PLOVDIV UNIVERSITY "PAISII HILENDARSKI"
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Biodiversity and distribution of the families Bolitophilidae, Diadocidiidae, Ditomyiidae, Keroplatidae и Mycetophilidae (Diptera) in the Oriental region

A B S T R A C T
of PhD thesis

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Field of higher education: **4. Natural sciences, mathematics and informatics**
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Scientific advisor:
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The PhD thesis contains 264 pages and includes: 9 tables, 71 figures, 4 appendices and 295 literary sources, of which 5 are in Cyrillic and 290 are in Latin.

The dissertation was discussed and proposed for public defense at an extended meeting of the Department of Zoology, Faculty of Biology at the Plovdiv University “Paisii Hilendarski”. (Protocol № 487 from 23.02.2023).

The defense of the dissertation will take place on ……. from ……. o’clock in the ……..… of the Faculty of Biology at PU "Paisii Hilendarski", 2 Todor Samodumov St.

The materials related to the defense are available to the interested parties at the Department of Zoology and in the library of PU "Paisii Hilendarski".

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1. INTRODUCTION

The object of the present study is the representatives of the families Bolitophilidae, Diadocidiidae, Ditomyiidae, Keroplatidae, and Mycetophilidae, belonging to the superfamily Sciaroidea (Insecta: Diptera: Nematocera). To date, a total of 258 genera with 5782 species in the five families have been described for the world. Fungus gnats are distributed all over the globe – from Greenland and Svalbard to the subantarctic islands. They are numerous in forest ecosystems of different types (Økland 1994), preferring moderately moist forest habitats. Fungus gnats are rare in drier forests, but also avoid too-wet habitats, except for those inhabiting the rainforests in the equatorial and subequatorial climatic zones. With the exception of those inhabiting the tundra, they are not found outside forest habitats and do not inhabit arid regions.

According to a recent study of the vertical structure of insect diversity in Amazonia, fungus gnats (of the family Mycetophilidae) were found to exist in greater abundance and species diversity around the ground surface (0 m) and less in the forest upper floors (32 m) although they are also present there. (Amorim *et al.* 2022). According to some estimates, fungus gnats represent 50–80% of all insects caught in traps in temperate forest habitats (Yakovlev 1988). The larvae of most species develop in the fruiting bodies of fungi and are mycetophagous, a small number are xylomycetophagous, zoomycetophagous, zoophagous, or bryophagous (Bechev 2000). The diet of the imago is poorly studied (Amaral *et al.* 2022).

2. PREVIOUS RESEARCH ON THE FUNGUS GNATS OF THE ORIENTAL REGION

First scholarly sources and description of species until the end of the 19th century

The first scientific information about the fungus gnats of the Oriental region dates back to 1848. In the article "List of the specimens of dipterous insects in the collection of the British museum", the British entomologist Francis Walker (1809 – 1874) described the species *Mycetophila bimaculata*. Walker (1856). He later described *Platyura venusta* from material collected by William Wilson Saunders. In 1857, the physician (and zoologist) serving in the Dutch army, Carl Ludwig Doleschall (1828 – 1859), described the species *Sciophila tropica* (Doleschall 1857). The Dutch entomologist Frederik van der Wulp (1818 – 1899) reported *Glaphiroptera winthemii* from Sumatra (Wulp 1892).

The little information available on the fungus gnats of the Oriental region in the 19th century is included in the catalogs published by Bigot (1891) and Wulp (1896).

As a result of the research, until the end of the 19th century, only 4 species of fungus gnats were known for the region (Table 1) – 3 from the family Mycetophilidae and 1 from the family Keroplatidae.

Scholarly sources from the first half of the 20th century (1901 - 1950)

Research on fungus gnats in the Oriental region during the period under review began with the studies of Johannes C. H. de Meijere (1866 – 1947) on the order Diptera in Southeast Asia (De Meijere 1907, 1916, 1924).

In the same period, Enrico Brunetti (1862 – 1927) began to work, and in 1912 he published a monograph on the biodiversity of Diptera (excluding the families Chironomidae and Culicidae) in India. In this work, 74 new species of the families Mycetophilidae and Keroplatidae are described (Brunetti 1912). In 1920, Brunetti published the "Catalogue of Oriental and South Asiatic Nemocera", according to which the currently known species of fungus gnats for the Oriental region were 87 (Brunetti 1920).

In the 1920s, Ronald A. Senior-White (1891 – 1954) published studies on the order Diptera of the Indian subcontinent and the island of Sri Lanka (Senior-White 1921, 1922, 1924).

In the period 1924 – 1935, Frederick Wallace Edwards (1888 – 1940) published a number of studies on Diptera in the Oriental region and in particular on the suborder Nematocera in Sri Lanka, Java, Sumatra, Borneo and the Philippines. As a result of his work, a total of 57 new species were published for the Oriental region (Edwards 1926, 1929, 1931, 1932, 1933, 1935).

There were 178 species from the region described in the first half of the 20th century, and 33 publications (Table 1).

Scholarly sources from the second half of the 20th century (1951– 2000)

In the following two decades, records of fungus gnats in the Oriental region are scarce and are available only for the family Keroplatidae. The authors Tollet, Colless and Coher worked mainly during the period and published studies on the genera *Platyceridion*, *Chetoneura*, *Macrocera* (Tollet 1955; Colless 1962; Coher 1963, 1988).

In 1973 Colless & Leipa published a catalog of the fungus gnats in the Oriental region "A catalog of the Diptera of the Oriental region - Volume 1, Suborder Nematocera" (Colless & Liepa 1973). It includes 183 species for the region, and it represents the most up-to-date similar work for the studied group of insects.

In the last decade of the 20th century, several authors worked on the suborder Nematocera in the Oriental region, providing new faunal and taxonomic data. Among the authors with the most publications in this period are Geir E. E. Søli, on the family Mycetophilidae (Søli 1995, 1996 1997), Dimitar Bechev (Bechev 1994, 1997), Rauno Väisänen, (Väisänen 1996) and others.

There were 253 species from the region described in the second half of the 20th century, and 40 publications (Table 1).

Scholarly sources from the period 2001 – 2022

The mentioned authors Søli (Søli 2002), Bechev (Bechev 2009; Bechev & Kazandzhieva 2020; Kazandzhieva & Bechev 2022) and Väisänen (Väisänen 2013, 2014) continued their research in the first two decades of the XXI century, when new names emerged among the studies of fungus gnats in the Oriental region, such as Ian Ševčík, who is working

on the taxonomy and phylogeny of fungus gnats in the region (Ševčík 2000, 2001, 2009, 2010, 2012).

