.** Segment IX is longer dorsad than ventrad. Segment X longer than wide with rounded triangular excision in dorsal view; small bilobed epiproct (anal sclerite) present and the mesal and lateral lobes well separated; paraproct composed of tergal strap and sclerotized U-shaped apical band with reduced, slim filiform median lobe. Gonopod bisegmented; harpagones monolobed, dorsum low and long. Phallic organ composed of phallobase (short phallosome and most developed endosoma), aedeagus and parameres; parameres stout erectile processes, capitate by short dorsal and long ventral setae; phallosomal tenon and gonopodal tendon well developed; aedeagus with single dorsal and bifid ventral arms.

**Etymology.** *sudar* from “*sudár*” slender, slim in Hungarian, refers to the slim median lobe (lingua at Schmid) of the paraproctal complex (apical band of Schmid).

**Acknowledgement** – We thank Brian J. Armitage and Tatyana I. Arefina for sending specimens collected by Canadian zoologist in Vietnam and stored in the Royal Ontario Museum; Kjell Arne Johanson head of Zoological Department for sending holotype and 3 paratypes of *Rhyacophila bidens* deposited at the Swedish Museum of Natural History; Tibor Kovács collection manager at the Mátra Museum of the Hungarian Natural History Museum for providing the holotype of *Rhyacophila szaboi* Kiss and Owen Lonsdale, collection manager at the Canadian National Collection for providing type and non-type materials collected by Fernand Schmid in various states of India.

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doi: [10.1103/RevModPhys.75.715](https://doi.org/10.1103/RevModPhys.75.715)

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## Lepidoptera from the Pantepui. Part V. New Lycaenidae (Theclinae: Eumaeini)

M. COSTA<sup>1</sup>, Á.L. VILORIA<sup>2</sup>, S. ATTAL<sup>3</sup>, M. BENMESBAH<sup>4</sup>, A.F.E. NEILD<sup>5</sup> & ZS. BÁLINT<sup>6</sup>

<sup>1</sup>Mauro Costa, Res. Las Cumbres, Avenida Las Acacias, La Florida, Caracas 1020-A, Venezuela.  
Email: mauro13x50@gmail.com

<sup>2</sup>Ángel L. Viloría, Centro de Ecología, Instituto Venezolano de Investigaciones Científicas (IVIC), Apartado Postal 20632, Caracas 1020-A, Venezuela. Email: aviloría@ivic.gob.ve

<sup>3</sup>Stéphane Attal, 5-15 Rue Olivier-Noyer, 75014 Paris, France. Email: stephane.attal@wanadoo.fr

<sup>4</sup>Mohamed Benmesbah, 21 Rue des Marronniers 31830 Plaisance du Touch, France. Email: modjojojo66@hotmail.com

<sup>5</sup>Andrew F.E. Neild, Courtesy Research Scientist (Lepidoptera), Florida Museum of Natural History, McGuire Center, University of Florida, PO Box 112710, Gainesville, FL 32611-2710, USA. Email: andrew.neild@blueyonder.co.uk

<sup>6</sup>\*Zsolt Bálint, Department of Zoology, Hungarian Natural History Museum, H-1088 Budapest, Baross utca 13, Hungary. Email: balint.zsolt@nhmus.hu (\*corresponding author)

**Abstract.** Two new species of butterfly (Lepidoptera, Papilionoidea, Lycaenidae) from the Pantepui (Venezuela) are described; *Ocaria faurei* Bálint, Attal & Costa, sp. nov. and *Strymon auyana* Bálint, Benmesbah & Viloría, sp. nov. (Lycaenidae: Theclinae: Eumaeini). Notes and data are provided on the representatives of the genera *Ocaria* Clench, 1970 and *Strymon* Hübner, 1818 found in the Pantepui and in its adjacent areas in southern Venezuela with a particular focus on endemism.

**Resumen.** Se describen dos nuevas especies de mariposas (Lepidoptera, Papilionoidea, Lycaenidae) de diversas localidades del Pantepui (Venezuela): *Ocaria faurei* Bálint, Attal & Costa, sp. nov. y *Strymon auyana* Bálint, Benmesbah & Viloría, sp. nov. (Lycaenidae: Theclinae: Eumaeini). Se proveen datos y anotaciones sobre los representantes de los géneros *Ocaria* Clench, 1970 y *Strymon* Hübner, 1818 encontrados en el Pantepui y áreas adyacentes en el sur de Venezuela con particular enfoque en el endemismo.

**Keywords.** Akopán Tepui, Auyán Tepui, Gran Sabana, *Ocaria*, Ptari Tepui, Roraima, *Strymon*, Wokomong, endemism.

### INTRODUCTION

This work is the fifth paper in the series dedicated to the Lepidoptera fauna of the Pantepui *sensu* Costa *et al.* (2014a); the first paper deals with the concept of the Pantepui, its biogeography, and its butterfly endemism; the following parts (Costa *et al.* 2014b, 2016 and 2017) are devoted to the description of some new taxa discovered during several expeditions carried out in the last ten years.

The type locality of the two lycaenid butterfly species we are describing here is Auyán Tepui (Figs. 1–2), which is one of the largest of the

Amazonian-Guianan shield tepuis and well known for its exceptional natural beauty, and especially for Churún Merú, better known as the Angel Falls, the highest waterfall in the world. This tepui is known to be inhabited by many endemic biological taxa, including amphibians, birds, reptiles and plants (Celsa Señaris *et al.* 2009), and amongst them the recently discovered nymphalid butterflies *Archaeogramma claritae* Costa, 2014 and *Perisama tepuiensis* Attal & De Marmels, 2012.

The lycaenid fauna of Venezuela is poorly known. Special effort is necessary to get even basic knowledge about its diversity (Neild 1996: 11).



**Figures 1–2.** Auyán Tepui (southeastern Venezuela). 1 = Panoramic view of the southern slopes from the Río Okoiné, midway between Uruyén (a small Pemón village) and Guayaraca Camp. 2 = Habitat of *Ocaria faurei* and *Strymon auyana* spp. nov., between El Danto and El Peñón, 1700 m (05°44'19"N, 62°32'14"W) (photos: Mauro Costa).

In this paper, describing two presumed endemic species from two widely distributed Panamerican genera, and discussing their congeners recorded in the Pantepui region, we hope that we contribute to a better understanding of this lesser known Venezuelan butterfly family.

## MATERIALS AND METHODS

Holotypes and most paratypes are to be deposited in the Museo del Instituto de Zoología Agrícola, Facultad de Agronomía, Maracay, Venezuela (MIZA). Specimens are also deposited in the

Hungarian Natural History Museum, Budapest, Hungary (HNHM) and in the research collection of Mauro Costa, Caracas, Venezuela (MC). Type material of previously described taxa has been consulted personally (ZsB) in the Natural History Museum, London (Bálint & Goodger 2003, Bálint *in prep.*) or using photos on the Butterflies of America website (Warren *et al.* 2017). Material in the HNHM was used for comparison and monographs of Neotropical Lycaenidae and published papers as references in the descriptions were consulted (Draudt 1919–1920, D’Abrera 1995).

Precise geo-coordinates are given in Table 1 for taxa supposedly endemic to the Pantepui region, with the aim that exact locality documentation may support authorities to achieve habitat oriented actions for the conservation of the endemic biota.

Standard entomological techniques were used for collecting and dissecting specimens (Winter 2000). Wing measurements were collected from actual specimens using the ocular calliper of a light microscope Olympus SZX12. Three measurements are presented in mm in each description, for the fore and the hind wing: length of radial vein measured from vein base to terminus + length of anal vein measured from vein base to terminus + lengths between radial vein and anal vein termini. Specimens were digitalized either in the HNHM or in the home laboratory of Stéphane Attal (Paris).

After dissection, the abdomen and genitalia were placed in a plastic microvial containing glycerol and pinned to the same pin as the specimen, inventoried in the HNHM as “Bálint gen. prep. no. #####”, and labelled accordingly. Many hair-streak lycaenid genera have uniform genitalia showing no qualitative characters helpful for interspecific discrimination, but wing coloration, wing pattern, and wing shape, as well as spatial and temporal distribution, all offer more reliable traits for taxonomic identification (*cf.* Nicolay & Robbins 2005, Busby *et al.* 2017). Therefore the genitalia of the new species are basically figured with the aim of documentation, and as a basis for an extensive future systematic revision of the genera involved

## RESULTS

Family LYCAENIDAE, [Leach, 1815]

Subfamily THECLINAE, Swainson, 1831

Tribe EUMAEINI, Doubleday, 1847

**Genus *Ocaria* Clench, 1970**

***Ocaria faurei* Bálint, Attal & Costa, sp. nov.**

(Figures 3–12)

*Material examined* (n = 11). *Holotype* (Figs. 3–4): ♂, Venezuela, Bolívar, Auyán Tepui, El Peñón, 1850 m, 16-I-2017, *M. Costa*, *M. Benmesbah* (MIZA). *Allotype* (Figs. 5–6): ♀, *idem*, 03-IV-2015, *M. Costa* (MIZA). *Wing measurements in mm* (see “Materials and Methods”): holotype forewing = 13.5+11+12, hindwing = 11+11+11; allotype forewing = 12+9+11, hindwing = 9+10+9. *Paratypes* (n = 9, Venezuela, Bolívar): 1♂, Roraima, Base Camp, 1900 m, 29-III-2007, *M. & C. Costa* (MC); 1♀, Ptari Tepui, Base Camp, 2000 m, 27-XII-2014, *M. Costa* (MC); 1♂, Auyán Tepui, entre El Danto y El Peñón, 1700 m, 25-III-2013, *M. Costa* (HNHM), Bálint gen. prep. no. 1526; 1♂, *idem*, 20-I-2017, *M. Costa*, *M. Benmesbah* (MIZA); 1♀, Akopán Tepui, 1400 m, 25-XII-2014, *M. Costa* (HNHM), Bálint gen. prep. no. 1626; 1♂, Ptari Tepui, Base Camp, 2000 m, 25-XII-2014, *M. Costa* (MIZA), Bálint gen. prep. no. 1625; 1♂, Auyán Tepui, El Peñón, 1850 m, 16-I-2017, *M. Costa*, *M. Benmesbah* (MIZA); 1♂, Auyán Tepui, El Danto, 1500 m, 15-I-2017, *M. Costa*, *M. Benmesbah* (MIZA); 1♂, *idem*, 1750 m, 20-I-2017, *M. Costa*, *M. Benmesbah* (HNHM).

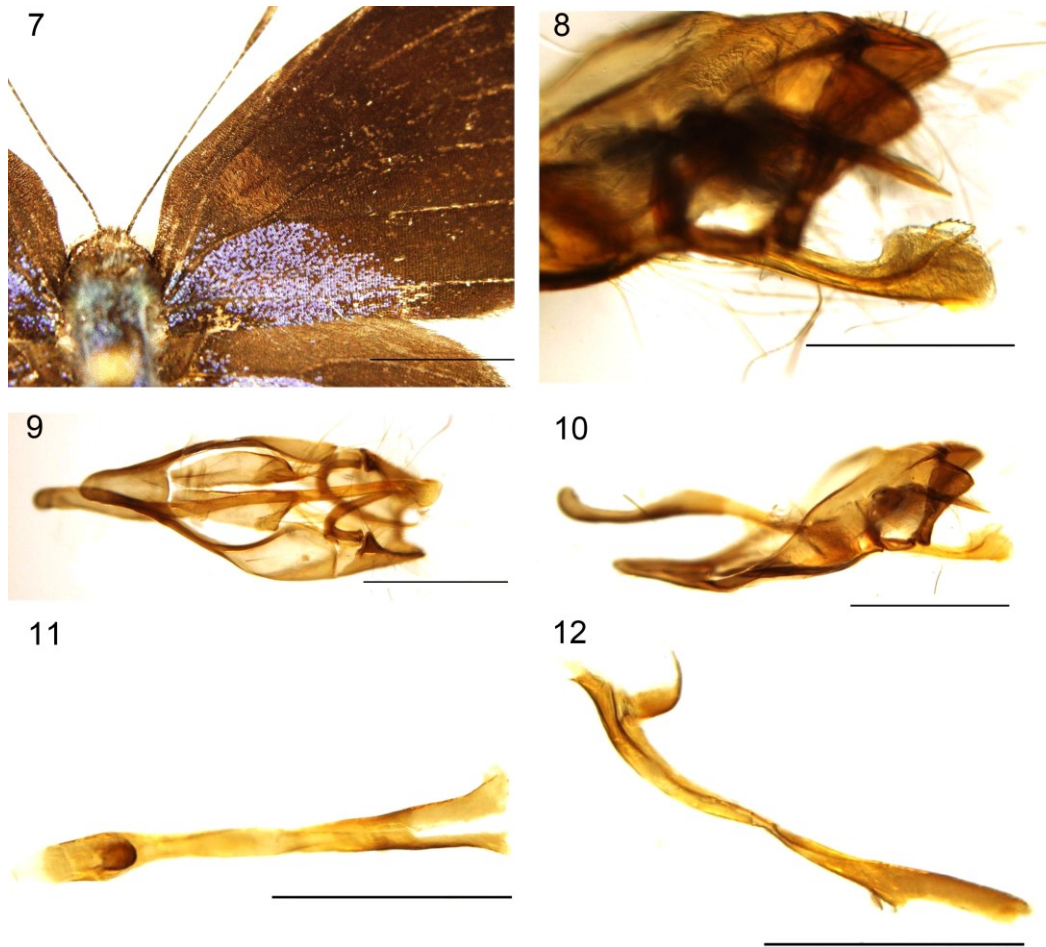
*Classification.* This species belongs to Eumaeini because it has ten forewing veins, “greyhound shaped” male genitalia lacking a juxta and a male foretarsus that is fused, used for walking, and stubby tipped (Eliot 1973). It is placed in the genus *Ocaria* Clench, 1970 (type species: *Thecla ocrisia* Hewitson, 1868) because the terminus of the aedeagus is flat and triangular-shaped with a serrated ventral keel (Clench 1970, Fig. 1; see Fig. 8), and belongs to the *O. aholiba* (Hewitson, 1867) species group because the dorsal forewing scent patch fills almost the entire discal cell area (Bálint & Costa 2012; see Fig. 7).

