

RESEARCH PAPER

## Two new species of *Rohdendorfia* (Diptera: Syrphidae) from Central Asia

Ximo MENGUAL<sup>1)</sup> & Anatolij V. BARKALOV<sup>2)</sup>

<sup>1)</sup> Zoologisches Forschungsmuseum Alexander Koenig, Leibniz-Institut für Biodiversität der Tiere, Adenauerallee 160, D-53113 Bonn, Germany; e-mail: x.mengual@leibniz-zfmk.de

<sup>2)</sup> Institute of Systematics and Ecology of Animals, Russian Academy of Sciences, Siberian Branch, 11 Frunze str., 630091 Novosibirsk, Russia; e-mail: bark@eco.nsc.ru

Accepted:  
7<sup>th</sup> July 2019

Published online:  
18<sup>th</sup> July 2019

**Abstract.** Two new species of the flower fly genus *Rohdendorfia* Smirnov, 1924 (Diptera: Syrphidae) are described, *Rohdendorfia bella* Mengual, sp. nov. and *Rohdendorfia khakimovi* Barkalov, sp. nov. A full description and images of both new species are given, as well as an identification key for the species of this genus. Molecular sequences from mitochondrial cytochrome c oxidase I (COI) gene and nuclear ribosomal 28S and 18S rRNA genes are also provided for the new species. The studied specimens of *Rohdendorfia bella* Mengual, sp. nov. are the first record of the genus *Rohdendorfia* from India and represent the first individuals collected in the state of Jammu and Kashmir.

**Key words.** Diptera, Syrphidae, *Rohdendorfia*, flower flies, hoverflies, new species, identification key, DNA barcode, India, Kashmir, Ladakh, Pamir, Tajikistan

**Zoobank:** <http://zoobank.org/urn:lsid:zoobank.org:pub:3A47B57E-D527-4F9F-8084-F0CF92C5B396>  
© 2019 The Authors. This work is licensed under the Creative Commons Attribution-NonCommercial-NoDerivs 3.0 Licence.

### Introduction

*Rohdendorfia* Smirnov, 1924 is a small genus of flower flies (Diptera: Syrphidae) restricted to the Palaearctic Region. BARKALOV & NIELSEN (2010) revised the genus, which currently comprises three described species (*Rohdendorfia alpina* Sack, 1938, *R. dimorpha* Smirnov, 1924, and *R. montivaga* Violovitsh, 1984) after *R. bactriana* Violovitsh, 1984 was synonymized with *R. dimorpha* (BARKALOV & NIELSEN 2010).

*Rohdendorfia* species are not very abundant in collections and they are found in high altitudes usually above 2500 m a.s.l. (BARKALOV & NIELSEN 2010). Data on the biology, adult habitat and immature stages are known only for *R. alpina* (BARKALOV & NIELSEN 2010, SPEIGHT 2017). The species resemble species of the genera *Platycheirus* Le Peletier & Serville, 1828 and *Melanostoma* Schiner, 1860, and due to this great similarity *Rohdendorfia* was considered a subgenus of *Platycheirus* by some authors in the past (THOMPSON & ROTHERAY 1998). Molecular evidence supports the generic status of *Rohdendorfia* (MENGUAL et al. 2008, THOMPSON & SKEVINGTON 2014, MENGUAL 2015) and there are morphological characters to separate it from

other closely related genera (BARKALOV & NIELSEN 2010, HUO 2014).

In this work two new species of *Rohdendorfia*, *R. bella* Mengual sp. nov. and *R. khakimovi* Barkalov sp. nov., are described from Central Asia, namely from the region of Ladakh, in Kashmir, and from Pamir, Tajikistan. Full descriptions of the two new species are given, as well as a modification of the identification key to *Rohdendorfia* species from BARKALOV & NIELSEN (2010).

### Material and methods

**Area of study.** Specimens of *Rohdendorfia bella* Mengual sp. nov. were collected near the Tso Moriri lake (32°54' N 78°18' E) in the region of Ladakh, northwest India in the Jammu and Kashmir State. Flower flies were collected using a hand net between 5050 and 5749 m a.s.l. (around 32°59' N 78°26' E).

Specimens of *Rohdendorfia khakimovi* Barkalov sp. nov. were sampled on Koi-Tezek mountain ridge, Pamir, Tajikistan (37°29' N 72°47' E), *circa* 4300 m a.s.l. (Fig. 1).

**Taxonomy protocols.** Most of the collected specimens were pinned in the field. Some adults were kept in alco-





Fig 1. Type locality of *Rohdendorfia khakimovi* Barkalov, sp. nov. in Tajikistan (37°29' N 72°47' E).

hol and brought to the laboratory, where they were dried using an automated Critical Point Dryer (CPD) Leica EM CPD300 after being studied, and a few specimens were kept in alcohol for further DNA analyses. Male genitalia were detached before the drying process with the CPD. These specimens were glued to cardboard pieces for their preservation and further study.