In the same period Heikki Hippa published a considerable number of studies on the subfamilies Manotinae and Lygistorrhininae (Hippa 2006, 2008, 2009, 2010, 2011), and László Papp (1946 – 2021), whose work was distinguished by extensive studies on fungus gnats in Taiwan (Papp 2002, 2004, 2005). The three authors mentioned have published a number of joint studies on the region.

As a result of research on the mycetophilid fauna in the Oriental region, in the period 2001 – 2022, 331 species of fungus gnats were described and 71 publications were published (Table, 1).

Scolarly sources from the subregion of Southeast China

The greatest contribution to the study of the mycetophilid fauna in the Southeast China subregion was made by the author Hong Wu, who contributed more than 60 publications in the period 1986–2022, covering almost all families of fungus gnats. In the said period, Hong Wu collaborated with other authors, such as Ding Yang, Le-Yi Zheng, Hua-Chao Xu, Xiao-Xia Yu, Yi-Ping Wang, Jian Cao, etc.

More recent research on the subregion has been published collectively by Quingyun Wang, Junhao Huang, Lei Qi and Hong Wu (Wang *et al*. 2021, Qi *et al*. 2022).

Table 1. Number of publications and described species according to periods

Period	until 1900	1901 – 1950	1951 – 2000	2001 – 2022	total
Publications	4	33	40	71	148
Described species	3	178	253	331	765

3. AIM AND OBJECTIVES OF THE STUDY

The aim of the study is to clarify the species diversity and zoogeographic features of the mycetophilid fauna in the Oriental region, based on faunal and taxonomic studies, and summarizing all available data.

To accomplish this goal, the following **tasks** were set:

1. Collecting all literature data on the five families of fungus gnats for the Oriental Region, including a review of all the literature for China, and separation of the species known from the southern Chinese provinces, part of the Oriental Region;

2. Examination and determination of materials collected from the region of Southeast Asia, received from the Natural History Museum – Ljubljana, as well as the author's personal materials collected during a month-long expedition in the northern part of Borneo;

3. Development of a modified scheme for the systematization of the geographical distribution of the taxa in the Oriental region, which will serve to present the data on the localities of the taxa;

4. Creation of a complete faunal list of fungus gnats in the region, which will serve for the subsequent publication of the "Catalogue of fungus gnats of the Oriental region";

5. Creation of a database containing all faunal and zoogeographical information for the region;

6. Analysis of the information from the database on the taxonomic structure of the mycetophilid fauna of the Oriental region and comparison with the Palaearctic, Afrotropical and Australasian-Oceanic regions;

7. Analysis of the information from the database on the zoogeographic features of the mycetophilid fauna of the Oriental region and comparison with the Palearctic, Afrotropical and Australasian-Oceanic regions.

4. BRIEF GEOGRAPHICAL CHARASTERISTICS OF THE RESEARCHED REGION

For boundaries of the Oriental region, we adopt the boundaries used in regional Diptera catalogs such as Crosskey (1980), Evenhuis (1989, 2006), etc. Weber's line is taken as the boundary between the Oriental and Australasian-Oceanic regions, and the following provinces are included from the territory of China to the Oriental region: Fujian, Guangdong, Guangxi, Guizhou, Hainan, Hong Kong, Hunan, Jiangxi, Shanghai, Yunnan, Zhejiang, and also Taiwan (Fig. 1.).

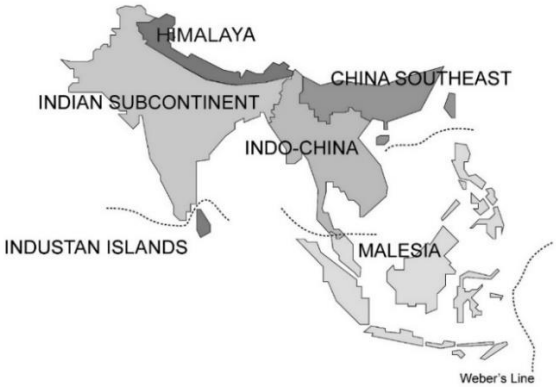


Fig. 1. Boundaries and subregions of the Oriental region, adopted in the study

Relief, climate and biomes

In general, the region has a relatively high relief and is characterized by significant changes in the elevation of the landscape. Even islands have rugged topography, from Mount Yushan in Taiwan to Mount Kinabalu in Malaysia and Mount Puncak Jaya in Indonesia (Leinbach & Frederick 2023).

According to the Worldwide bioclimatic classification system according to Rivas-Martínez *et al.* (2011) the Oriental region predominantly experiences a tropical climate, except for the Himalayan subregion and parts of Southeast China where there are temperate climate zones.

In the Oriental region, the largest area is covered by the tropical and subtropical moist broadleaf forest biome (Olson *et al*. 2001).

5. MATERIAL AND METHODS

5.1. Material

For the preparation of the dissertation, materials from Southeast Asia, provided by the Slovenian Museum of Natural History in Ljubljana (Prirodoslovni muzej Slovenije) and materials collected by the author during an expedition to the northern part of the island of Borneo in 2019, were examined.

The specimens from all localities are stored in 75% alcohol in the collection of the Regional Natural History Museum – Plovdiv.

All faunal data known for the Oriental region up to and including 2022 are included in the study. For this purpose, a complete bibliographic reference was made in Web of Science, Fungus Gnats Online and the library of Prof. Bechev.

5.2. Methods

5.2.1. Field methods

Field work methods for collecting material include collection with an entomological net, as well as stationary methods – Malaise trap – Townes style.

5.2.2. Laboratory methods

Specimens are examined under a stereomicroscope to analyze morphological characters (wing venation, eyes, mouthparts, etc.). To determine each species, microscopic examination of the male copulatory apparatus is performed.

5.2.3. Taxonomic methods

Families and genera are determined by external taxonomic characters with the help of taxonomic keys, and species by microscopic examination of the male terminalia.

Whole insect and wing photographs were taken under a stereomicroscope, and genitalia photos – under a microscope with a Motic 2 digital camera or a Canon EOS 750D camera.