**Diagnosis.** Within the *Ocaria aholiba* species group (see Bálint & Costa 2012), *O. aholiba* is superficially the most similar species but *O. faurei* differs as follows: the ventral forewing surface (1) is without a conspicuous discoidal line (in *O. aholiba* the discoidal line is strongly patterned with gleaming scales), (2) the postmedial pattern consists of a dark line (in *O. aholiba* this line is formed by gleaming scales) and (3) the submarginal area is lighter than the more basal areas (in *O. aholiba* the submargin is the same colour as the medial area). The Central American *Ocaria clenchi* (K. Johnson, 1992) is also similar, but the forewing dorsal surface in the male of that species is completely black, and the ventral wing surface is a paler brown with pinkish and reddish postmedial-submarginal areas, and with no gleaming scales.

**Description.** *Wings* (Figs. 3–7). **Male:** Dorsal surface: forewing black with blue basal area, discal cell with scent patch coloured black distally and light brown basally, fringes brownish red. Hindwing with more extensive forewing blue coloration, black colour restricted to marginal area, widening progressively towards apex from M3, vein terminus Cu1 with 1 mm tail and Cu2 terminus with 5 mm tail, fringes black. Ventral surface: forewing basal and medial area dark brown, postmedian and submargin lighter, antemarginal area dark brown, postmedial line dark brown running continuously from vein costa to Cu2 not reaching the anal margin with a few irregularly scattered bright scales along its distal edge. Hindwing basal and medial areas dark brown, postmedian and submargin lighter with complex patterns, antemargin dark brown but



**Figures 3–6.** *Ocaria faurei* sp. nov. type material. 3–4 = holotype male (3 = dorsal, 4 = ventral). 5–6 = paratype (“allotype”) female (5 = dorsal, 6 = ventral). (scale bars 1 = cm) (photos: Gergely Katona, HHNM).



**Figures 7–12.** *Ocaria faurei* sp. nov. anatomy. 7 = holotype in dorsal view showing the head, thorax, and forewing scent patch (scale bar = 4 mm), 8 = aedeagus terminus with flat and subrectangular shaped antero-dorsal keel, 9 = male genital capsule, ventral view, 10 = *idem*, lateral view, 11 = female ductus bursae in ventral view, 12 = *idem*, lateral view (scale bars: Fig. 8 = 0.6 mm and 9–12 = 1 mm) (photos: Zsolt Bálint, HNHM)

between vein Cu1 and inner margin patterned; submedial pattern comprised of gleaming scales running from vein Sc + R1 to vein M3 broken into two sections as absent in space M1-Rs; lighter postmedial area with zigzagged pattern running from costa to inner margin formed by a dark brown line bordered distally along its edge, and by random scattered gleaming scales in the postmedial area distal to this line, running from space M1-Rs to inner margin; a large dark red antemarginal crescent-shaped patch basally enclosing a black marginal spot in Cu2-Cu1, another less visible antemarginal red patch in 2A-Cu2 with a small patch of gleaming scales distal to this, the red scaling spilling over into the adjoining tornal

space; tornus black with gleaming blue scales basally. *Female*: similar to male, but wing surface area somewhat smaller, dorsal wing structural blue restricted to hindwing with more extensive marginal black border, ventral wing surface coloration lighter and pattern sharper, orange-red antemarginal patches in 2A-Cu2 much larger.

*Body.* Head (Fig. 7). *Male and female*: vertex and frontoclypeus covered by black hair-like scales, labial palpus with middle segment black-haired in its lower part with some white scales mixed, terminal segment short and pointed, eyes large and hairy; antennal flagellum and club dorsally black with white ventral scaling in each segment, club reddish brown. Thorax and legs:



covered with dark hair-like scales, excluding tibia and tarsus with normal scaling. Abdomen: dorsally and laterally gleaming blue, ventrally brown.

**Genitalia** (Figs. 8–12). Male with common-place eumaeine structures without brush organ, capsule flat and bullet-shaped in lateral view, with valval and tegumenal anterior hairs, tegumen with a large pair of long and slender gnathi curved with pointed termini, posterior tegumen sclerotized, vinculum membranous but upper and lower borders sclerotized, saccus with  $\frac{3}{4}$  subzonal aedeagus length, apically rounded in ventral view, valva stretched and oval-shaped in lateral view with a conspicuous apical project, lower part sclerotized, aedeagus longer than genital capsule, internal (subzonal) section short with  $\frac{1}{4}$  aedeagus length and external (extrazonal) section long, posterior end upwardly open and upturned with a slightly sclerotized antero-dorsal keel dentate dorsally and somewhat subrectangular in lateral view (Figs. 8–10). Female genitalia lamella antevaginalis approximately half ductus length and composed of two long sclerotized plates divided by a membranous area, ductus simple and membranous with sclerotized anterior parts attaching to bursa (Figs. 11–12).

**Variations.** The eleven specimens taken show almost no variation in size, coloration or pattern, the only notable difference is the extension of the marginal black border and the blue basal scaling (which is more extended in females). Worn specimens appear to be somewhat darker blue and the ventral pattern fades away, therefore old specimens are not easy to identify as they display only the most general eumaeine pattern.

**Type locality.** Southeastern Venezuela, Bolívar state, Auyán Tepui, El Peñón, 1850 m (05°44' 40"N; 62°32'27"W).

**Bionomics.** *O. faurei* sp. nov. is known from several tepuis in the Gran Sabana (eastern Pantepui) such as Roraima, Auyán, Akopán and Ptari Tepui. The Gran Sabana is an immense plateau on the Guiana Shield whose area reaches 10,800 km<sup>2</sup> with elevations between 800 and 1200 m. On this plateau there rise abruptly a large number of tepuis, some of which reach up to 2800 m eleva-

tion, each isolated from its neighbours by the surrounding lower land. Each tepui is contoured by a ring of vegetation that covers the steeply inclined slopes up to where the vertical walls begin (normally around 2000–2200 m). The fact that this new species occurs on the slopes of different isolated tepuis, combined with the fact that it has never been reported from intermediate elevations (800–1200 m) of the Gran Sabana (much more sampled than the tepuis), suggest that *O. faurei* is most likely an endemic Pantepuian species.

The habitat of *O. faurei* is located on tepui slopes, between 1400 and 2000 m elevation. In these areas the slope is predominantly rocky being formed by the fall of boulders and smaller debris released by the erosion of the cliffs; the soil is therefore poor in nutrients giving rise to dense scrub vegetation (Fig. 2) with low-lying plants (2–6 m) except in protected sites or along streams where small forests up to 10–12 m high can be found. In this environment, on sunny days, *O. faurei* adults can be seen constantly looking for nectar sources during the hottest hours of the day (10:00 – 14:00); the flight is very fast and nervous, probably adapted to these areas, normally of strong winds and rich in predators (birds).

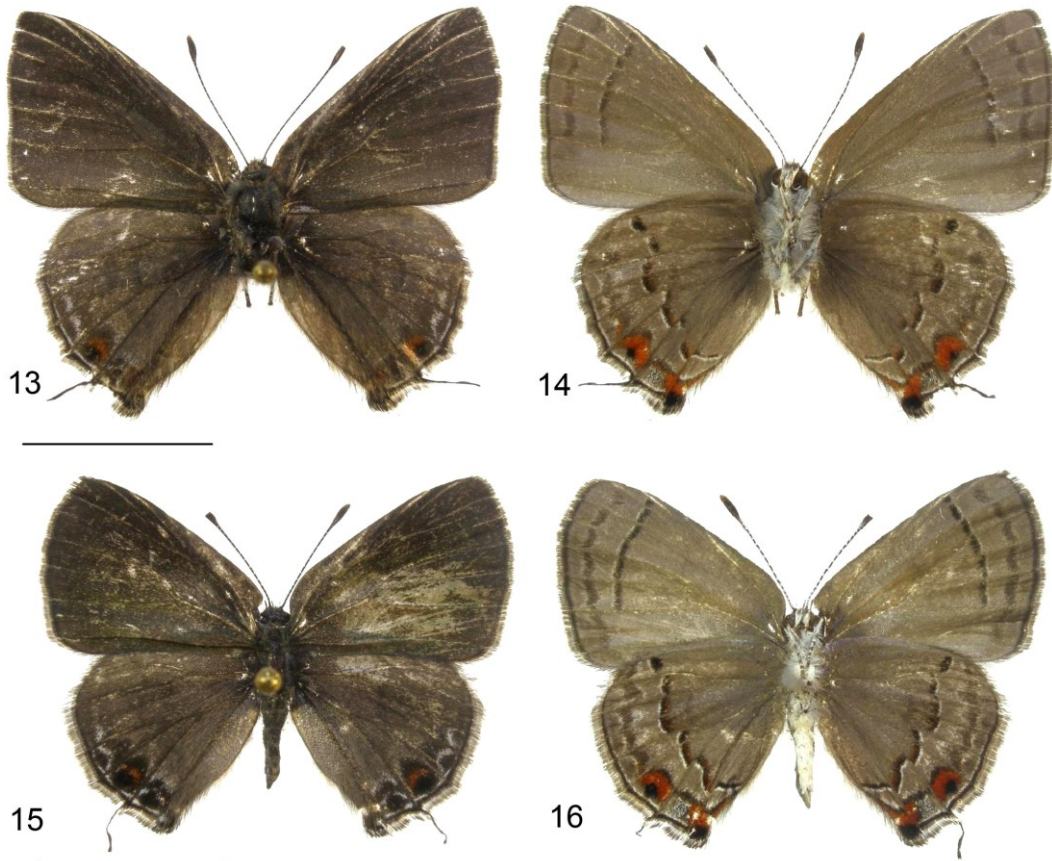
**Etymology.** This species is dedicated to Denis Faure (France) in gratitude for his contribution to Neotropical biodiversity research.

### Genus *Strymon* Hübner, 1818

#### *Strymon auyana* Bálint, Benmesbah & Vilorio, sp. nov.

(Figures 13–20)

**Material examined** (n = 5). **Holotype** (Figs. 13–14): ♂, Venezuela, Bolívar, Auyán Tepui, El Danto, 1500 m, 28-III-2015, M. Costa (MIZA), Bálint gen. prep. no. 1535. **Allotype** (Figs. 15–16): ♀, Venezuela, Bolívar, Auyán Tepui, entre El Danto y El Peñón, 1750 m, 20-I-2017, M. Costa, M. Benmesbah (MIZA). **Wing measurements in mm** (see “Materials and Methods”): holotype forewing = 14+8.5+11, hindwing = 8+9 +8.5; allotype forewing = 11+8.5+9, hindwing = 7.5+8+9.



**Figures 13–16.** *Strymon auyana* sp. nov. type material. 13–14 = holotype male (abdomen removed for dissection) (13 = dorsal, 14 = ventral). 15–16 = paratype (“allotype”) female (15 = dorsal, 16 = ventral). (scale bars = 1 cm) (photos: Gergely Katona, HNHM).