Morphological terminology follows THOMPSON (1999) and THOMPSON et al. (2010). To identify the collected specimens, THOMPSON & ROTHERAY (1998) and THOMPSON & SKEVINGTON (2014) were used to determine the genus. Then, the work by BARKALOV & NIELSEN (2010) was used to key out the species. In addition, material of this genus deposited in the Institute of Systematics and Ecology of Animals (ISEA) and the Zoologisches Forschungsmuseum Alexander Koenig (ZFMK) collections and the original descriptions of the *Rohdendorfia* species were used to compare our material with the already described and known species of this genus.

Identification and location labels are indicated with quotation marks (" "), and each line on the label is separated by a double forward slash (//). Handwritten information on labels is indicated in italics. At the end of each record, between square brackets ([ ]) and separated by a comma, the number of specimens and sex, the holding institution, and the unique identifier or number are given.

The EVENHUIS (2009) standard acronyms were used for the following entomological collections:

- |      |   |
|------|---|
| CNC  | Canadian National Collection of Insects, Arachnids and Nematodes, Ottawa, Canada;   |
| ISEA | Institute of Systematics and Ecology of Animals, Siberian Branch of the Russian Academy of Sciences, Novosibirsk, Russia; |
| ZFMK | Zoologisches Forschungsmuseum Alexander Koenig, Bonn, Germany.  |

Google Earth ® version 7.3.0 (Google Inc., 2017) was used to get the geographic coordinates of the type local-

ity. All measurements are in millimeters and were taken using a reticule in a Leica M165 C and Stemi 2000-C microscopes. Photographs were composed using the Zerene Stacker 1.04 (Richland, Washington, USA) software, based on images of pinned specimens taken with a Canon EOS 7D camera mounted on a P-51 Cam-Lift (Dun Inc., VA, USA) and with the help of Adobe Lightroom (version 5.6). Body length was measured from the anterior oral margin to the posterior end of the abdomen, in lateral view. Wing length was measured from the wing tip to the basicosta.

**DNA sequences.** One to two legs or the entire specimen from the ethanol preserved or dry pinned specimens were used for DNA extraction. Extractions were carried out using the NucleoSpin Tissue DNA Extraction kit (Machery-Nagel, Düren, Germany) following the manufacturer's instructions; samples were resuspended in 100 µl ultra-pure water. Entire specimens or remnants of specimens were preserved and labelled as DNA voucher specimens for the purpose of morphological studies and deposited at the ZFMK, as listed in 'Examined material' below.

DNA primers and PCR amplification protocols for the mitochondrial protein-coding cytochrome c oxidase subunit I (COI) gene, the D2–3 region of the nuclear ribosomal 28S rRNA gene and a small fragment of the nuclear ribosomal 18S rRNA gene were the same as described in MENGUAL et al. (2008, 2012). Amplified DNA was electrophoresed on 1.5% agarose gels for visual inspection of amplified products. PCR products were enzymatically treated with ExoSap-IT (USB, Cleveland, OH, USA) and then sequenced (using the PCR primers) in both directions. The sequences were edited for base-calling errors and assembled using Geneious R7 (version 7.1.3, Biomatters Ltd.). All new sequences were submitted to GenBank (see 'Genetics' section below for the accession numbers).

## Taxonomy

### *Rohdendorfia bella* Mengual, sp. nov.

(Figs 2–8, 9–11)

**Type locality.** India, Jammu and Kashmir State, Ladakh, near Tso Moriri (lake), 32°54'N 78°18'E, 5333 m a.s.l.

**Type material.** HOLOTYPE: ♂, "INDIA: Jammu and Kashmir State, // Ladakh, near Tso Moriri (lake), // 32°54'N 78°18'E, 5333 m, // 25–28.viii.2010. // Leg.: I. Abela-Hofbauerová" "DNA voucher specimen // ZFMK, Lab code // D268 // Bonn, Germany" "HOLOTYPE // *Rohdendorfia bella* // Mengual 2018" [red label]" "ZFMK DIP // 00027140" [barcode] [ZFMK]. PARATYPES: INDIA: Jammu and Kashmir State, Ladakh, near Tso Moriri (lake), Leg. I. Abela-Hofbauerová (all specimens): 8 ♀♀, 5052 m, 25–28.viii.2010 [ZFMK, ZFMK-DIP-00027162, ...27163, ...27164, ...27165, ...27166, ...27167, ...27168, ...27206–DNA voucher D305]; ♀, 5053 m, 25–28.viii.2010 [ZFMK, ZFMK-DIP-00027208]; ♂, 5053 m, 25–28.viii.2010 [ZFMK, ZFMK-DIP-00027209]; 4 ♂♂, near the camp site, 5330 m, 25–28.viii.2010 [ISEA, ZFMK-DIP-00027141; ZFMK, ZFMK-DIP-00027142, ...27213, ...27214]; 12 ♀♀, near the camp site, 5330 m, 25–28.viii.2010 [ISEA, ZFMK-DIP-00027175; ZFMK, ZFMK-DIP-00027169, ...27170, ...27171, ...27172, ...27173, ...27174, ...27176, ...27177, ...27178, ...27215, ...27216]; 4 ♀♀, 5050 m, 25–28.viii.2010 [ZFMK, ZFMK-DIP-00027179, ...27180, ...27181, ...27182]; 5 ♂♂, 5333 m, 25–28.viii.2010 [CNC, ZFMK-DIP-00027145, ZFMK, ZFMK-DIP-00027146, ...27147, 27212, ...27207–DNA voucher D307]; 25 ♀♀, 5333 m, 25–28.viii.2010 [CNC, ZFMK-DIP-00027204; ISEA, ZFMK-DIP-00027184, ...27197; ZFMK, ZFMK-DIP-00027183, ...27185, ...27186, ...27187, ...27188, ...27189, ...27190–DNA voucher D271, ...27191, ...27192, ...27193, ...27194, ...27195, ...27196, ...27198, ...27199, ...27200, ...27201, ...27202, ...27203, ...27205, ...27210, ...27211]; ♀, 5700 m, 20–23.viii.2010, with *Potentilla pamirica*, *Arenaria bryophylla*, *Thylacospermum* sp. [ZFMK, ZFMK-DIP-00027161]; ♀, 5685 m, 20–23.viii.2010, with *Potentilla pamirica*, *Astragalus confertus*, *Thylacospermum* sp. [ZFMK, ZFMK-DIP-00027160]; ♂, 5035 m, 25–28.viii.2010 [ZFMK, ZFMK-DIP-00027144]; 2 ♀♀, 5035 m, 25–28.viii.2010 [ZFMK, ZFMK-DIP-00027159, ...27217]; ♂, 5340 m, 25–28.viii.2010 [ZFMK, ZFMK-DIP-00027143]; 11 ♀♀, 5340 m, 25–28.viii.2010 [ZFMK, ZFMK-DIP-00027148, ...27149, ...27150, ...27151, ...27152, ...27153, ...27154, ...27155, ...27156, ...27157, ...27158].