Used photography, macro photography and micro photography software includes:

EOS Utility 3.9.0 for Windows software was used to capture specimens with a camera through the microscope. Focus stacking was done with Helicon

Focus 5 software. Motic 2 microscope camera images were taken with Motic Live Imaging Module software.

Graphic materials are processed with Corel Draw 11, Adobe Photoshop CS and Adobe Illustrator 8.

Classification and nomenclature of taxonomic characters

The classification adopted in the present study follows that of Edwards (1925), modified mainly by Tuomikoski (1966a), Väisänen (1984) and Matile (1990), updated with the subfamily Sciarokeroplatinae by Papp and Ševčik (2005b) and with the acceptance of Lygistorrhininae and Platyurinae as subfamilies of Keroplatidae (Mantič *et al.* 2020).

The nomenclature used and the manner of designation of body parts, wing veins and terminalia is according to Søli (1997; 2017). The nomenclature of Blagoderov & Ševčík (2017) was adopted for the designation of wing veins in the family Keroplatidae.

5.2.4. Methods in the analysis of fauna and zoogeographic analyses

All available information on the distribution of taxa in the Oriental and other zoogeographic regions is entered into a database in Microsoft Excel 2016. Information on the distribution by subregions of the Oriental region is also entered into the database.

5.2.5. Representation and processing of geographic information.

Geographic and biogeographic terminology and borders

Instead of biogeographical kingdoms or zoogeographical regions, we use the concept of regions, which is used in the English-language literature. These zoogeographic regions are Afrotropical, Australian-Oceanic, Nearctic, Neotropical, Oriental and Palearctic. The boundaries of these regions are the boundaries used in regional Diptera catalogs such as Crosskey (1980), Evenhuis (1989, 2006), etc.

Modified scheme representing the geographical distribution of species

To reflect the geographical distribution of species, we use a modified scheme for systematizing the geographical distribution of species in the Oriental region. The scheme was developed based on the World Geographical Scheme for Recording Plant Distributions (Brummitt 2001) and on the basis of generally accepted terrestrial zoogeographical divisions, for example that in the Catalog of Evenhuis (2006). The difference is that we separate Nepal, Bhutan and the northern states of India in the Himalayan subregion, the islands of Sri Lanka, the Maldives and the Laccadive Islands in a separate region, and

include the southeastern provinces of China as the Southeast China region (Fig. 2.).

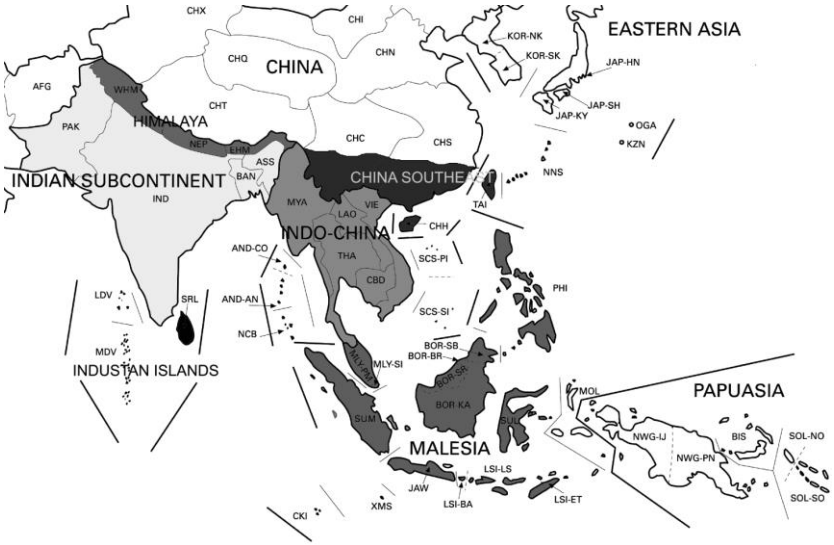


Fig. 2. Map of the subregions, countries and provinces in the Oriental region, adopted in the dissertation

6. RESULTS AND DISCUSSION

6. 1. Taxonomic studies

This part presents the results of the taxonomic research. Four species new to science are described and data are presented for 7 problematic species of the genus Leia and 1 of the genus Greenomyia. Two of the species new to science have been published - differential diagnoses are presented for them with original figures from the publications (fig. 3. - fig. 7.). Taxonomic keys have been prepared for the species of the genus Stenophragma and the genus Chetoneura. For the remaining two unpublished species, differential diagnoses are presented in the abstract. Their full description and publication is pending. In the process of work, six homonyms of species published from China were also established.

6.1.1. Species new to science

Family **KEROPLATIDAE**

Subfamily **KEROPLATINAE**

Tribe **ORFELIINI**

Genus ***Chetoneura*** Colless, 1962

Chetoneura lagangensis Kazandzhieva & Bechev 2022

Kazandzhieva, S., Bechev, D. (2022) A new species of Chetoneura Colless from Borneo (Diptera: Keroplatidae). *Zootaxa* 5104 (4): 593–599.

Diagnosis. R-M fusion short, tergite IX about twice as long as wide, gonostylus elongate in ventral view, with elongate sharp apical spine. Sc unclear distally. Scutum light yellowish brown, in other species of *Chetoneura* brown, in *Ch. davidi* yellowish, with lateral margins and two submedian longitudinal stripes dark. Coxae light, yellowish, in other species brown, in *Ch. davidi* partly yellowish.

Type material. Holotype: ♂, MALAYSIA: Sarawak: Gunung Mulu National Park, Lagang cave, 14.07.2019, Sweep net, S. Kazandzhieva leg. (in ethanol, in RNHM of Plovdiv, Bulgaria).

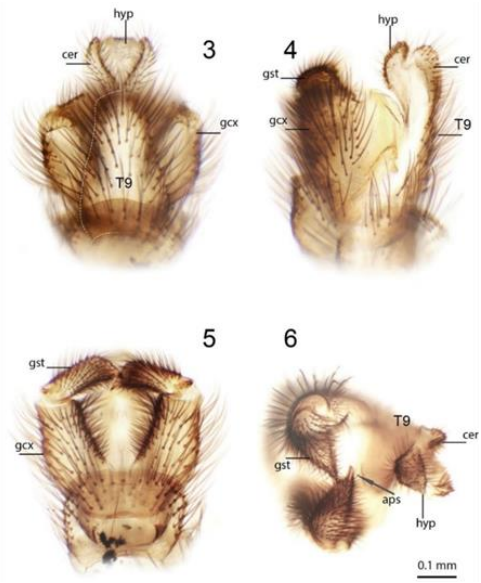


Fig. 3. ***Chetoneura lagangensis*** Kazandzhieva & Bechev, 2022 – male terminalia: **3** – dorsal view, **4** – lateral view; **5** – ventral view; **6** – apical view (orig) T9 = tergite IX.