*Paratypes* (n = 3; Venezuela, Bolívar, Auyán Tepui): 1♀, El Danto, 1500 m, 14-01-2017, M. Costa, M. Benmesbah (MIZA); 1♂, *idem*, 20-I-2017, M. Costa, M. Benmesbah (HNHM); 1♀, Auyán Tepui, entre El Danto y El Peñón, 1700 m, 04-IV-2015, M. Costa (MIZA), Bálint gen. prep. no. 1536 (HNHM).

*Classification.* *Strymon auyana* sp. nov. belongs to the Eumaeini because it has ten forewing veins “greyhound shaped” male genitalia lacking a juxta, and a male foretarsus that is fused, used for walking, and stubby tipped (Eliot 1973). It belongs in the genus *Strymon* Hübner, 1818 (type species: *Strymon melinus* (Hübner, [1813])) because it has anteriorly pointing “teeth” on the dorsal surface of the valvae (Robbins & Nicolay 2002, Figs. 1–8; see Fig. 19), and belongs to the

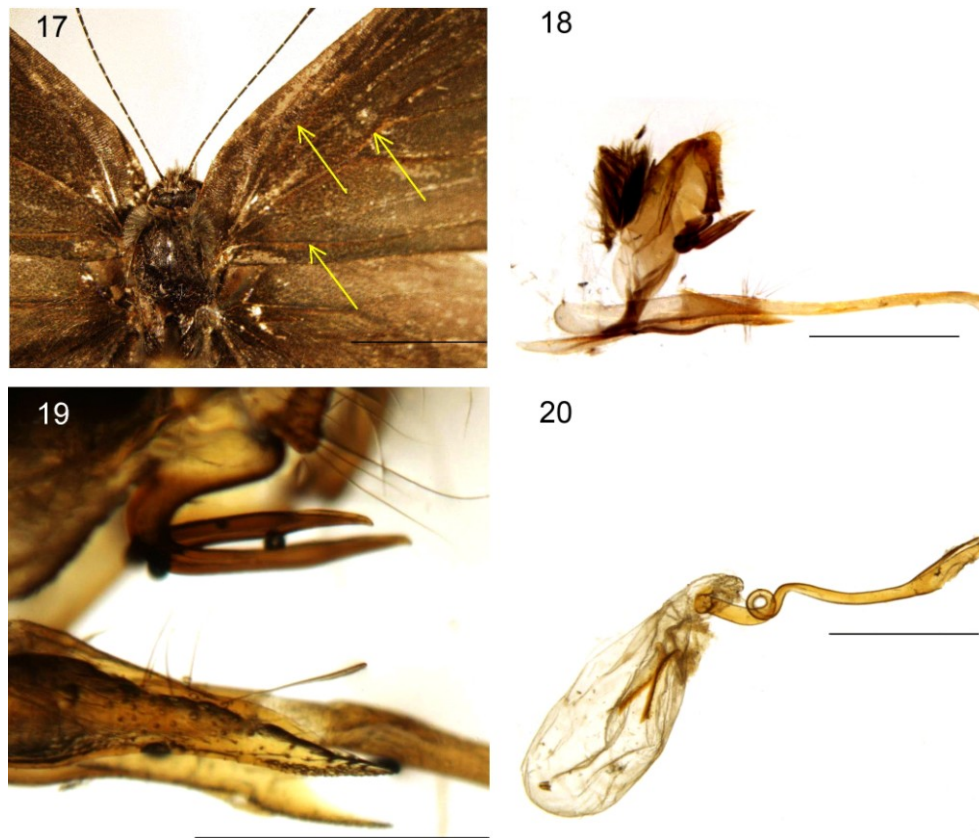
*S. melinus* species group *sensu* Robbins & Nicolay (2002), because the male dorsal forewing surface lacks a scent patch and the genitalia are identical, or nearly so, to those of *S. melinus* (Robbins & Nicolay 2002: Figs. 9, 18).

*Diagnosis.* Within the *S. melinus* species group of Nicolay & Robbins (2005) *Strymon auyana* sp. nov. shares with *S. cyanofusca* the trait that the dorsal hindwing submarginal area is blue-scaled, but the new species has a much darker appearance both in dorsal and ventral views; the ventral surface postmedian bands are bordered basally with dark brown scales with only traces of dark orange, while other group members have reddish or red scaling basally. The new species has a distinctive appearance compared to *S. rufofusca* as well, notably the overall dark coloration, rufous scaling on

the veins and the blue dorsal scaling along the hindwing marginal area. The obviously different *S. lamasi* has conspicuous white arrow-head patterns in the ventral hindwing submargin; these are barely apparent in *S. auyana*, being reduced to diffuse scales.

*Description.* External sexual dimorphism weak, sexes similar in size, but female hindwing shorter (see wing measurements above). *Wings* (Figs. 13–17). Dorsal surface: forewing greyish black with paler brown fringes (no scent patch in male); hindwing ground colour same as forewing but submargin between veins M2 and Cu1 with faint dusting of blue scales, submarginal orange

spot in space M2-M3 crescent-shaped and distally embracing a large black spot, a single narrow 3 mm long black tail at vein Cu2 terminus; margin lined with black and basally edged with a thin line of bluish scales; veins covered by rufous scales in both wings (visible under larger magnification). Ventral surface: forewing dark greyish brown, paler along the inner margin, narrow marginal black line, with fringes composed by brown and white scales, faint submarginal line of darker grey crescents, broken at each vein, from costa to vein Cu2, postmedial line dark brown, curving gently from costa to Cu2, bordered narrowly distally with greyish white, and scattered traces of orange scales basally; hindwing colours as in forewing,



**Figures 17-20.** *Strymon auyana* sp. nov. anatomy. 17 = holotype in dorsal view showing the head, the basal and medial parts of the forewing with no scent patch; the rufous scalings along the principal veins are indicated by arrows (scale bar = 8 mm). 18 = male genital capsule, lateral view (scale bar = 1 mm). 19 = valva apex with anteriorly pointing “teeth” in lateral view (scale bar = 0.6 mm). 20 = female corpus bursae with the characteristically looped ductus in lateral view (scale bar = 1.2 mm). (photos: Zsolt Bálint, HNHM).

narrow marginal black line, basally bordered narrowly with greyish white, with paler brown fringes; a faint submarginal darker brown band from Cu1 to the tornus, followed distally by a scattering of whitish scales occasionally vaguely crescent shaped, postmedian line from costa to inner margin formed by interrupted dashes coloured as in forewing, a submarginal cubital black spot joined basally with a wide and vivid orange crescent lined basally with a thin dark brown crescent, a faint dusting of submarginal dark grey and whitish scales in Cu1–M3, black tornal spot followed basally by a large orange patch thinly lined basally with dark grey then whitish scales.

*Body.* Head (Fig. 17). Eyes hairy, frons grey and densely covered with longer piliform scales, labial palps white ventrally but last segment black. Thorax and cervix with a pair of brush composed by long and erecting scales. *Genitalia* (Figs. 18–20). Male, vinculum with a pair of brush organs, tegumen large with a small central projection; uncus large and sclerotized, falces straight with pointed apices and as long as sacculus, valva narrow and pointed in lateral view, aedeagus 2.5 times longer than valval length with apices slightly downturned, cornutus slender and acuminate (Figs. 18–19). Female, genitalia ductus bursae with simple sclerotized loop, ductus seminalis arises from unsclerotized posterior end of ductus bursae, ductus with a pair of large signa with central sclerotization and pointed caudad, as is typical for congeners (Fig. 20).

*Variation.* The five type specimens show little variation in size, coloration and pattern, the only notable phenomenon is the extension of the submarginal blue scaling in the dorsal hindwing surface, as the two specimens collected in 2015 seem to possess less blue scaling compared to the three specimens taken in 2017. However, a larger sample most probably would demonstrate more variation in size and coloration, as has been recorded in other *Strymon* species (see Nicolay & Robbins 2005).

*Type locality.* Southeastern Venezuela, Bolívar state, Auyán Tepui, El Danto, 1500 m, 05°43' 45"N; 62°32'24"W (Fig. 37).

*Bionomics.* *Strymon auyana* sp. nov. is known only from the slopes of Auyán Tepui, one of the largest of the Guiana Shield, between elevations of 1500–1750 m. The habitat is the same as the above described *O. faurei* sp. nov. and of other known Pantepuian lycaenids (*Ocaria elisa* Bálint & Costa 2012, *Calycopis matho* (Godman & Salvin, 1887), *Cyanophrys roraimiensis* Johnson & Smith, 1993) with the peculiarity that all five known specimens have been found exclusively along streams, that is, in more protected and humid environments. The elevation of the habitat and absence from other tepuis suggests that the species is probably endemic to Auyán Tepui. Most of the endemic Pantepui butterflies are usually found on the slopes of other tepuis, but as of our current knowledge, *S. auyana* joins a very limited group of species restricted to a single tepui (*Perisama tepuiensis* Attal & De Marmels and *Archaeogramma claritae* Costa (Costa et al. 2014b)); all three are endemic to Auyán Tepui.

*Etymology.* The species is named after the type locality. The species name is formed by latinising „Auyán” and treating it as a female noun in apposition.

## DISCUSSIONS

### Notes on *Ocaria* species recorded in the Pantepui region

(Figures 21–26)

In the diagnosis we have pointed to characters that help to discriminate the new species. Here, we further explore this topic. As noted earlier, the genus *Ocaria* sensu Robbins (2004) can be subdivided into various species groups having distinctive wing shapes, patterns and coloration (Bálint & Costa 2012). The new species *O. faurei* belongs to the *aholiba* species group and in that aggregation an undescribed species from southeastern Brazil (represented by a pair deposited in the HHM) has similar male dorsal wing surface coloration. However, the underside pattern of the Brazilian specimens is distinctive, having a conspicuous white median line crossing the forewing

surface from the costa to the anal angle with a lighter ground colour, somewhat like *O. aholiba*. The dorsal blue coloration with brown underside ground colour, plus the reduced pattern, all make *O. faurei* somewhat reminiscent of sympatric *O. elisa*. However, these two taxa are conspicuously different in size (*O. elisa* is much larger with forewing costa length > 14 mm), wing shape (the wing shape of *O. elisa* is rounder), male androconia (*O. elisa* discal cell with scent patch coloured brown distally and black basally) and fine details of the hindwing ventral postmedian pattern (in *O. elisa* the postmedian area has extensive gleaming scales). On the basis of these character differences and available site data (spanning several years and different tepuis), we consider *O. faurei* to be distinct from any of the known *Ocaria* species.

The genus *Ocaria* has more than 15 species in the Neotropical region (Robbins 2004, Bálint & Costa 2012). In the Pantepui two supposedly endemic species have been recorded to date; the above described *O. faurei*, and *O. elisa* Bálint & Costa, 2012. A third widely distributed species, *Ocaria thales* (Fabricius, 1793), has been reported from the Gran Sabana up to maximum elevations of 1100 m and is not a Pantepui endemic. In the following list we present our unpublished Pantepui records of the latter two species and briefly annotate them.