**Description. Male.** Head (Figs 2–3, 6). Face black, with distinct facial tubercle, concave below antennal insertion, pale pilose, with grey silver pollinosity laterally and below antennae leaving central area of tubercle shiny. Mouth edge protruding, laterally shiny. Gena black, broad, shiny, pale pilose. Lunule black, shiny. Frontal triangle black, pale pilose with some black pile laterally at level of antennal insertion, shiny medially with grey silver pollinosity laterally on eye margin. Eye bare, slightly dichoptic (distance between eyes in dorsal view equal to diameter of ommatidium). Vertical triangle slightly upraised, black, shiny, pale pilose. Antenna black; arista black, thick. Occiput black, pale pilose, with grey silver pollinosity on ventral 2/3.

Thorax (Figs 2–3). Scutum and scutellum black, shiny with blue metallic iridescence, with short pale pile; postpronotum bare; subscutellar fringe with pale pile. Pleuron black, shiny, pale pilose; metaepisternum and metasternum bare; calypter pale; plumula large, pale; halter pedicel and capitulum pale; posterior spiracular fringes yellow. Wing hyaline, entirely microtrichose; stigma dark brown. Alula broad, broader than costal cell. Legs entirely black, with short pile, except metafemur with some long pale pile anteroventrally, shorter than width of metafemur.

Abdomen (Figs 2–3). Unmargined, parallel-sided, pale pilose on lateral margins, black pilose medially; terga 1–3 with long pale pile on lateral margins. Terga 1 and 2 black; terga 3 and 4 black with two squarish yellow maculae; terga 5 and 6 black; sternum 1 dark, yellow posteriorly; sternum 2 yellow, darker medially; sterna 3–5 yellow; sterna 6–8 dark. Male genitalia as in Figs 9–11.

**Female** (Figs 4–5, 7). Similar to male except for normal sexual dimorphism and: face and frons shiny, except lateral grey silver pollinose vitta on each side; on frons, these pollinose vittae run on eye margin dorsally up to half distance between antennal insertion and anterior ocellus. Metafemur with short pile. Abdominal sterna entirely yellow; tergum 1 black; terga 2–5 yellow with black fascia on posterior margin, and sometimes along some lateral margin of these terga.

**Variation.** Some male paratypes have 2 smaller yellow maculae on tergum 2 and/or basal yellow fascia on tergum 5. Size of abdominal yellow maculae varies among specimens studied.

**Length** (n=5). Body: 7.9 mm (7.5–8.1); wing: 6.1 mm (5.5–6.2).

**Genetics.** The GenBank accession numbers for this species are: 28S rRNA gene (MH282902, specimen ZFMK-DIP-00027140; MH282903, specimen ZFMK-DIP-00027190), 18S rRNA gene (MH282904, specimen ZFMK-DIP-00027140; MH282905, specimen ZFMK-DIP-00027190), COI gene (MH282897, specimen ZFMK-DIP-00027140; MH282898, specimen ZFMK-DIP-00027190; MH282899, specimen ZFMK-DIP-00027206; MH282900, specimen ZFMK-DIP-00027207). All the obtained COI sequences were identical, with only one nucleotide change in the specimen ZFMK-DIP-00027190 compared to the other three specimens. The two 28S rDNA sequences and the two 18S rDNA sequences were identical, respectively.