Family **MYCETOPHILIDAE**

Subfamily SCIOPHILINAE

Genus ***Stenophragma*** Skuse, 1890

Stenophragma borneense Bechev & Kazandzhieva 2020

Bechev, D., Kazandzhieva, S. (2020) A new species of *Stenophragma* Skuse from Borneo (Diptera: Mycetophilidae: Sciophilinae). *Zootaxa*, 4819, 195-200.

Diagnosis. With a yellow-brownish body coloration *Stenophragma borneense* differs from the darker species *S. hirtipenne*, *S. picticorne* and *S. meridianum* in which the body is brown to dark brown, and *S. bickeli* and *S. collessi* in which the body is light brown to brown. Body color in *S. paponorum* (only females known) is red, reddish-yellow (according to the original description). In the genital structure *S. borneense* resembles *S. collessi* a little, in having regular rows of short spines, but in *S. collessi* there are nine rows, while in *S. borneense* there are four rows. Also, spines on gonostyle in *S. borneense* are a greater number and the form of tergite9 is different. A basic difference from *S. paponorum* is in the angle in the basal part of the Cu-fork between M_4 and CuA: in *S. borneense* the angle between M_4 and CuA is close to 90 degrees (M_4 is strongly curved basally), in *S. paponorum* it is close to 45 degrees (Matile 1991: Fig. 12), also the basal stripe of the wing is incomplete.

Type material. Holotype: Male, MALAYSIA: Sarawak, Kubah National Park, 800 m, 1°35’17.9” N 110°11’31.8” E, 21–23.vii.2019, Malaise trap, Leg. Kazandzhieva (in RNHM – of Plovdiv, Bulgaria).

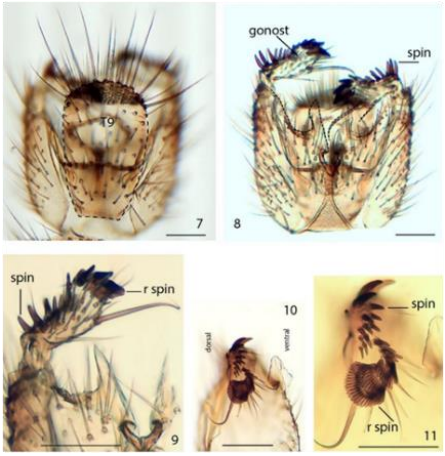


Fig. 4
Stenophragma borneense
Bechev& Kazandzhieva, 2020
7 – male terminalia, dorsal view; **8** – ventral view; **9** – left gonostyle, ventral view; **10** and **11** – distal part of left gonostyle, frontal view (**9**, **10** and **11** – male paratype, genitalia disassembled). (orig.)
Scale 0,1 mm

Genus ***Monoclona*** Mik, 1886

Monoclona sp. n.

Diagnosis. Base of M_{1+2} about three times shorter than r-m. Gonostyles narrow, sharpened, with apical tooth. Internal procession of gonostylus complex, without apical tooth.

Material: 1 ♂, THAILAND: Doi Inthanon, 1200m, 98°32'E, 18°32'N, 11–19.11.1988, leg. Chantarmongkol (in alcohol in the collection of RNHM – Plovdiv).

Genus ***Acnemia*** Winnertz, 1864

Acnemia sp. n.

Diagnosis. Scutum brown, evenly colored. Gonostyles narrowing apically, covered with long dark setae, gonocoxal apodemes ending with pointed upwards brush-like appendages.

Material: 1 ♂, CHINA: Zhejiang province, Long Wang Shan, 600m, 30°28'14"N, 119°22'17"E, 4.6.1999, light trap, leg. Ignac Sivec (in alcohol in the collection of RNHM – Plovdiv).

6.1.2. Problematic species

As a result of the taxonomic studies, 7 problematic species of the genus *Leia* and 1 of the genus *Greenomyia* were established with morphological differences with the rest of the oriental species of the genera, which are supposed to be new to science, but due to insufficiently clear taxonomic characteristics given in the literature, they need to be compared with material of the genera to fully clarify their taxonomic status.

6.1.3. Taxonomic keys to genera

Key to the extant species of *Stenophragma* Skuse, 1890

1. Thorax and abdomen light brown to dark brown. Australian species **2**

- Thorax and abdomen yellow-brownish or reddish-yellow. Non-Australian species. **6**

2. Thorax and abdomen deep brown to dark brown **3**

- Thorax light brown **5**

3. Coxae yellow. ..... ***S. hirtipenne*** Skuse

- At least hind coxae deep brown **4**

4. M_4 strongly sinuous (Skuse 1890: Plate XIX, Fig. 5 ..... ***S. picticorne*** Skuse

- M_4 not sinuous (Skuse 1888: Plate XXXI, Fig. 9) ..... ***S. meridianum*** (Skuse)

5. M_4 strongly curved basally (Oliveira & Amorim 2012: Fig. 3). Tergite 9 with apex as wide as base, rounded distally, with typical waist close to apex (Oliveira & Amorim 2012: Fig. 7). Gonostyle with numerous strong spines, median branch with two rows of short spines (Oliveira & Amorim 2012: Figs 9–11) ..... ***S. bickeli*** Oliveira & Amorim

- M_4 moderate curved basally (Oliveira & Amorim 2012: Fig. 4). Tergite 9 widening to the apex (Oliveira & Amorim 2012: Fig. 16). Gonostyle with three strong spines of different sizes and with nine regular rows of short spines (Oliveira & Amorim 2012: Fig. 18)..... ***S. collessi*** Oliveira & Amorim

6. Thorax and abdomen reddish-yellow. The angle between M_4 and CuA is close to 45 degrees (M_4 not strongly curved basally) (Matile 1991: Fig. 12). Basal stripe of the wing incomplete. Only females known.....