***Ocaria elisa* Bálint & Costa, 2012**

(Figures 21–24)

*Material examined* (n = 11). Venezuela, Bolívar: 1♂, Talud Ptari Tepui, Salto Iworé, 1400 m, 19-XII-2014, *M. Costa* (HNHM); 1♂, Talud Ptari Tepui, 2000 m, 25-XII-2014, *M. Costa* (MC); 1♀, Talud Ptari Tepui, Salto Iworé, 1400 m, 19-XII-2014, *M. Costa* (MC); 1♀, Talud Ptari Tepui, 1800 m, 27-XII-2014, *M. Costa* (MC); 2♀, idem, but 2000 m (MC, HNHM); 1♂, Auyán Tepui, El Peñon, 1850 m, 16-I-2017, *M. Costa/M. Benmesbah* (MC); 1♂, idem, 21-XII-2012, *M. Costa* (MC); 1♀, Auyán Tepui, entre El Danto y El Peñon, 1750 m, 29-III-2015, *M. Costa* (MC); 1♀,

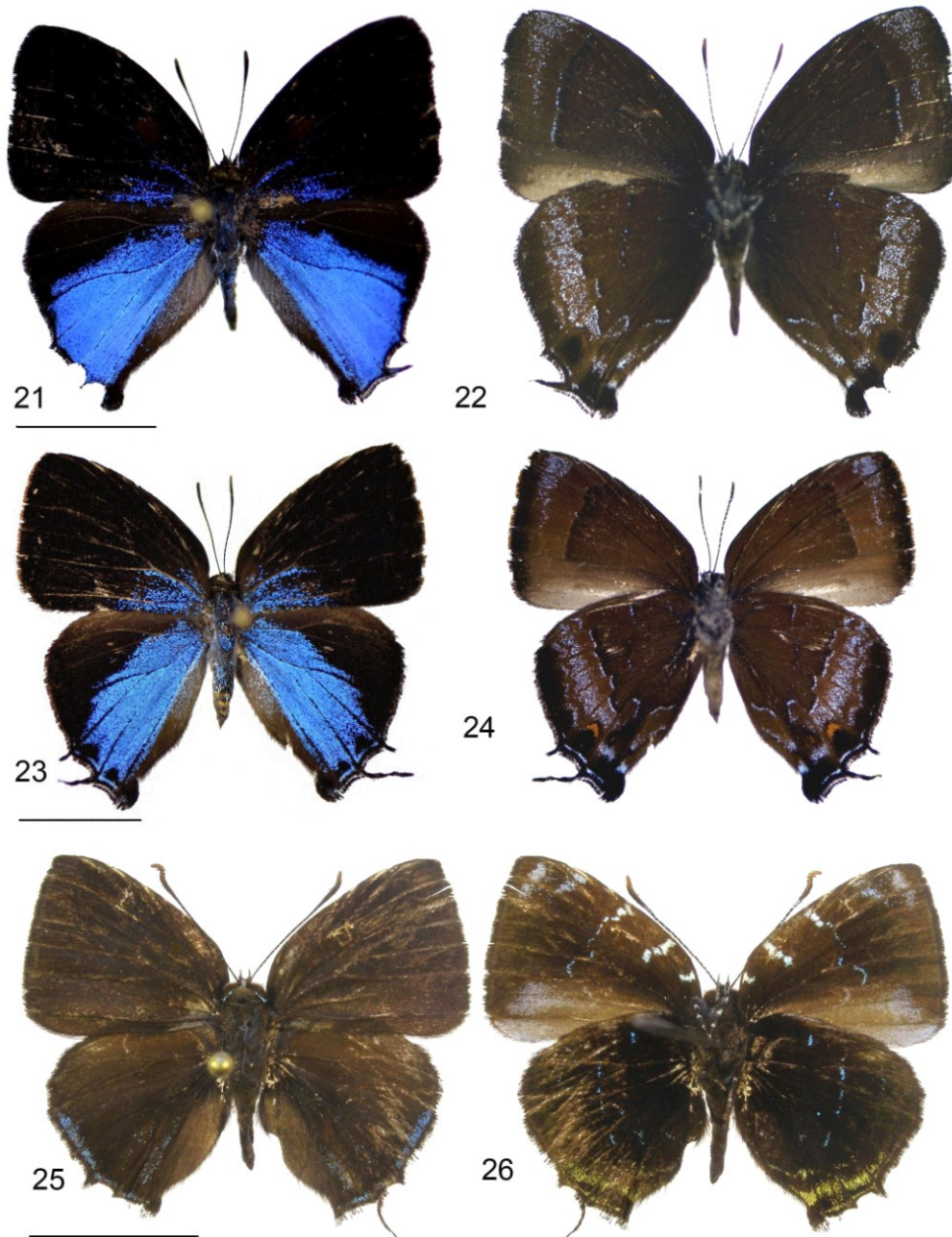
Ptari Tepui, 1900 m, 14-XII-2015, *M. Costa* (MC); 1♀, Talud Ptari Tepui, Salto Iworé, 1400 m, 16-XII-2015, *M. Costa* (MC).

*Remarks.* This species was described recently from the mountains of the Sierra de Lema (Gran Sabana), at an elevation of 1400 m (Bálint & Costa 2012). The additional records presented here suggest that the species occurs more frequently at higher elevations and is widespread on the slopes of other tepuis, sharing the very same habitat as *O. faurei*. As in the case of this latter species, there is no record of *O. elisa* from mid elevations (800–1200 m) of the well-sampled Gran Sabana, so we consider this taxon also to be endemic to the Pantepui. A female specimen of *O. elisa* has also been recorded from Mt. Wokomong (Guyana) by Steve Fratello (erroneously reported in Bálint & Costa 2012, Figs. 13–14, from Mt. Roraima, Brazil). Mt. Wokomong is part of the Pantepui (Costa et al. 2014a: 196–198) and, in light of these new records for *O. elisa*, its presence in the Guyanan Pantepui does not seem strange. Although this record was known to us, the specimen could not be examined physically, therefore it was not listed among the paratypes by Bálint & Costa (2012); there was also some doubt that it could be the female of an undescribed taxon of the *O. aholiba* species group illustrated in the same paper (Bálint & Costa 2012: 308, Figs. 15–16). New evidence obtained in recent expeditions have led to the conclusion that the male represented in Figs. 15–16 from Mt. Roraima (Guyana) was indeed the above described *O. faurei*, while the female from Mt. Wokomong (Figs. 13–14) does in fact belong to *O. elisa*. Eumaeine hairstreak females are often difficult to associate with males (cf. Busby et al. 2017) and specimens are in need of thorough evaluation as the Mt. Wokomong female testifies.

***Ocaria thales* (Fabricius, 1793)**

(Figures 25–26)

*Material examined* (n = 5). Venezuela, Bolívar: 1♂, entre S. Elena e Icabarú, km 21, 1000 m, 31-XII-1985, *M. Costa* (MC); 1♂, idem, km 36,



**Figures 21-26.** Additional *Ocaria* species recorded in southeastern Venezuela. 21-24 = *Ocaria elisa* Bálint & Costa, 2012. 21-22 = male, Ptari Tepui, 1900 m, 14.XII.2014 (21 = dorsal, 22 = ventral). 23-24 = female, Auyán Tepui, 1750 m, 29. III.2015 (23 = dorsal, 24 = ventral view). 25-26 = *Ocaria thales* (Fabricius, 1793), male, Sierra de Lema, 1100 m, 1.IV.2007, (25 = dorsal, 26 = ventral). (scale bars = 10 mm; note how *O. elisa* is larger than *O. thales*) (photos: Gergely Katona, HNHM).

900 m, 01-I-1986, *M. Costa* (MC); 1♂, Sierra de Lema, La Escalera, 1100 m, 01-IV-2007, *M. Costa* (HNHM); 1♂ and 1♀, Talud Ptari Tepui, vía Salto Iworé, 1000 m, 11-XII-2015, *M. Costa* (MC).

*Remarks.* This is a Panamerican species (not a Pantepui endemic) recorded from Mexico to southern Brazil, Argentina (Warren *et al.* 2017) and Paraguay (D'Abrera 1995: 1169); it is easy to

identify on the basis of its distinctive wing shape, pattern and coloration.

**Notes on *Strymon* species recorded in the Pantepui region**

(Figures 27–36)

The genus *Strymon* has more than 50 species in the Neotropics (Nicolay & Robbins 2005). In the Pantepui and its underlying areas six of them have been recorded. It is easy to separate these species on the basis of male wing characters, as the key below demonstrates. Hitherto undescribed endemic or unrecorded *Strymon* species may occur in the region (for example: *S. astiocha* (Prittwitz, 1865) *S. istapa* (Reakirt, [1867]) *S. melinus* Hübner, [1818], *S. rufofusca* (Hewitson, 1877)). If they are reported the key presented below will have to be updated.

***Strymon lucena* (Hewitson, 1868)**

(Figures 27–28)

*Material examined* (n = 1): 1♂, Venezuela, Bolívar, Auyán Tepui, El Peñón, 1850 m, 16-I-2017 *M. Costa*, *M. Benmesbah* (MC).

*Remarks.* Robbins (2010: 30) comments on the nomenclatural and taxonomic problems identifying this species and its relatives. The single specimen captured matches well with the type of *Thecla lucena* described on the basis of material originating from Venezuela. The presence of this unique specimen of a widespread lowland Amazonian species, at such a high elevation as El Peñón in Auyán Tepui, can be attributed to straying; strong uplift currents may in fact transport butterflies to areas far from their normal habitat, as happens occasionally with the finding of solitary specimens of common lowland species on the summits of the highest tepuis, as is the case of a male specimen of *Marpesia chiron* (Fabricius, 1775) found (MC) on the plateau of Mt. Roraima at an altitude of 2750 m or a male specimen of *Prepona claudina sardanapalus* (H. Bates, 1860) found near the summit of Sororopán Tepui (2050 m) at 1900 m.

***Strymon megarus* (Godart, [1824])**

(Figures 29–30)

*Material examined* (n = 8). Venezuela, Bolívar: 2♂, 1♀, vía Karuay-Iworé, 1050 m, 04-I-2012, *M. Costa* (MC); 1♂, vía Uruyén-Guayaraca, 1000 m, 22-III-2013, *M. Costa* (MC); 1♂, Auyán Tepui, entre Uruyén y Guayaraca, 1000 m, 28-III-2013, *M. Costa* (MC); 1♂, Auyán Tepui, Guayaraca, 1100 m, 10-I-2017 *M. Costa*, *M. Benmesbah* (MC); 1♂, 1♀, *idem*, 21-I-2017 *M. Costa*, *M. Benmesbah* (MC).

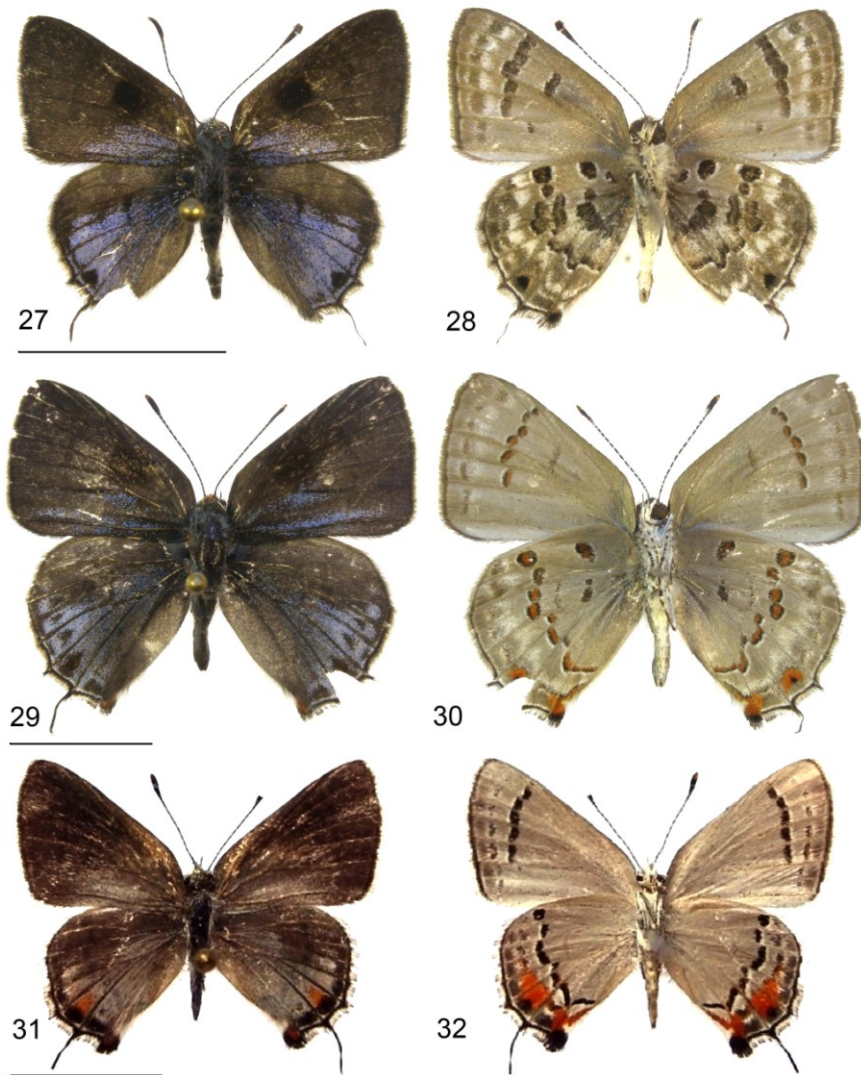
*Remarks.* This is a Panamerican species recorded from Mexico to southern Brazil (D'Abbrera 1995: 1239 [as *S. basilides* Geyer], Warren *et al.* 2017). Robbins (2010) distinguishes three phenotypes characteristic of the Transandean, Amazonian and Atlantic areas (*sensu* Brown 1982), leaving open the question whether they are distinct species or geographical or clinal forms. All specimens reported from areas underlying the Pantepui match well with the Transandean phenotype.