**Differential diagnosis.** This new species is very similar to *R. khakimovi* Barkalov sp. nov. Males of *R. bella* Mengual sp. nov. have short pile on protibiae, and metafemora with some long pale pile medially, but shorter than metafemur width. They can be distinguished from males of *R. montivaga* and *R. khakimovi* Barkalov sp. nov. by the shape of the male genitalia (see Figs 9–14) and from the males of *R. dimorpha* by the pilosity of the metafemur and by the male genitalia. As stated by BARKALOV & NIELSEN (2010) and corroborated by the present study, females of *R. montivaga* and *R. dimorpha* are sometimes indistinguishable, and the presence of conspecific males may help to identify them. Females of *R. bella* Mengual sp. nov. are very similar to those of *R. montivaga* and *R. dimorpha*, and they can only be separated from them using the distribution of the specimens, DNA barcodes, or conspecific males. Females of *R. khakimovi* Barkalov sp. nov. can be distinguished from females of these three taxa using the grey pollinosity on frons as stated in the key.

**Etymology.** The specific epithet is derived from the Latin *bellus* meaning pretty, lovely (BROWN 1956: 130). Species epithet to be treated as an adjective.



Figs 2–8. *Rohdendorfia bella* Mengual, sp. nov. 2–3 – holotype male (ZFMK-DIP-00027140). 2 – dorsal view; 3 – lateral view. 4–5 – paratype female (ZFMK-DIP-00027194); 4 – dorsal view; 5 – lateral view. 6 – holotype male, frontal view. 7 – paratype female (ZFMK-DIP-00027194), frontal view. 8 – holotype male, metaleg, lateral view. Scale bars: 2–5 – 1 mm, 6–8 – 0.5 mm..

**Biology.** Some paratypes were collected in areas with *Potentilla pamirica* Th.Wolf, *Arenaria bryophylla* Fernald, *Thylacospermum* sp., and *Astragalus confertus* Bunge.

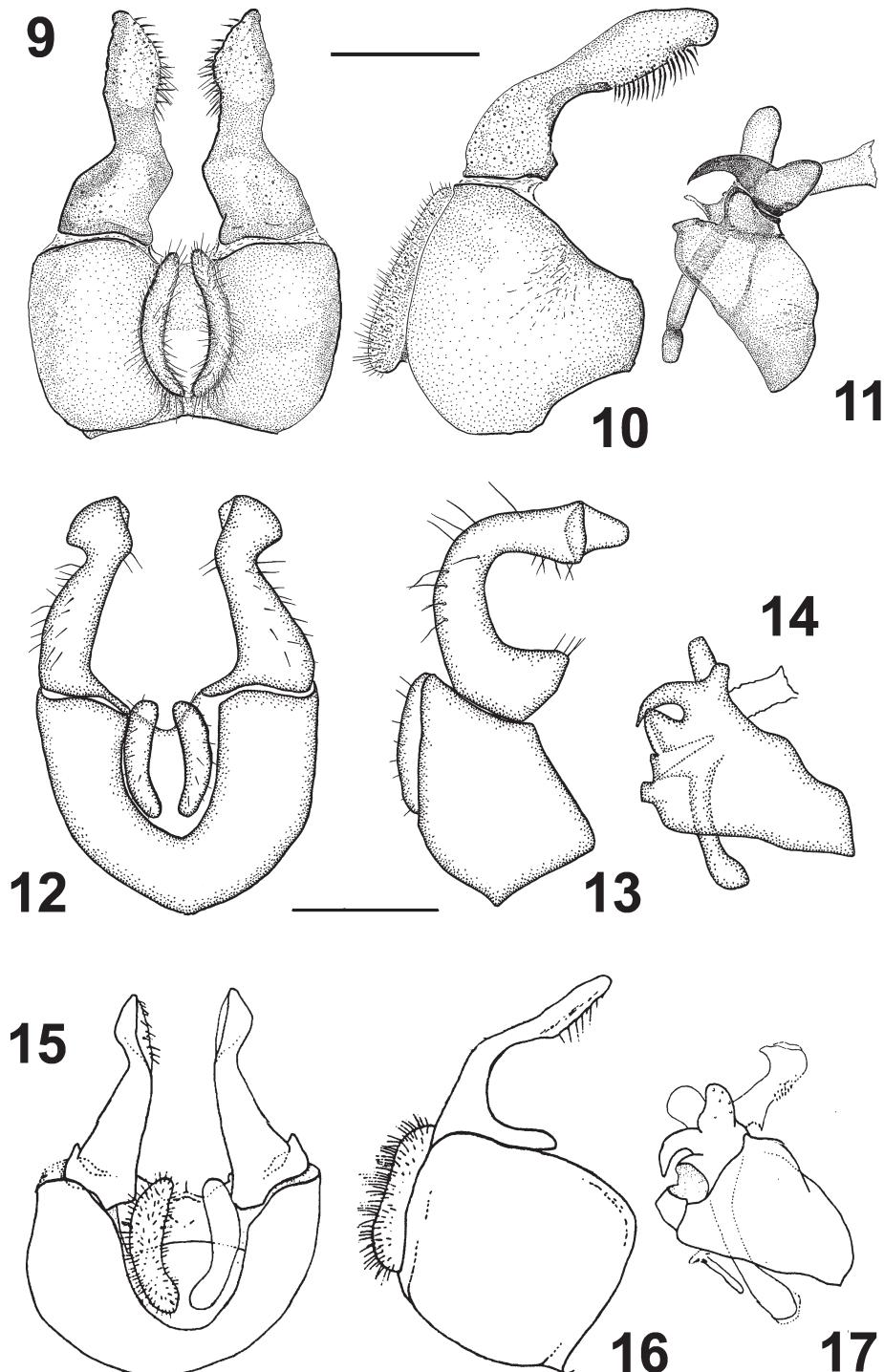
**Geographical distribution.** Only known from the Ladakh region, in northwest India. The studied specimens are the first records of the genus *Rohdendorfia* collected in India, and the first individuals from the state of Jammu and Kashmir.