..... ***S. paponorum*** Matile

- Thorax and abdomen yellow-brownish. The angle between M_4 and CuA is close to 90 degrees (M_4 strongly curved basally) (Fig. 5). Basal stripe of the wing almost complete..... ***S. borneense*** Bechev & Kazandzhieva

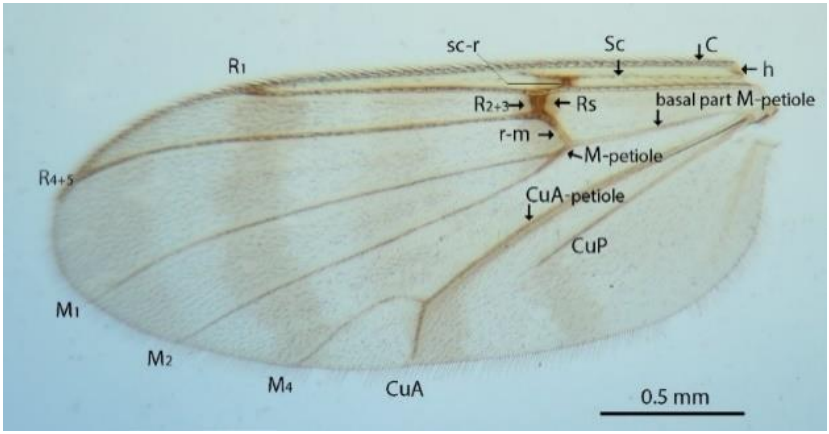


Fig. 5. Wing of ***Stenophragma borneense*** Bechev & Kazandzhieva, 2020 (orig.)

Key to the extant species of *Chetoneura* Colless, 1962

1. 1.R-M fusion very short (Fig. 6). Tergite IX slightly longer than broad or up to about 1.7 as long as wide, not subtriangular. **2**

- R-M fusion as long as r-m or more. Tergite IX shorter than broad, subtriangular **4**

2. Scutum yellowish, with lateral margins and two submedian longitudinal stripes dark. Tergite IX slightly longer than broad, length/width ratio about 1/1. Form of tergite IX—Fig. 7.1 ***Ch. davidi*** Ševčík, Hippa & Burdiková

- Scutum light yellowish brown, without bands or brown, with thin darker brown oblique bands. Tergite IX apparently longer than broad, length/width ratio about 4/3 or more **3**

3. Tergite IX length/width ratio about 4/3. Form of tergite IX—Fig. 8. Gonostylus stout, with a thorn-like apical spine (Colless 1962: Fig. 1c) ***Ch. cavernae*** Colless

- Tergite IX length/width ratio about 5/3. Form of tergite IX—Fig. 9. Gonostylus not stout, elongated in ventral view, with elongated sharp apical spine (Figs 5–6) ……. ***Ch. lagangensis*** Kazandzhieva & Bechev

4. Fore tibia without apical spur ***Ch. oligoradiata*** (Papp)

- Fore tibia with very short apical spur ***Ch. shennonggongensis*** Amorim & Niu

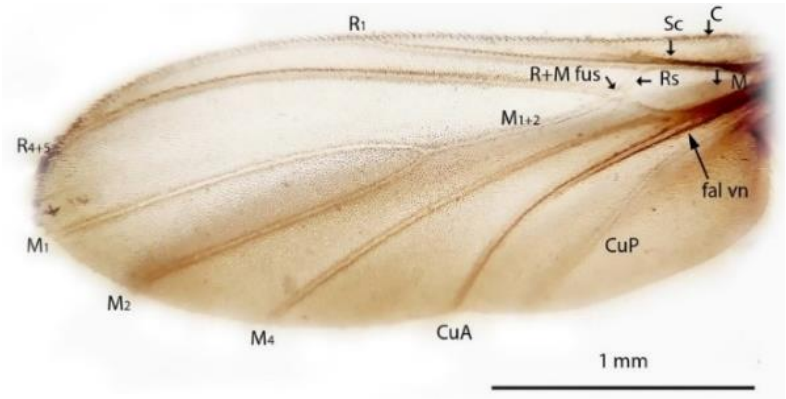


Fig. 6. Wing of ***Chetoneura lagangensis*** Kazandzhieva & Bechev, 2022 (orig.)

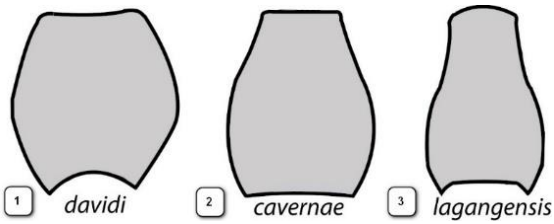


Fig. 7. Shape of tergite IX (not in scale) – 1 ***Ch. davidi*** (from Ševčík *et al*. 2021: Fig. 13C), 2 – ***Ch. cavernae*** (from Colless 1962: Fig. 1c, 3 – ***Ch. lagangensis*** (orig.)

6.1.4. Established nomenclature problems (homonyms)

In the process of work, six homonyms of species of families Keroplatidae and Mycetophilidae (Diptera) described from China were found. The dissertation provides information about the authors who first published the species names and synonymy.

- ***Orfelia maculata*** Cao et Xu in Cao *et al.*, 2008
- ***Mycetophila elegans*** Wu, 1997
- ***Mycetophila grata*** Wu, He & Yang, 1998
- ***Mycetophila sylvatica*** Wu & Yang, 1997
- ***Sciophila bicolor*** Brunetti, 1912
- ***Mycomya magna*** Wu & Yang, 1993

6. 2. Faunistic studies

In the Faunistic part, information is given on 825 species from 116 genera. For each genus established for the Oriental region, a world distribution map is with number of species by region, information on valid name, type species, publication in which it is described, and synonyms are given. Localities are given in Latin as in the literature.

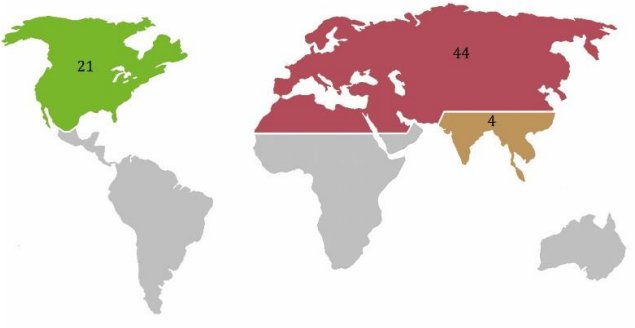
For each species, established for the Oriental Region from literature data, a valid name, type locality, publication in which it was reported, synonymy, and distribution by subregion, country, and province (based on the created modified scheme for the systematization of geographic distribution) are given (Fig. 2).