***Strymon sabinus* (Felder & Felder, 1865)**

(Figures 31–32)

*Material examined* (n = 1). 1♂, Venezuela, Bolívar, Auyán Tepui, El Peñón, 1850 m, 03-IV-2014, *M. Costa* (MC).

*Remarks.* D'Abbrera (1995: 1238) indicates the distribution as Colombia to Brazil, and figures the “holotype” of *T. sabinus* (actually a syntype, see Bálint & Goodger 2003) and a female from “Venezuela, Valencia”. Le Crom & Johnson (1997) recorded and figured *S. sabinus* from “Colombia, Meta, Remolinos”. Robbins (2004) placed the taxa *Thecla sabinus* (type locality: “Bogotá”) and *Thecla promissa* Möschler, 1883 (type locality: “Surinam”) in synonymy. The holotype of *T. promissa* is a male specimen, whilst the known syntype of *T. sabinus* is a female; they represent most probably the same species correctly known as *Strymon sabinus*. The presence of this apparently lowland taxon on the high slopes of Auyán Tepui is unusual; however it seems to be a stray, as in the case of *S. lucena* above.



**Figures 27-32.** Additional *Strymon* species recorded in southeastern Venezuela. 27–28 = *Strymon lucena* (Hewitson, 1868), male, Auyán Tepui, 1850 m, 16.I.2017 (27 = dorsal, 28 = ventral). 29–30 = *Strymon megarus* (Godart, [1824]), male, Auyán Tepui, 1100 m, 21.I.2017 (29 = dorsal, 30 = ventral). 31–32 = *Strymon sabinus* (Felder & Felder, 1865), female, Auyán Tepui, 3.IV.2014 (31 = dorsal, 32 = ventral). (scale bars = 1 cm; note the respective size differences of the three species) (photos: Gergely Katona, HHNM).

***Strymon serapio* (Godman & Salvin, 1887)**

(Figures 33–34)

*Material examined* (n = 2). Venezuela, Bolívar): 1♂, Chimantá Massif, Akopán Tepui, Camp. Base, 2000 m, 28-XII-2013 *M. Costa* (MC); 1♀, *idem*, 30-XII-2013, *M. Costa* (MC).

*Remarks.* D’Abrera (1995: 1238) indicates that the species “*serapio*” has a Central American

distribution (“Mexico to Panama”), whilst Warren *et al.* (2017) note its occurrence in Texas (as a stray), and extend its range to southern Brazil. Robbins (2004) listed ten available names as junior synonyms of *S. serapio*; specimens and types of these taxa appear on the Warren *et al.* (2017) website (which follows Robbins 2004), indicating that (a) either there is a single species with unusually wide phenotypical plasticity or (b) there is a complex of several species. Indeed, Robbins (2010: 32) suggests that in his concept of



*S. serapio* there is probably more than one species. On the basis of the material at our disposal we are unable to reach a satisfactory decision about the taxonomy of the various phenotypes. However, we remark that in light of the working hypothesis “b” the Chimantá Massif material may represent an undescribed taxon or represents an Amazonian-Guianan species. The Chimantá Massif is an impressive group of 12 tepuis whose plateau cover a total area of 616.5 km<sup>2</sup> and, with the slopes included, this reaches almost 1000 km<sup>2</sup> (Costa et al. 2014a: 196–197); the elevation of the Chimantá plateau varies between 2100 and 2650 m. This taxon is surely a resident of the summits; the two specimens (male and female) were collected on the expedition to the plateau of Akopán (2000 m) in December 2013. The habitat is characterized by the vegetation of the tepuian plateau, where most plant genera and species are endemic (for example, *Brocchinia* Schultes, 1830,

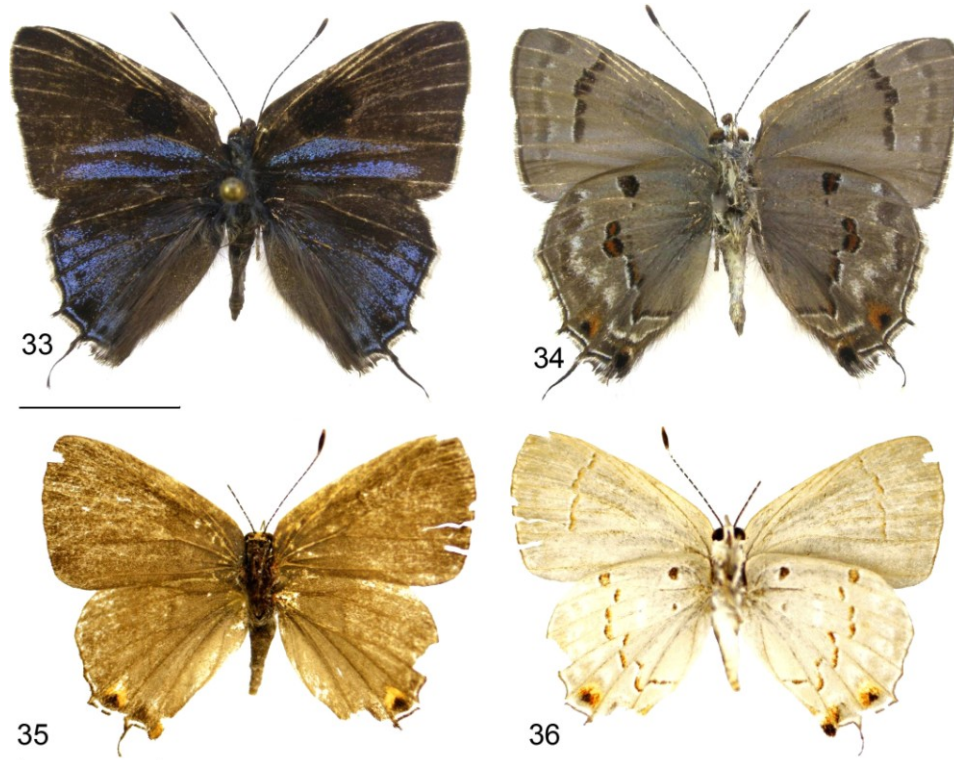
*Stegolepis* Klotzsch ex Körnicke, [1872], and *Bonnetia* von Martius, [1826]); it is very unlikely that a lowland species can adapt to this type of environment.

***Strymon ziba* (Hewitson, 1868)**

(Figures 35–36)

Material examined (n=1). 1♀, Venezuela, Bolívar, Sierra de Lema, La Escalera, 1450 m, 16-IV-1984, M. Costa (MC).

*Remarks.* This is one of the most widespread American hairstreaks, a pest of Bromeliaceae (Robbins 2010). It is recorded from Mexico to southern Brazil and Argentina (Warren et al. 2017). Robbins (2010) notes that it is a common lowland species in the Neotropics. We consider this specimen to represent a stray, and do not consider *S. ziba* to belong to the Pantepui fauna.



**Figures 33–36.** Additional *Strymon* species recorded in southeastern Venezuela. 33–34 = *Strymon serapio* (Godman & Salvin, 1887), male, Akopán Tepui, 2000 m, 28.XII.2013 (33 = dorsal, 34 = ventral). 35–36 = *Strymon ziba* (Hewitson, 1868), female, Sierra de Lema, 1450 m, 16.IV.1984 (35 = dorsal, 36 = ventral). (scale bars = 10 mm; note the respective size difference of the two species) (photos: Gergely Katona, HNHM).



Figure 37. Geographical location of the tepuis mentioned in this paper for *Ocaria* and *Strymon* taxa (compilation: Gilles Séraphin).

Table 1. Details of localities referred to in the text and on the map (Fig. 37) for taxa endemic to the Pantepui region: *Ocaria elisa*, *O. faurei* sp. nov., *Strymon auyana* sp. nov. and *S. serapio* (or a possibly undescribed species).

LOCALITY	COORDINATES	ELEVATION	SPECIES
<b>Ptari Tepui</b>			
Salto Iworé	05°43'34"N; 61°48'36"W	1400 m	<i>O. elisa</i>
Between Punto Phelps and Base Camp (Ptari Tepui)	05°45'32"N; 61°48'53"W	1800 m	<i>O. elisa</i>
	05°45'41"N ; 61°48'59"W	1900 m	<i>O. elisa</i>
Base Camp (Ptari Tepui)	05°45'41"N ; 61°48'49"W	2000 m	<i>O. elisa</i> , <i>O. faurei</i>
<b>Akopán Tepui</b>			
Akopán tepui slope	05°12'34"N; 62°00'32"W	1400 m	<i>O. faurei</i>
Base Camp	05°11'38"N; 62°02'41"W	2000 m	<i>S. serapio</i> (possible new taxon)
<b>Auyán Tepui</b>			
El Danto	05°43'45"N; 62°32'24"W	1500 m	<i>S. auyana</i> , <i>O. faurei</i>
Entre El Danto y El Peñón	05°44'19"N; 62°32'14"W	1700 m	<i>S. auyana</i> , <i>O. faurei</i>
El Peñón	05°44'40"N; 62°32'27"W	1850 m	<i>O. elisa</i> , <i>O. faurei</i> ,
<b>Mt. Wokomong</b>			
Mt. Wokomong slopes	Not available	1500 m	<i>O. elisa</i>
<b>Mt. Roraima</b>			
Base Camp	05°08'52"N; 60°46'53"W	1900 m	<i>O. faurei</i>

**Key to the *Strymon* species of the Pantepui  
based on males**

1. Male, dorsal forewing surface without scent patch, ventral hindwing surface with submarginal spot in space Sc+R1-Rs. .... **2**  
 – Dorsal forewing surface with scent patch, ventral hindwing surface with additional postbasal or median spot in space Sc+R1-Rs ..... **3**
2. Dorsal wing surface basal areas with structural blue colour on both wings, ventral wing surface ground colour light grey ..... ***S. sabinus***  
 – Dorsal wing surface basal areas brown without structural coloration, ventral wing surface ground colour greyish dark brown ..... ***S. auyana* sp. nov.**
3. Hindwing ventral surface without postbasal markings ..... ***S. serapio***  
 – indwing ventral surface with postbasal markings ..... **4**
4. Dorsal wing surface without blue scaling ..... ***S. ziba***  
 – Dorsal wing surface with blue scaling ..... **5**
5. Ventral wing surface postbasal and medial pattern composed of orange and brown coloured scales with conspicuous discal spots ..... ***S. lucena***  
 – Ventral wing surface postbasal and median pattern composed of red and brown scales with faint or missing discal spot ..... ***S. megarus***

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## Revisiting the genus *Aethaloptera* Brauer (Trichoptera, Hydro- psychidae, Macronematinae): new species and records

J. OLÁH

János Oláh, Residence postal address: Tarján u. 28, H-4032 Debrecen, Hungary. E-mail: profolah@gmail.com

**Abstract.** The taxonomic potential of speciation traits, the adaptive structural components of the phallic head that build the early stages of reproductive barriers was applied in our first revision of the *Aethaloptera* genus with unsettled obscured taxonomy. The present paper complements the first revision and is based on the examination of the historical *Aethaloptera* collection of the Natural History Museum, London. The difficulty of presenting the tiny, subtle, but stable divergences in the speciation traits is discussed. The presented graphical copy of phenomic reality delineates species reliably if the matrices of the drawings from various populations, clearly visualizes empirically, without geometric morphometrics, that the detected shape divergences are larger than the combined variation ranges of the artefacts and of the infra-populations. Based upon the lateral profiles of the phallic head two new species complexes: *A. dispar* and *A. maxima* and four new species have been described: *A. nulta* sp. nov., *A. pipa* sp. nov., *A. feltora* sp. nov. and *A. pricei* sp. nov.

**Keywords.** Speciation trait, phallic head, new species.

### INTRODUCTION

The taxonomy of *Aethaloptera* genus was based primarily on tibial spur formula, on wing venation and on forewing pattern of the brown spots (Kimmins 1962). Most of these characters are represented by neutral traits less stabilised in the elaborated networks of protective mechanisms against the stochastic nature of random impacts. Already Kimmins (1962) has recognised that male genitalia, though similar, are not uniform in details and the variations do not correlate with spur and wing characters. This discordance has generated the widespread view of the widely distributed and highly variable species. Accordingly the four African species were considered to represent only a single species with local forms (Kimmins 1962). Others have suggested a more diverse nature of the genus, at least in the Afrotropical faunal region (Lestage 1936, Marlier 1943, Statzner & Gibon 1984, Ogbogu 2005). Only a detailed study of long series of specimens could help to solve the taxonomy of the *Aethaloptera* genus (Barnard 1980). However, the principle and practice of population sampling that

is to collect large number of specimens from each habitat is only a dream in the present devastated state of our taxonomy.