***Rohdendorfia khakimovi* Barkalov, sp. nov.**

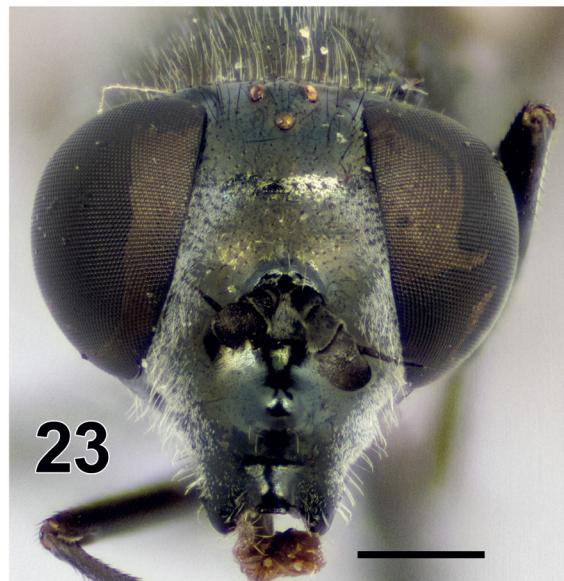
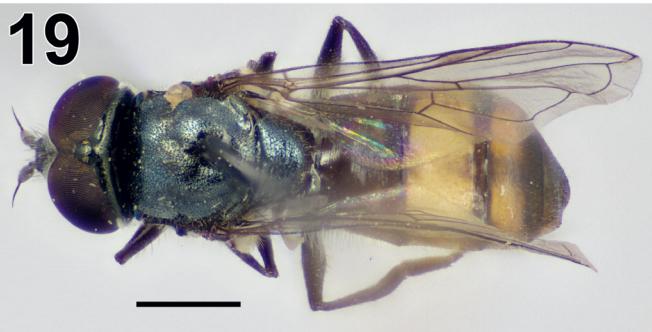
(Figs 1, 12–14, 18–24, 35)

**Type locality.** Tajikistan, Gorno-Badagshan Autonomous Region, Pamir, mountain pass Koi-Tezek, 37°29' N 72°47' E, 4370 m a.s.l. (Fig. 1).

**Type material.** HOLOTYPE: ♂, “Tajikistan, Gorno-Badakhshan // Autonomous Region // Pamir, pass Koi-Tezek // 4370 m asl, 37°29' N 72°47' E // 17.vii.2018 (Leg. A. Barkalov) // *Rohdendorfia* // *khakimovi* // Barkalov sp. n.” // Holotype” [ISEA]. PARATYPES: 5 ♂♂ 28 ♀♀, same place and date as holotype, Leg. A. Barkalov [ISEA]; 7 ♀♀, same place and date



Figs 9–17. Male genitalia. 9–11 – *Rohdendorfia bella* Mengual, sp. nov. 9 – epandrium, dorsal view; 10 – epandrium, lateral view; 11 – hypandrium, lateral view. 12–14 – *Rohdendorfia khakimovi* Barkalov, sp. nov. 12 – epandrium, dorsal view; 13 – epandrium, lateral view; 14 – hypandrium, lateral view. 15–17 – *Rohdendorfia alpina* Sack, 1938 (adapted from CLAUSSEN 1988). 15 – epandrium, dorsal view; 16 – epandrium, lateral view; 17 – hypandrium, lateral view. Scale bars = 0.2 mm.



Figs 18–24. *Rohdendorfia khakimovi* Barkalov, sp. nov. 18–19 – paratype male (ZFMK-DIP-00055236); 18 – dorsal view; 19 – lateral view. 20–21 – paratype female (ZFMK-DIP-00055237); 20 – dorsal view; 21 – lateral view. 22 – paratype male (ZFMK-DIP-00055236), frontal view. 23 – paratype female (ZFMK-DIP-00055237), frontal view. 24 – paratype male (ZFMK-DIP-00055236), metaleg and sternite, lateral view. Scale bars: 18–21 – 1 mm, 22–24 – 0.5 mm.

as holotype, Leg. V. Zinchenko [ISEA]; 1 ♂ 2 ♀♀, same place and date as holotype, Leg. A. Barkalov [ZFMK, ZFMK-DIP-00055236-DNA voucher D412, ...55237, ...15937-DNA voucher D410]; 2 ♀♀, TAJIKISTAN: Gorno-Badagshan Autonomous Region, Shungan District, environs of kishlak Nishusp, Bigshondara gorge, 20.vii.2018, Leg. A. Barkalov [ISEA].