Example:

Family ***BOLITOPHILIDAE*** Winnertz, 1864

Genus ***BOLITOPHILA*** Meigen, 1818

BOLITOPHILA Meigen, 1818: 220. TYPE SPECIES: *Bolitophila cinerea* Meigen, 1818, bysubsequent designation (Westwood 1840: 127).



Subgenus ***BOLITOPHILA*** Meigen, 1818

TYPE SPECIES: *Bolitophila cinerea* Meigen, 1818, by subsequent designation (Westwood1840: 127).

Bolitophila* (*Bolitophila*) *antennata Ševčík & Papp, 2004

Bolitophila antennata Ševčík & Papp, 2004: 56 (♂). TYPE LOCALITY: Taiwan, China.

Known localities: **CHINA SOUTHEAST**: Taiwan (Ševčík & Papp 2004).

For the species from which material was examined, information is given on valid name and sex, number of individuals, detailed information about the locality, date of collection, by whom the material was collected.

Species new to science are marked with ****, new to the Oriental region with ***, new to the subregion with **, and new faunistic data with *.

Example:

Cordyla bidenticulata Sasakawa & Ishizaki, 2003 ***

Cordyla bidenticulata Sasakawa & Ishizaki, 2003: 107 (♂ ♀). TYPE LOCALITY: Japan, Honshu.

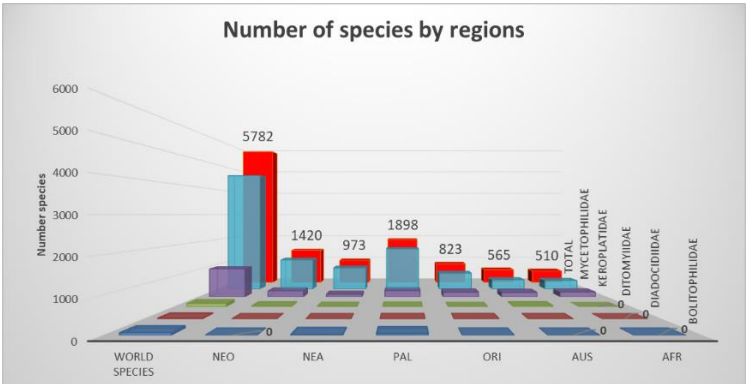
*** **New faunistic data**: **INDO-CHINA**: Thailand: Chiangmai Zoo Lichtfalle, 400m 98°57'E, 18°49'N; 7 – 14.11.1988, Leg. Chantarmongkol. & Malicky; 1 ♂. **The species is new to the Oriental region.**

6.3. Taxonomic composition of the fauna of the Oriental region

The review of all the available data on the fungus gnats of the Oriental region, which was lacking until now, shows that the fauna is still rather poorly studied compared to that of the Palaearctic and commensurately studied compared to the Afrotropics and Australasia (Fig. 8).

The analysis of the taxonomic structure of the fauna at the family and subfamily level shows that all 5 families of fungus gnats are represented in the Oriental region, with the largest number of species being Mycetophilidae and Keroplatidae.

At the family level, the structure of the Oriental fauna is similar to that of the Palearctic and Nearctic, due to the presence of the families Bolitophilidae, Diadocidiidae and Ditomyiidae. In terms of the higher percentage presence of Keroplatidae (21%), the fauna of the Oriental region is similar to that of the Afrotropics (35%) and Australasia-Oceania (29%). (Fig. 8). The family Diadocidiidae (7 species), subfamilies Gnoristinae (17 genera and 51 species) and Manotinae (4 genera and 124 species, with 1 genus and 15 species in the Palearctic) are well represented in the region.



	World species	NEO	NEA	PAL	ORI	AUS	AFR
BOLITOPHILIDAE	63	0	21	44	4	0	0
DIADOCIDIIDAE	26	4	2	9	7	5	0
DITOMYIIDAE	101	32	11	16	7	35	0
KEROPLATIDAE	1018	212	91	217	172	164	176
MYCETOPHILIDAE	4574	1172	848	1612	633	361	334
TOTAL	5782	1420	973	1898	823	565	510

Fig.8. Number of species in the world by families and biogeographic regions. Abbreviations: NEO = Neotropical, NEA = Nearctic, PAL = Palearctic, ORI = Oriental, AUS = Australasian-Oceanian, AFR = Afrotropical

Despite the relatively poor study of the region, the largest number of genera have been established in it (116, compared to 258 for the world and 115 for the Palearctic - fig. 9). The family Keroplatidae is represented by the greatest diversity of genera in the region (42).

	World genera	NEO genera	NEA genera	PAL genera	ORI genera	AUS genera	AFR genera
BOLITOPHILIDAE	1	0	1	1	1	0	0
DIADOCIDIIDAE	1	1	1	1	1	1	0
DITOMYIIDAE	9	6	3	3	4	2	0
KEROPLATIDAE	98	35	22	29	42	33	32
MYCETOPHILIDAE	149	55	76	81	68	66	41
TOTAL	258	97	103	115	116	102	73

Fig. 9. Number of genera according to families and biogeographic regions

The genus *Manota* (12.8%) is represented by the largest percentage of species is the, followed by the genus *Mycomya* (10.9%) – fig. 10.

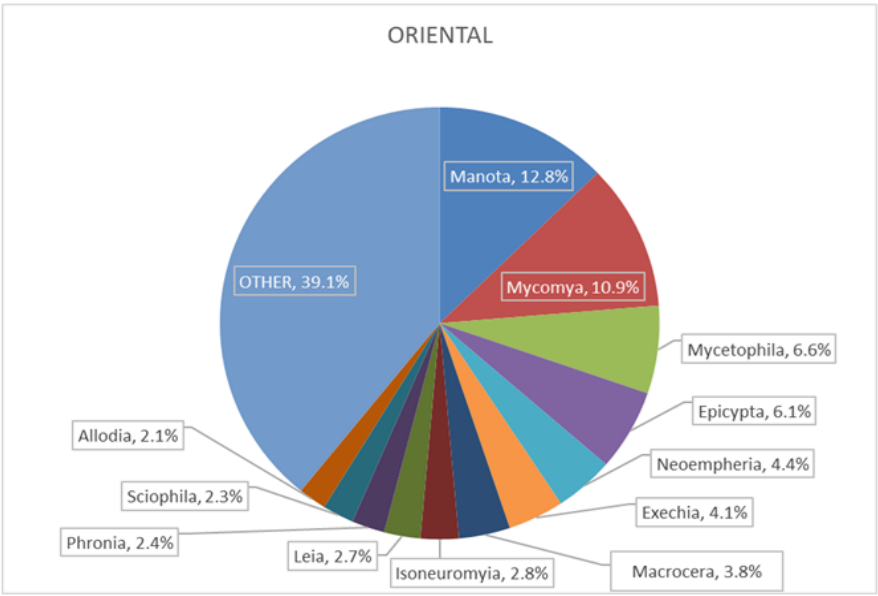


Fig. 10. Genera with above 5% and 2 – 5% of the species in the region. Those with 1 – 2% and under 1% are included in OTHER