The discovery of speciation traits, the adaptive structural components of the phallic organ that build the early stages of reproductive barriers, has initiated our first trial to revise the obscured *Aethaloptera* genus applying the lateral profile of phallic head for species delineation (Oláh 2018). After publishing this paper we have received the entire *Aethaloptera* collection of the Natural History Museum, London to supplement our first trial. In this paper we give some additional evidences of subtle, but stable divergences between the phallic head of species. We demonstrate the stability and applicability of the phallic head, as adaptive speciation trait in new species delimitation based on the re-examination of some old historical specimens kept pinned and dry as well as on the study of materials from some new collections stored in alcohol. The immense taxonomic potential of the complex invaginated internal structures is not utilised here in distinguishing between species.

### How to present subtle divergences?

At the Macronematinae subfamily the highly specialised derived state in the organisation of the phallic structure is the result of modification by reduction and simplification, a kind of complexity increase by incremental subtraction (Esteve-Altava *et al.* 2013). The primordial phallic structures (aedeagus, endotheca, endophallus, and endothecal processes) have been abbreviated and moved to the apical region of the phallotheca. Thereafter they became retracted (inverted or invaginated) inside the very tip of the tubular phallotheca (Oláh 2018). The resulted compact phallic head retained or even increased its complexity by inversion, anisomerism, unpaired structures, density of connections, path and cluster development (Oláh *et al.* 2014). The simple head with this inverted complexity is under the permanent pressure of sexual integration. This intense pressure has induced and powered the apparently high diversity of adaptive shape divergences.

The neutral traits of spur number, wing venation and forewing spot pattern are exposed to stochastic mechanisms with random variation. The adaptive speciation trait of the phallic head with very elaborated and complex internal structure has subtle, but well-defined and rather stable shape divergences. Its stability is maintained by a network of very complex protective mechanisms (Oláh & Oláh 2017). Moreover, we have learnt from sophisticated molecular genetic studies on *Drosophila* genus that even a very simple divergence in shape profiles, like a simple lobe on a key genitalic structure, is organised, produced and protected by very complex cooperation of several thousand sequences in quantitative trait loci and superimposed by epistatic and epigenetic interferences and sequence interactions (Oláh *et al.* 2017). It was just a modern wishful dream of reductionism in the gene industry to abstract the reality into mathematical and statistical models how the building of such a complex system like the inverted phallic head of the *Aethaloptera* genus with incremental subtraction is organised by integration on molecular level.

Studying subtle phenomic differences on the speciation traits we work nearby the structural diverging point of the initial split criteria. Contrary to the basic problem of genomic virtuality, here we face the challenge how to present, by drawings, the phenomic reality of speciation trait with tiny shape divergences in fine phenomics, because: (1) according to the “identity of indiscernibles” every entity is different; (2) therefore every subtle and stable divergence of speciation trait has some level of individual variation; (3) moreover, there are various hybrids from contact zone with intermediate byproducts; (4) every consecutive drawings prepared by the same person from the same individual is different; (5) every person has different drawing style and capacity. In addition to these challenges we have surveyed eleven potential sources of artefacts in order to pay due attention in distinguishing between subtle adaptive divergences, artefacts and infra-population trait variations (Oláh *et al.* 2015).

The best empirical solution to the presentation problem of these tiny divergences is to compose and to build matrices of the drawn diverged speciation traits from as much populations as possible. We use the word “matrix” in its original sense: the basic material of something, the ground, the origin or the parent Mather (=mater) of species delineation. This original sense of “everything” is abstracted in mathematics to rectangular array of grids, in rows and columns to express numbers, symbols or anything when using the word “matrix”. This graphical copy of phenomic reality delineates species reliably if the matrices of the drawings from various populations, clearly visualizes empirically, without geometric morphometrics, that shape divergence is larger than the combined variation range of artefacts and of infra-populations. We have experienced and documented in several caddisfly taxa that the epistemic power/visual perception of the multiple drawings concentrated in matrices is demonstrative and convincing compared to the single drawing of a particular specimen (Oláh *et al.* 2013, 2014, 2015, 2016, 2017).

In *Aethaloptera* genus the drawings of lateral profile of the phallic head properly observable by

stereomicroscopy are the most stable form of presentation to document species level divergences. The dorsal, ventral and caudal forms of phallic head are not stable; their actual shape is highly dependent on the opening state of the aperture rim, moreover the caudal view is very sensitive to slight changes of viewing angles.

## MATERIALS AND METHODS

The old historical material of MacLachlan, Ulmer, Martynov, Mosely and Kimmins deposited in the Natural History Museum, London are composed of mostly pinned female specimens. The study of old dry pinned specimens is not easy and is highly taxon-specific. We need to cut some apical abdominal segments with the genitalia or need to remove the entire abdomen for cleaning, clearing and dissecting. Frequently we need to cut the head and thorax also for preparation. In some taxa like *Rhyacophila* the abdomen removal from pinned dry specimens is easier. In the case of *Aethaloptera* female it is almost impossible. The abdomen is usually fully packed with eggs and usually broken together with the metathorax. Moreover female taxonomy, especially at the Afrotropical species is not elaborated. We believe that in the case of caddisflies it is advisable to transfer dry pinned ordinary specimens to alcohol; otherwise its proper study is difficult or almost impossible, especially in the case of microcaddisflies. From the Natural History Museum, London we have examined all the materials which were stored in alcohol, but only those pinned specimens which have and give important taxonomical information at the present level of our knowledge.

*Depositories.* Natural History Museum, London, (NHMUK); formerly the British Museum Natural History, London, England (BMNH).

Oláh Private Collection, Debrecen, Hungary, under national protection by the Hungarian Natural History Museum, Budapest, Hungary (OPC).

Queensland Museum, Brisbane, Australia (QM).

Zoologisches Museum, Hamburg, Germany (ZMH)

## TAXONOMY

### *Aethaloptera* Brauer, 1875

Character ranking to establish the taxonomical position of the genus *Aethaloptera* has recently been summarized and presented by ranking synapomorphies (Oláh 2018). The Macronematinae subfamily was delimited in the Hydropsychidae family by the elongated antennae; the Polymorphanisini tribe by the vestigial mouthparts; the *Aethaloptera* genus by the false discal cell, the species group inside the *Aethaloptera* genus by the position of the aperture slit on the apical ending of the phallotheca; and the species by the shape of the phallic head.

### *Aethaloptera dispar* species group

According to the area principle this is the ancestral species group being distributed in very large area over the Afrotropical, Palaearctic, Oriental and Australasian faunal regions. The area principle is confirmed by the fact that all members of the group have the plesiomorphic character state of the terminal opening of the phallotheca: the group is delimited by the apical or nearly apical, slightly apicodorsal position of the aperture rim of the invaginated distal end of the phallotheca, the entrance atrium and its apical opening with the rim configuration (Oláh 2018).

### Afrotropical species

Based on discordances between variations of spur, wing and phallic head, Kimmins (1962) has considered that *A. dispar* and *A. maxima* may be only local forms of one widely distributed species. According to Lestage (1936) and Marlier (1943) *A. dispar* alone may represent 3 species just in Belgian Congo. Applying the adaptive speciation trait of the phallic head we distinguish two species complexes in the Afrotropical species of the *A. dispar* species group: (1) *A. dispar* species complex having phallic head somewhat rounded subquadrangular; (2) *A. maxima* species complex having phallic head simply rounded.

***Aethaloptera dispar* complex**

This is a well-defined species complex with rounded sub-quadrangular lateral profile of the phallic head. Further divergences in the complex are organised by the particular formation of sub-quadrangularity of the phallic head as well as by the neck and head formation.

***Aethaloptera dispar* Brauer, 1875**

(Figures 1–7)

*Material examined.* **Democratic Republic of the Congo** (Congo, Zaire), 1900, leg. G.L.E. Andraee, 1900-38, NHMUK012501687, det. M. E. Mosely as *A. dispar*, (1 male, NHMUK).

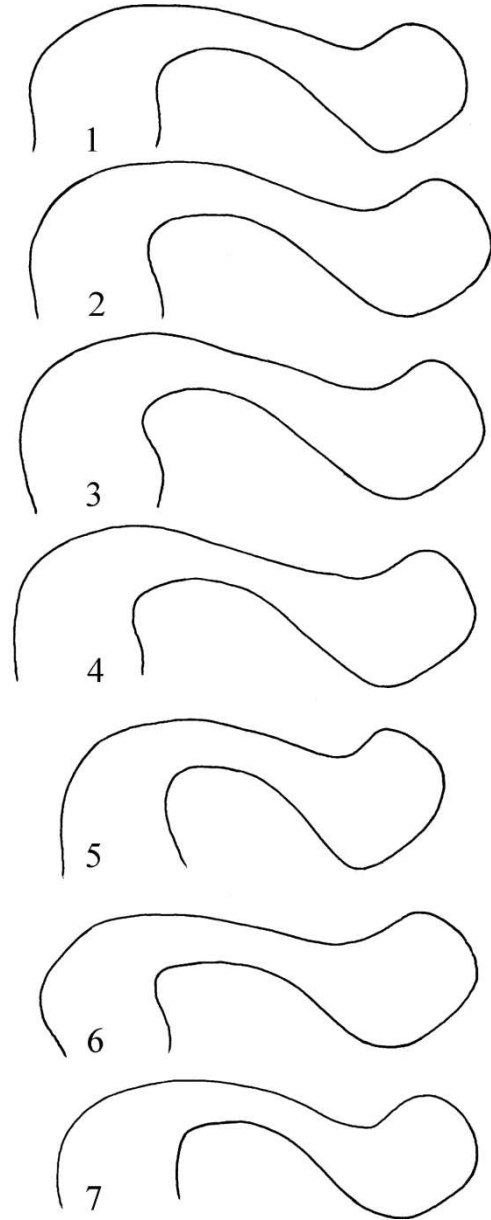
*Remarks.* The obliquely upward directed phallic head is typically sub-quadrangular. The head is low, that is the neck is almost as high as the head. The genuine species of *A. dispar* is reported here from Senegal (Lectotype) through Ghana and Republic of Congo to Democratic Republic of Congo.

***Aethaloptera nulta* sp. nov.**

(Figures 8–11)

*Material examined.* **Holotype: Malawi.** (Nyasaland), Ntundu, 7.VIII.1952, leg. Lewis Berner, 7-852-1, B.M.1953-668, NHMUK012501661, D. E. Kimmins det. 1954 as *A. dispar* (1 male, NHMUK). *Paratypes:* same as holotype (3 males, NHMUK; 1 male, OPC). **Zambia,** (North Rhodesia), Karambora, 1962, leg. E. Pinhey, B.M. 1962-428, NHMUK012501703, det. P.C. Barnard 1977 as *A. dispar* (2 males, 2 females; NHMUK). Zambia, (North Rhodesia), Karambora, Zambezi River, IV.1962, leg. E. Pinhey, B.M. 1962-428, NHMUK012501703, det. D.E. Kimmins 1962 as *A. dispar* (6 males, NHMUK; 3 males, OPC).

*Diagnosis.* The obliquely upward directed phallic head remained sub-quadrangular, but not typical of the nominate species *A. dispar*, somewhat widening apicad, somehow funnelling. The head is elongated, not low like in *A. dispar* that is the neck is only half as high as the head. The species is recorded from the basin of Zambezi River.



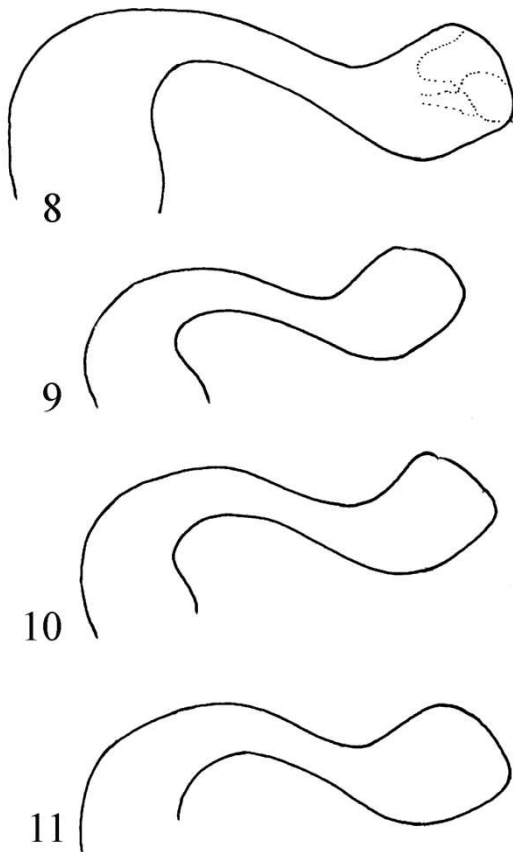
**Figures 1–7.** *Aethaloptera dispar* Brauer, 1875. Lateral profile of the phallic organ from various populations: 1 = Lectotype from Senegal, drawn by Barnard (1980); 2–5 = specimens from Republic of the Congo; 6 = specimen from Democratic Republic of Congo; 7=specimen from Ghana drawn by Kimmins (1962).