**Description.** **Male.** Head (Figs 18–19, 22). Face black, with distinct facial tubercle, concave below antennal insertion, pale pilose, with two stripes of grey dusting laterally, central part and lower part shiny. Mouth edge protruding, shiny. Gena low, shiny, black, with short black pilosity. Lunula black, shiny. Frontal triangle black, black and white pilose, shiny medially, with dense grey silver pollinosity laterally on eye margin. Eyes bare, connected for distance as long as vertical triangle. Vertical triangle distinctly upraised, black shiny, black pilose. Antenna black, with dense grey pollinosity, basoflagellomere yellowish ventro-basally; arista short, thick, black. Occiput black, pale pilose, shiny on dorsal 1/2 and with grey pollinosity on ventral 1/2.

**Thorax** (Figs 18–19). Scutum and scutellum black, shiny with short white and longer black fine pile; postpronotum bare; subscutellar fringe with pale pile. Pleuron black, shiny, pale pilose; metaepisternum and metasternum bare; calypter white; halter pedicel dark brown, capitulum white. Wing hyaline, entirely microtrichose; stigma dark brown. Alula brown, broader than costal cell. Legs simple, entirely black, with short pile; metafemur finely swollen medially, covered with yellow and black long pile, shorter than metafemur width (Fig. 24).

**Abdomen** (Figs 18–19, 24). Unmargined, parallel-sided, with short, erect pale pile, longer on sides of terga 1–2. Tergum 1 black; tergum 2 black with two small yellow maculae; terga 3–4 mostly orange-yellow with black anterior and posterior margins; tergum 5 mostly black with orange lateral sides. **Male genitalia** as in Figs 12–14.

**Female** (Figs 20–21, 23, 35). Similar to male except for sexual dimorphism and: frons comparatively broad (Fig. 23) with black pile medially and pale pile laterally; scutum with pile of equal length; pile on swollen central part of metafemur shorter than in male and adpressed; tergum 2 orange with narrow black fascia anteriorly and posteriorly (Figs 20–21).

**Variation.** Some male specimens have completely black basoflagellomere.

**Length (n=5).** Body: 4.8–7.2 mm; wing: 4.1–5.7 mm.

**Genetics.** The GenBank accession numbers for this species are: COI gene (MK415827, specimen ZFMK-DIP-00015937; MK415828, specimen ZFMK-DIP-00055236). The two obtained COI sequences were almost identical, with only one nucleotide change between specimens ZFMK-DIP-00015937 and ZFMK-DIP-00055236.

**Differential diagnosis.** See the diagnosis of *R. bella* Mengual sp. nov. Males of *R. khakimovi* Barkalov sp. nov. and *R. bella* Mengual sp. nov. can be distinguished by the shape of the male genitalia. Females of *R. khakimovi* Barkalov sp. nov. have triangular grey pollinose maculae on frons.

**Etymology.** The species is named in honor of the director of the Institute of Zoology and Parasitology of the Academy of

Sciences of the Republic of Tajikistan, Dr. Fayzali R. Khamidov, who organized the expedition to the Pamir region.

**Biology.** Adult flies were resting on stones and from time to time, they flew short distances of approximately 30–50 m. There were no flowers in this locality, and adult flies were concentrated in a small gorge, probably due to the absence of wind. Most of the adult flies were females, but some males, which look slightly different in the field, were also collected.

**Geographical distribution.** Only known from the type locality.

## Other examined taxa

### *Rohdendorfia alpina* Sack, 1938

**Material examined.** AUSTRIA: 1 ♀, Hohe Tauern, Virgental, oberstes Maurertal, 2300 m, 30.vii.1988, C. Claussen [ZFMK]. GEORGIA: 18 ♂♂ 20 ♀♀, Mtskheta-Mtianeti, Kazbegi area, base of glacier 6 km W Kazbegi, 42°39.61'N 044°33.39'E, 2800–3000 m, 2.viii.2001, J.-H. Stuke [ZFMK]; 12 ♀♀, Mtskheta-Mtianeti, Kazbegi area, gravel surface 3 km SSE Kobi, 42°31.21'N 044°30.92'E, 2800–3000 m, 31.vii.2001, J.-H. Stuke [ZFMK]. ITALY: 3 ♂♂ 1 ♀, Lombardy, Bormio, Stilfser Joch, 2700 m, 22.vii.1995, J.-H. Stuke [ZFMK]; 1 ♀, Stilfser Joch, Goldsee, 2708 m, 28.vii.1991, M. Hauser [ZFMK]; 1 ♀, Stilfser Joch, 2750 m, 20.viii.1992, M. Hauser [ZFMK]; 2 ♂♂ 5 ♀♀, Stilfser Joch, 2900 m, 27.vii.1993, M. Hauser [ZFMK]; 1 ♂, Stilfser Joch, 2900 m, 27.vii.1993, F. Geller-Grimm [ZFMK, ZFMK-DIP-00019928]; 1 ♀, Lombardy, Bormio, Valle del Braulio, 2300 m, 22.vii.1995, J.-H. Stuke [ZFMK]; 1 ♂ 2 ♀♀, South Tyrol, Vingschgau, Planaital, 2200–2600 m, 24.vii.1995, J.-H. Stuke [ZFMK]; 1 ♀, South Tyrol, Vingschgau, Planaital, 1900–2400 m, 28.vii.1993, M. Hauser [ZFMK]. RUSSIA: 1 ♂, Altai Republic, Ulaganskiy Rayon, 50.33° N 87.75° E, 2500–2800 m, 29–30.vi.2008, A. Barkalov [ZFMK]; 1 ♀, Altai Republic, Kosh-Agachsky District, 49.81° N 89.55° E, 2500–2800 m, 15–17.vii.2009, A. Barkalov [ZFMK].