6.4. Some zoogeographic characteristics of the fauna of the Oriental region

Currently, the studies on the zoogeography of fungus gnats are too few, which makes it difficult to draw conclusions about the zoogeography of the taxa in the world and in the subregions of the Oriental region.

6.4.1. Distribution of genera, established in the Oriental region

According to their distribution in the zoogeographical regions, the genera established in the Oriental region are classified into 22 categories. A comparison of the number of genera by category was made on fig. 11.

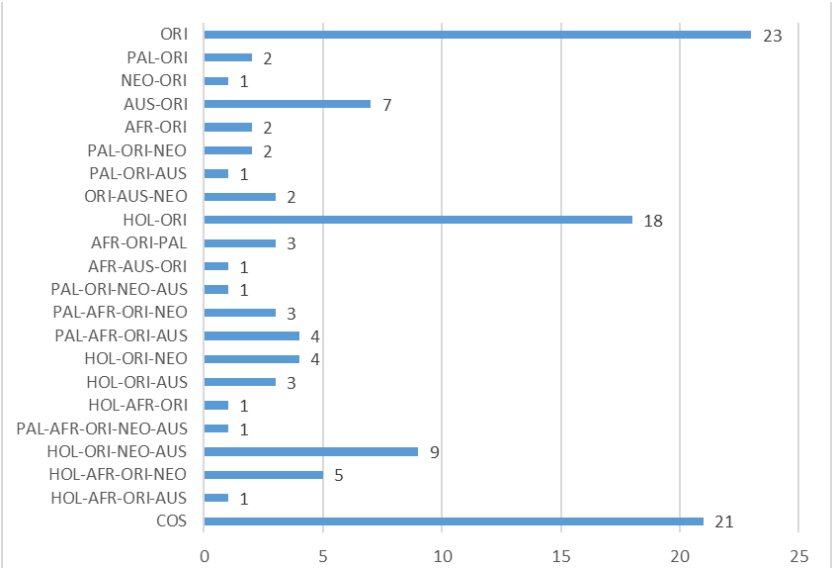


Fig. 11. Number of genera by arealographic categories

Abbreviations: COS – Cosmopolitan, ORI – Oriental Endemic, PAL – Palaearctic, HOL – Holarctic, NEO – Neotropical, AUS – Australian, AFR – Afrotropical

Out of 116 genera, 38 (32.8%) are widespread – 21 in all six zoogeographical regions, and 17 in 5 of them. Fifteen genera are known from 4 of the biogeographic regions, all of which are also distributed in the Palearctic or Holarctic, as well as the previous two categories.

These results indicate a probable Laurasian origin of the respective genera.

Of the genera established in 3 of the zoogeographic regions (28 genera), the following 3 are of interest: *Chiasmoneura* (1 Oriental, 7 Australian and 8 Afrotropical species), *Austrosynapha* (1 Oriental, 8 Australian and 36 Neotropical) and *Eumanota* (7 Oriental, 1 Australian and 5 Neotropical). The distribution of these genera points to a presumed Gondwanan origin, and the last three show the connection of the Oriental region with the Australasian and Neotropical regions (through Antarctica).

Twenty genera (17.2 %) are found only in the Oriental region and the Holarctic or Palearctic. These genera, as well as those widespread in all six or 5 zoogeographical regions, show a stronger influence of Oriental fauna from the Holarctic and Palaearctic than from Australasia-Oceania.

Of the genera distributed in 2 of the zoogeographical regions (12 genera), from a zoogeographic point of view the ones distributed in the Oriental region and Australasia-Oceania are *Euceroplatus*, *Xenokeroplatus*, *Acrodicrania*, *Indoleia*, *Sticholeia*, *Brachyradia* and *Stenophragma* (6%), showing the connection with Australasia-Oceania. The genera *Micrepimera* (2 Oriental species and 1 Afrotropical) and *Metanepsia* (2 Oriental and 7 Afrotropical) show the faunal relationship with Afrotropica.

Compared to the other regions (Fig. 12.), the Oriental has a significant amount of endemic genera (23).

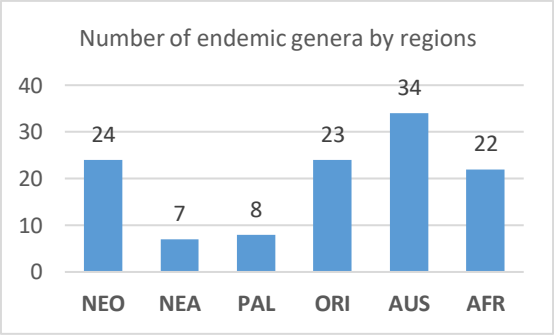


Fig. 12. Number of endemic genera by regions

6.4.2. Distribution of species established in the Oriental and other regions

The species established in both the Oriental and other biogeographical regions are 102. The largest number of common species is between the Oriental region and the Palearctic (73), which are most likely of boreal (northern) origin.

Sixteen species have a Holarctic-Oriental distribution. Most of them are known from Southeast China or the Himalayas (Nepal), Europe, Siberia and North America. These are Holarctic species that have a restricted range in the Oriental region, including only its more northern parts near the Palaearctic border.

The species distributed both in the Oriental Region and in Australasia-Oceania are 8. Most of them are reported from Malaysia (Borneo, Sulawesi or the Philippines) and New Guinea or Oceania, Two of them are also known from Thailand, one from New Guinea and from Taiwan.