*Description.* Medium-sized species. In alcohol the head and thorax yellowish brown, legs yellow, abdomen light, darker dorsally. Spur formula 032. Forewing length around 10 mm; wing colour pale, fading to yellowish brown; less pronounced and variously discernible seven brown spots present



on cross-veins and on fork junctions. Sc and R1 sinuous apically, fork 4 is long stalked in forewing. Fork R4 in hindwing sessile. The basic structure of the male genitalia is similar to *A. dispar*, but differs by the divergences in the phallic head formation as discussed in diagnosis.

*Etymology.* *nulta*, from „nyult” lengthened, elongated in Hungarian, refers to the upward elongated head, twice the length of the phallic neck.



**Figures 8–11.** *Aethaloptera nulta* sp. nov. Lateral profile of the phallic organ from various populations: 8 = Holotype male from Malawi; 9–11 = Paratypes from Zambia;

***Aethaloptera pipa* sp. nov.**

(Figures 12–15)

*Material examined.* **Holotype:** Democratic Republic of the Congo (Belg. Congo), Kabalo, V.1926, leg. Dr. Schoubeden(?), 1935-232,

NHMUK012501658, det. M.E. Mosely as *A. dispar* (1 male, NHMUK). *Paratypes:* same as holotype (5 males, NHMUK; 1 male, OPC). **Ghana**, Black Volta, at light, 1967, leg. T. Petr, 1968-267, NHMUK012501700, det. D.G. Gibbs as *A. dispar* (1 male, NHMUK). Ghana (Gold Coast), Afram River, Mankrong, 13.IX.1950, leg. Lewis Berner, Brit.Mus. 1953-668, NHMUK 012501654, det. D.E. Kimmins, 1957 and det. D. G. Gibbs as *A. dispar* (1 male, 1 female; NHMUK). **Sierra Leone**, Njala, II.–IV. 1925, at light, leg. E. Hargreaves, NHMUK012501640 (1 male, NHMUK).

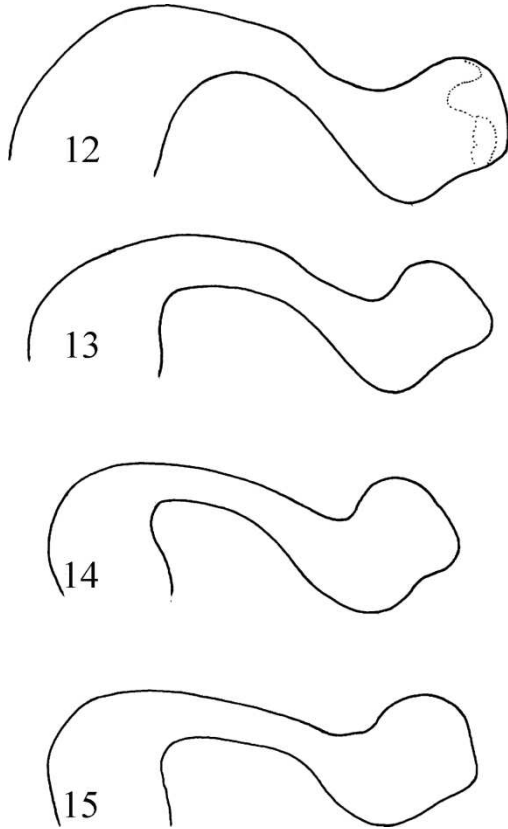
*Diagnosis.* The obliquely upward directed phallic head remained sub-quadrangular, but not typical of the nominate species *A. dispar*, and not funnelling like *A. nulta* sp. nov. somewhat irregularly patterned, but pipe-shaped and usually concave apicoventrad and convex apicodorsad. The head is elongated, like *A. nulta* sp. nov. and not low like *A. dispar*; the neck is lower than the head. The specie is recorded from Sierra Leone to Democratic Republic of the Congo.

*Description.* Medium-sized species. In alcohol the head and thorax yellowish brown, legs yellow, abdomen light, darker dorsally. Spur formula 032. Forewing length around 12 mm; wing colour pale, fading to yellowish brown; less pronounced and variously discernible seven brown spots present on cross-veins and on fork junctions. Sc and R1 sinuous apically, fork 4 is sessile in forewing. Fork R4 in hindwing sessile. The basic structure of the male genitalia is similar to *A. dispar*, but differs by the divergences in the phallic head formation as discussed in diagnosis.

*Etymology.* *pipa*, from „pipa” pipe, tobacco pipe in Hungarian, refers to the pipe-shaped modification of the phallic head.

***Aethaloptera maxima* complex**

This is a well-defined species complex with rounded lateral profile of the phallic head. Further divergences in the complex are organised by the particular formation of the circularity of the phallic head as well as by the neck and head formation.



**Figures 12–15.** *Aethaloptera pipa* sp. nov. Lateral profile of the phallic organ from various populations: 12 = Holotype male from Ghana, Volta River; 13 = Paratype from Ghana, Afram River; 14 = Paratype from Democratic Republic of the Congo; 15 = Paratype from Sierra Leone.

***Aethaloptera feltora* sp. nov.**

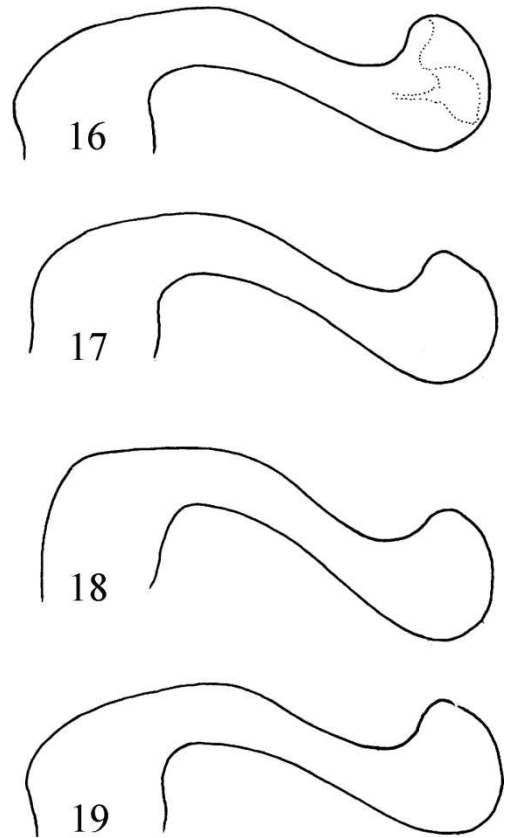
(Figures 16–19)

*Material examined.* **Holotype:** Zambia, Chipopo, Middle Zambesi, 25.X.1956, ZGC145, caddis pupae and adults from tigerfish stomach (few free) (1 male, NHMUK). *Paratypes:* same as holotype (16 males, NHMUK; 6 males, OPC).

*Diagnosis.* The obliquely upward directed phallic head remained rounded, but not typical of the nominate species *A. maxima*, somehow particularly patterned. The dorsoapical region of the phallic head upward directed with a blunt tip; it has some resemblance to a water drop.

*Description.* Large-sized species. In alcohol the head and thorax yellowish brown, legs yellow, abdomen light, darker dorsally. Spur formula 022. Forewing length around 14 mm; wing colour pale, fading to yellowish brown; less pronounced and variously discernible seven brown spots present on cross-veins and on fork junctions. Sc and R1 sinuous apically, fork 4 is stalked in forewing. Fork R4 in hindwing sessile. The basic structure of the male genitalia is similar to *A. maxima*, but differs by the divergences in the phallic head formation as discussed in diagnosis.

*Etymology.* *feltora*, from „feltör” upwards in Hungarian, refers to the upward directed apico-dorsal region of the phallic head.



**Figures 16–19.** *Aethaloptera feltora* sp. nov. Lateral profile of the phallic organ: 16 = Holotype male from Zambia, Middle Zambesi River; 17–19 = Paratypes from the Holotype’s population.

***Aethaloptera maxima* Ulmer, 1906**

(Figures 20–25)

*Material examined.* Male holotype destroyed (Weidner 1964). *Neotype* examined, drawn, designated and deposited in the Zoologisches Museum, Hamburg by Barnard (1980). Here, two males were examined and drawn collected together with the neotype and deposited in NHMUK: **South Africa**, Waterval River, National Road between Standerton and Greylingstad, 12.I.1959, C.S.I.R. Water Research, VAL 518A, Brit. Mus. 1960-383, NHMUK012501652, D.E. Kimmins det. as *A. maxima* (2 males, BMNH). **Zambia** (North-East Rhodesia), Upper Luangwa R., 27.VII.–13.VIII.1910, leg. S.A. Neave, 1911-177, NHMUK012501597, det. D.E. Kimmins, 1960 as *Chloropsyche maxima*, (1 male, BMNH).

*Remarks.* The obliquely upward directed phallic head is typically rounded, almost circular. The head is low, that is the neck is almost as high as the head. The genuine species of *A. maxima* is reported here from South Africa and Zambia.

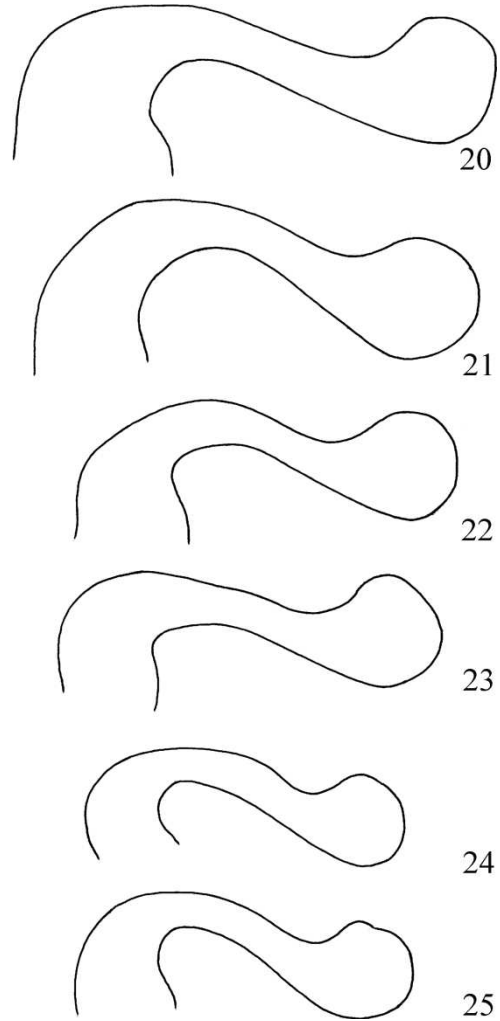
**Palaeartic species**

A single species represents the genus in the Palaeartic fauna region with a distributional range covering Far East Russia and China. The lateral profile of the phallic head is rather stable in all the known populations.

***Aethaloptera evanescens* (McLachlan, 1880)**

*Material examined.* **China**, Pai-se, Kwangsi, 29.III.1939, leg. Richardson, NHMUK012501559, det. M.E. Mosely as *A. rossica*, det. P.C. Barnard 1977 as *A. evanescens* (1 male, NHMUK).

*Remarks.* The single male specimen from China, Kwangsi deposited in the Natural History Museum, London has lateral profile of the phallic head identical with specimens examined from Far East Russia (Oláh 2018).