### *Rohdendorfia dimorpha* Smirnov, 1924

**Material examined.** KIRGYZSTAN: 1 ♂ 1 ♀, Alajskij range, environs of Taldyk Pass, 3620–3750 m, 16.vii.2003, V. Zinchenko [ZFMK, ZFMK-DIP-00019931, ...19932]. TAJIKISTAN: 64 ♂♂ 4 ♀♀, Varzobskoe gorge, 4 km NE kishlak Kalon, 3375 m, 39.08° N 68.86° E, 6.vii.2017, A. Barkalov & V. Zinchenko [ISEA].

### *Rohdendorfia montivaga* Violovitsh, 1984

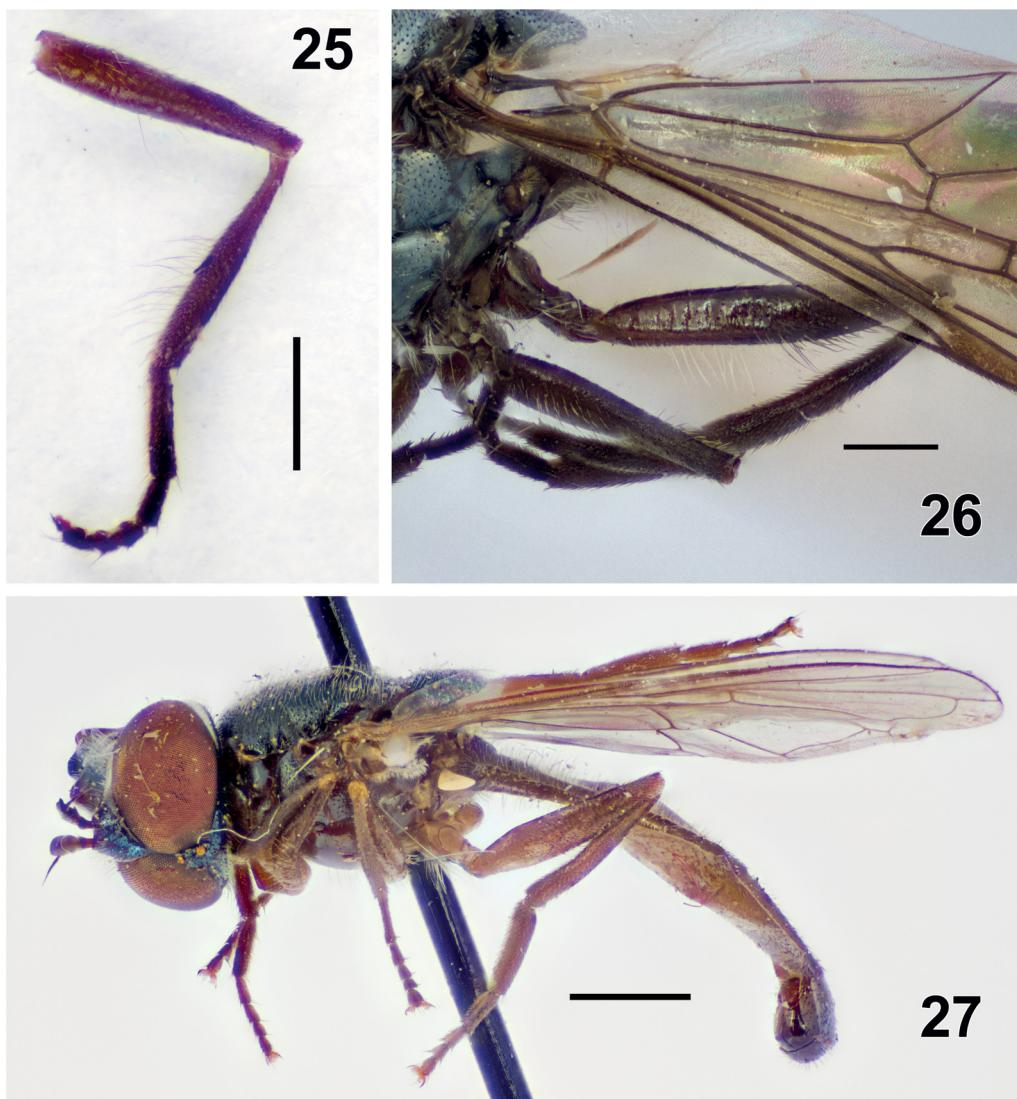
**Material examined.** KIRGYZSTAN: 1 ♂ 1 ♀, Kashgaria, Osh region, upper reaches of the Mal'tabar stream, 18.vii.2003, V. Zinchenko [ZFMK, ZFMK-DIP-00019929, ...19930]; 1 ♀, Terskej Alatau Mt. R., SW of Chon-Asuu Pass, 3720 m, 42°23'N 79°04'E, 15.viii.2004, D. Milko [ISEA]; 4 ♀♀, Southern Kirgizia, Alai Ridge, Taldyk Pass, 3800 m, 39°46' N 73°10'E, 12.vii.2000, D. Milko [ISEA]; 1 ♀, Southern Kirgizia, Alai Ridge, S slope, Shiman Pass, 3800 m, 39°39' N 72°14'E, 24.vii.2003, D. Milko [ISEA]; 2 ♀♀, Southern Kirgizia, Transalaj Mt. Ridge, Turparkol lake, 4650 m, 39°30'N 72°57'E, 22–23.vii.2003, D. Milko [ISEA]; 1 ♀, Southern Kirgizia, Transalaj Mt. Ridge, 1km W Taunmurun Pass, 3260 m, 39°38'N 73°37'E, 21.vii.2003, D. Milko [ISEA]; 1 ♂, Ak-Shyirak, W Mt. Ridge, N slope, ca. Besh-Kol Lake, 1960 m, 41°23'N 74°28'E, 22–29.vii.2003, D. Milko [ISEA].