One species has been reported from the Oriental Region and the Afrotropics, Allactoneura argentosquamosa, and it is assumed to be anthropogenically spread, probably through soil and plant material.

6.4.3. Number of species in the subregions of the Oriental region

The fewest species are known from the Indian subcontinent – 36 (4.4% of the total number of species for the Oriental region).

The next subregion in number of species is Industan islands with 50 species (6% of the total).

Third in number of species is the Himalayan subregion with 148 species (17.9%), followed by Indochina with 154 (18.7%). 241 species (29.2%) are known from Malesia.

The largest number of species are known from the region of Southeast China – 334 (40.5%).

7. CONCLUSIONS

1. At the conclusion of the conducted research, it was found that at the moment there are 825 species known for the Oriental region, representatives of 116 genera from all families of fungus gnats.

2. The review of the fungus gnat data of the Oriental region, which was previously lacking, shows that the fauna is still rather poorly studied compared to that of the Palaearctic and proportionately studied compared to the Afrotropics and Australasia-Oceania.

3. In the species *Stenophragma borneense* described by us, of which 22 specimens were examined, there is a noted variability in the venation of the wing – presence or absence of cell R4, including on both wings of the same individual, which has not been established so far.

4. For the 7 problematic species of the genus *Leia* and 1 of the genus *Greenomyi*a examined in the taxonomic studies, it is assumed that they are new to science due to morphological differences with the other oriental species, but in order to fully clarify their taxonomic status, it is necessary to compare them with materials from the genera.
5. According to the analysis of the structure of the Oriental fauna, it becomes clear that it has a greater similarity with that of the Palearctic and Nearctic. A similarity with both the Afrotropics and Australasia-Oceania is observed in terms of the greater presence of the family Keroplatidae.

6. Despite the relatively poor study of the Oriental region, the largest number of genera have been established in it – 116 genera, with 258 for the world and 115 for the Palearctic. These results are probably due to the fact that active evolutionary processes and formation are taking place in it, as a result of the complex configuration of the land.

7. The analysis of the taxonomic structure of the fauna at the genus level shows that the genus *Manota* is represented by the largest percentage of species, and the genus *Mycomya* is second in number of species. The subfamily Manotinae is represented by a large number of genera (4) and species (124).

8. Compared to other regions, the Oriental region has a significant amount of endemic genera (23), which are probably older phylogenetically and formed in it, with relatively smaller climatic changes, compared to the Holarctic, and geographical isolation.

9. The Oriental region is more closely related to the Holarctic and Palaearctic, due to the extensive terrestrial connection with the Palaearctic and the significant movements of fauna in the north-south direction and vice versa during the Pleistocene glaciations and interglacial periods.

10. At the moment, the zoogeographical analysis of the distribution of species in the sub-regions of the Oriental region is difficult due to insufficient data

8. DISSERTATION CONTRIBUTIONS

Contributions of an original scientific nature:

1. After collecting and summarizing all publications on fungus gnats in the Oriental region, the history of research in the region is presented for the first time.

2. 4 species new to science were identified, 2 of which were published based on materials collected by the author in Borneo (*Stenophragma borneense* Bechev & Kazandzhieva, 2020; *Chetoneura lagangensis* Kazandzhieva & Bechev, 2022) and 2 described based on materials from the Museum of Natural History – Lublyana in the taxonomic part of the dissertation (*Acnemia* sp. n., *Monoclona* sp. n.).

3. Taxonomic keys were made for the species of the genus *Stenophragma* and the genus *Chetoneura*.

4. As a result of the taxonomic studies, 7 problematic species of the genus *Leia* and 1 of the genus *Greenomyia* were established, which are assumed to be new to science, but in order to fully clarify their taxonomic status, it is necessary to compare them with material from the genera.

5. Variability in wing venation in *Stenophragma borneense* was established for the first time – presence or absence of R4, including on both wings of the same individual, which has not been established before.

6. Nomenclatural problems were identified – 6 homonyms of fungus gnat species published from China.

7. Based on the summarized literature data and the materials researched by the author, all known species for the Oriental region, the publications in which they were reported, and all their localities have been established. As a result of the conducted research, there are currently 825 known species, compared to 183 according to the last catalog (from 1973). After specifying the location of the types, it is planned to publish the results as a Catalog of the fungus gnats in the Oriental region.

8. Synonymy data for all genera and species reported for the Oriental region are summarized and presented.

9. One new genus (*Eudicrana*) and one new species for the Oriental region (*Cordyla bidenticulata*), 10 new genera and 10 new species for subregions of the Oriental region (Indochina, Malesia, Southeast China, Himalaya) were established. The faunal data for some genera and species have been enriched.

10. For the first time, an analysis of the taxonomic composition of the fauna was made at the family and subfamily level, as well as at the genus level.

11. For the first time, an analysis has been made and some zoogeographic characteristics of mycetophilid fauna of the Oriental region. Comparisons with neighbouring regions (Australasian-Oceanic, Afrotropical and Palaearctic) have also been made.

Contributions of an original scientific and applied nature:

1. A modified scheme for the systematization of the geographical distribution of taxa in the Oriental region was developed based on the World Geographical Scheme for Recording Plant Distributions (Brummitt 2001).

Publications on the topic of the dissertation:

1. Bechev, D., **Kazandzhieva, S.** (2020) A new species of *Stenophragma* Skuse from Borneo (Diptera: Mycetophilidae: Sciophilinae). Zootaxa, 4819 (1): 195-200.

2. **Kazandzhieva, S.**, Bechev, D. (2022) A new species of *Chetoneura* Colless from Borneo (Diptera: Keroplatidae). Zootaxa, 5104 (4): 593–599.

Participation in scientific conferences with materials on the subject of the dissertation:

1. **Kazandzhieva, S.** 2020. On the importance of faunal lists for the ecological studies. Twelfth scientific conference for students and young scientists "Ecology – a way of thinking", 01.11.2020, PU "Paisii Hilendarski", Faculty of Biology.

2. **Kazandzhieva, S.** 2022. Dissertation results on the topic: *Biodiversity and distribution of the families Bolitophilidae, Diadocidiidae, Ditomyiidae, Keroplatidae and Mycetophilidae (Diptera) in the Oriental Region*. Fourteenth scientific conference for students and young scientists "Ecology – a way of thinking", 21.05.2022, PU "Paisii Hilendarski", Faculty of Biology.

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