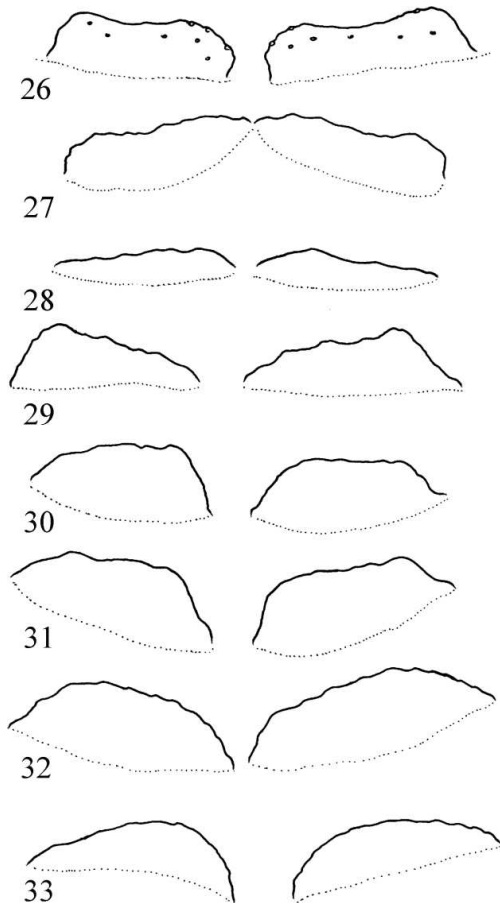
**Figures 20–25.** *Aethaloptera maxima* Brauer, 1906. Lateral profile of the phallic organ from various populations: 20 = Neotype series from South Africa, Waterval River; 21 = South Africa; Vaal River; 22 = Namibia, Orange River; 23 = Namibia, Rundu; 24–25 = South Africa, Kunene River.

**Oriental species**

***Aethaloptera dyakana* Banks, 1920**

(Figure 26)

*Material examined.* **Brunei**, 200', Rampayoh River, waterfall below LP 195, 1-3.III.1982, leg. G.S. Robinson, 7-852-1, BM.1982-156, NHMUK



**Figures 26–33.** The pair of setose sclerites on sternite VIII of the known Oriental species: 26 = *A. dyakana*; 27 = *A. malickyi*; 28 = *A. punctata*; 29 = *A. sexpunctata*; 30–32 = *A. wellsae* from Australia; 33 = *A. wellsae* from New Guinea.

012501678, det. P.C. Barnard 1982 as *A. sexpunctata* (1 female, NHMUK; 1 female, OPC).

**Remarks.** The species is known from a single female collected in Borneo. Ulmer (1951) has synonymized it with *A. sexpunctata* and Barnard (1980) also listed it under *A. sexpunctata*. Based on area principle it was reinstated as a valid species (Oláh 2018). Here we have examined the pair of setose sclerites on the sternite VIII of a female specimen from Brunei and it was clearly diverged and distinguishable from the setose sclerites of the known Oriental species. The setose sclerites are rather high compared to *A. malickyi* and *A. punctata*; sub-quadrangular with concave dorsum, not laterad triangular like *A. sexpunctata* or hump shaped like *A. wellsae*.

***Aethaloptera punctata* (Banks, 1920)**

(Figure 28)

**Material examined.** **Indonesia**, Sumatra, Lahat, 1916, leg. John Henderson Esq., slide, NHMUK010114297, Mosely Coll. B.M. 1938-443 (1 female, NHMUK). **Malaysia**, Perak, Ipoh, Kinta River, XI.1913–III.1914, leg. J. Henderson, NHMUK012501662, det. P.C. Barnard as *A. sexpunctata* (2 females, 1 female without genitalia, NHMUK). Malaysia, Brit. Mus. slide No 98, NHMUK010114298, det. P.C. Barnard as *A. sexpunctata* (1 female, NHMUK).

***Aethaloptera sexpunctata* (Kolenati, 1859)**

(Figure 29)

**Material examined.** **India**, Bihar, Pusa, 27.II.1924, leg. Krishna, T.B. Fletcher Coll. Brit. Mus. 1936-643, NHMUK012501526, det. M.E. Mosely as *A. sexpunctata* (1 male, NHMUK). **Myanmar** (Burma), Prome, 17.II.1917, at light, NHMUK 012501545, det. M.E. Mosely as *A. sexpunctata* (1 male, NHMUK).

**Australasian species**

***Aethaloptera wellsae* Oláh, 2018**

(Figures 30–33)

*Aethaloptera wellsi* Oláh, 2018: 11–13. The incorrect original spelling is corrected here as a justified emendation: *Aethaloptera wellsae* Oláh, 2018. The holotype was repatriated from MPC to QM.

**Material examined.** **Australia**, 20 mls W of Tully, Q. 20.IV.1964, leg. I. F. B. Common & M. S. Upton, NHMUK012501540 (1 female, NHMUK). **New Guinea**, Port Moresby, 1887, leg. Kowald, McLachlan Coll. B. M. 1938-674, B. M. genitalia slide ♀ 99, NHMUK012501546 (1 female, NHMUK). Brit. Mus. Slide No. 99, NHMUK010114296, female genitalia, det. P.C. Barnard as *A. sexpunctata*.

**Remarks.** On the New Guinean specimen the wing venation and forewing spot pattern are simi-

lar to *A. wellsae* Oláh, 2018 described from nearby in northeastern Australia. The pair of setose sclerites on the eighth sternite seems more regularly arch-shaped on New Guinean specimen. This is the first record of *A. wellsae* in New Guinea.

***Aethaloptera meyi* species group**

This derived species group with restricted distribution to the Afrotropical fauna region was established by the anterad moved dorsal position of the aperture rim of the invaginated distal end of the phallosome, the entrance atrium and its apical opening with the rim configuration.

***Aethaloptera meyi* Oláh, 2018**

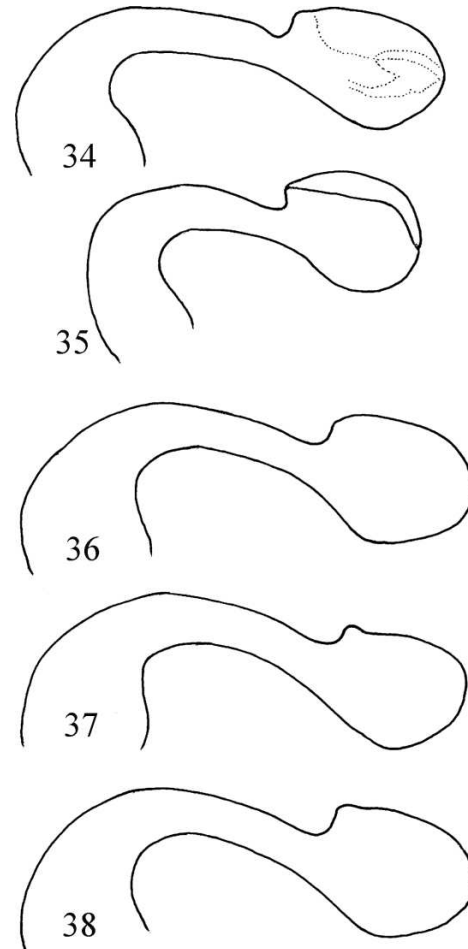
*Material examined.* **Uganda**, West Nile, Albert Nile, Pakwach, 26,29.IV.1956, leg. P.S. Corbet, B.M.1956-751, det. as *A. dispar* (150 males, BMNH; 6 males, OPC). Uganda, West Nile, near Laropi, 27–28.IV.1956, leg. P.S. Corbet, B.M. 1956-751, NHMUK 012501701, P.S. Corbet E.A.F.R.O.Coll. det as *A. dispar*, (9 males, BMNH). Uganda, Victoria Nile, L. Kyoga, near Namasale, 1.V.1956, leg. P.S. Corbet, 1956-751, P.S. Corbet E.A.F.R.O. Coll. 157, det. as *A. dispar* (4 males, 10 females; BMNH). **Sudan** (South Sudan), White Nile, Sudd, Jonglei VIII, lagoon, 6°50'–7°08'N, 31°18'–30°50'E, January 1983, leg. P. Warig, pres. Roland Bailey, NHMUK 012501655, det. P.C. Barnard 1983 as *A. dispar* (1 male, OPC).

***Aethaloptera pricei* sp. nov.**

(Figures 34–38)

*Material examined.* **Holotype:** **Sudan** (South Sudan), White Nile, Sudd, Jonglei VIII, lagoon, 6°50'–7° 08'N, 31°18'–30°50'E, January 1983, leg. P. Warig, pres. Roland Bailey, NHMUK 012501655, det. P.C. Barnard 1983 as *A. dispar* (1 male, BMNH). **Paratypes:** same as holotype (7 males, BMNH; 3 males, OPC).

*Diagnosis.* In the obscured taxonomical state of the genus this remarkable species distinguished



**Figures 34–38.** *Aethaloptera pricei* sp. nov. Lateral profile of the phallic organ from various populations: 34 = Holotype: Sudan (South Sudan), White Nile, Sudd; 35 = Holotype: lateral profile viewed from slightly apicodorsal view to see the aperture rim. 36–38 = Paratypes: Sudan (South Sudan), White Nile, Sudd.

easily from the other member of the *A. meyi* species group was determined by Barnard (1980) as *A. dispar*, the nominate species of another species group, the *A. dispar* species group. This new species, like the other known 3 species of the *A. meyi* species group (*A. felalla*, *A. karima*, *A. meyi*) has the aperture rim moved dorsad as compared to the apical rim position at the *A. dispar* species group. *Aethaloptera pricei* sp. nov. differs from the known species of the group by having the lateral profile of the phallic head abbreviated, more rounded, not elongated; the lateral profile is more produced ventrad into variously developed ventral triangle hump.

*Description.* Medium-sized species. In alcohol the head and thorax yellowish brown, legs yellow, abdomen light, darker dorsally. Spur formula 032. Forewing length around 12 mm; wing colour pale, fading to yellowish brown; less pronounced and variously discernible seven brown spots present on cross-veins and on fork junctions. Sc and R1 sinuous apically, fork 4 is short stalked in forewing. Fork R4 in hindwing sessile. The basic structure of the male genitalia is similar to *A. karima*, but differs by the divergences in the phallic head formation as discussed in diagnosis.

*Etymology.* This species was named and dedicated to Benjamin Price, from the Natural History Museum, London to remember his significant contribution by sending historic and newly collected materials to the revisions of several limnephilid genera.

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# Bibliography of hydrobiological research on the Gemenc and Béda – Karapanca floodplains of the River Danube (1498 – 1436 rkm) including the publications of the Danube Research Institute of the Hungarian Academy of Sciences between 1968 and 2017

Á. BERCZIK & M. DINKA

Árpád Berczik & Mária Dinka, Hungarian Academy of Sciences, Centre for Ecological Research, Danube Research Institute 1113. Budapest, Karolina út 29. E-mails: [berczik.arpad@okologia.mta.hu](mailto:berczik.arpad@okologia.mta.hu); [dinka.maria@outlook.hu](mailto:dinka.maria@outlook.hu)

**Abstract.** A compilation of the published research from the Danube Drava National Park on the Gemenc and Béda-Karapanca floodplains of the River Danube is presented. 79 publications are included which were focused on this area and accomplished by the Danube Research Institute.

**Keywords.** Bibliography, floodplains, Danube-Drava National Park, Gemenc, Béda-Karapanca.

## INTRODUCTION

The Danube River is *ca.* 2850 km long. Its middle section, which crosses the Carpathian Basin is accompanied by a *ca.* 25 000 hectare active floodplain (having a water level fluctuation of 8 m) with several side arms. This area represents a unique natural resource in Europe and from 1996 it was designated as the Danube - Drava National Park, a Ramsar site, and included as a UNESCO Biosphere Reserve.

After some pilot studies, the Danube Research Institute of the Hungarian Academy of Sciences together with the International Association for Danube Research (IAD) in 1996 organized its 31<sup>st</sup> conference in Baja near the Gemenc floodplain. The purpose of this conference was to highlight the extraordinary value of this area and the need for more comprehensive research programmes in the region. It also emphasised the growing significance of research on active floodplains. Following the conference the Hungarian Academy of Sciences and different Hungarian state research funds (like AKP, OTKA, KAC, NKFP) agreed to

fund further research in the area. It was of special significance that, thanks to the invitation of professor Dr. Emil Dister (Aueninstitut Rastatt, Germany), our institute could submit a common tender in collaboration with the Aueninstitut Rastatt to the Deutsche Bundesstiftung Umwelt (DBU, Osnabrück, Germany) for an ecological research project. This project would lay the foundation for the natural protection of the Gemenc-Béda-Karapanca floodplains. The tender was successful and accomplished between 2006 and 2010.

The present bibliography includes all the works concerning this area. Author names of staff members of Danube Research Institute, Centre for Ecological Research of HAS are in capitals. Publications supported by the DBU financed project, the names of authors are written in bold.

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