## Key to species of the genus *Rohdendorfia*

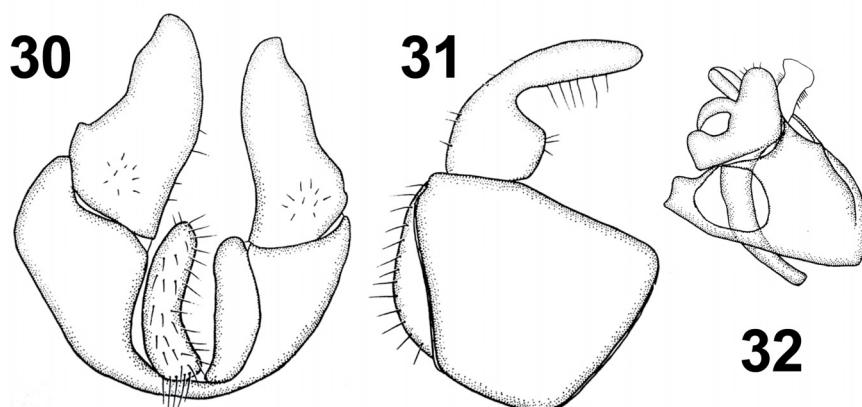
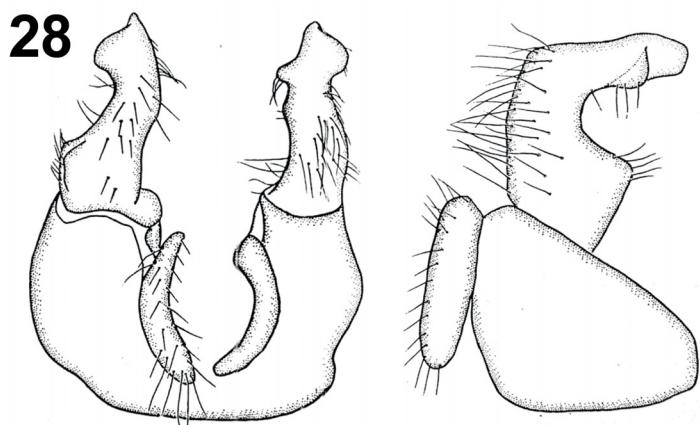
(Modified from BARKALOV & NIELSEN 2010).

- 1 Eyes widely separated on frons: females (Figs 4, 7, 20, 23). ..... 6
- Eyes meeting on frons: males (Figs 2, 6, 19, 22). ..... 2
- 2 Protibia with long pile ventrally (Fig. 25). Male genitalia as in Figs 15–17. Distribution: European Alps, northern Caucasus, Altai, Sayan. ..... ***R. alpina* Sack, 1938**

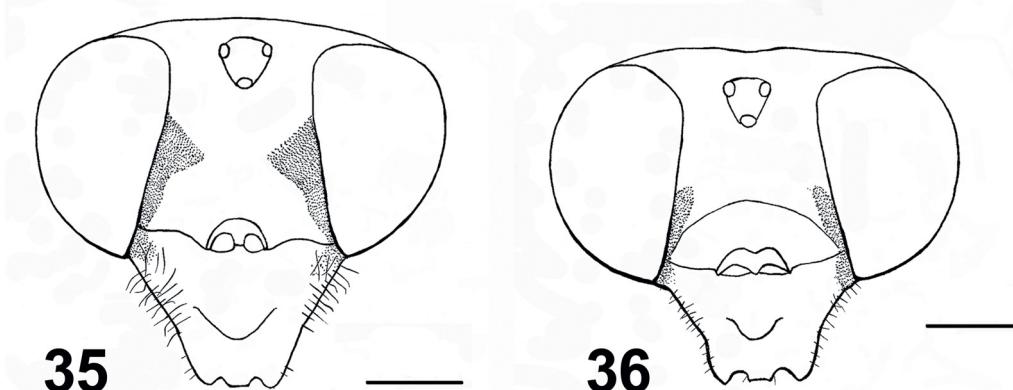
- Protibia with short pile ventrally (Figs 6, 22). .... 3
- 3 Metafemur only with dark short (mostly adpressed) pile, without long erect pile anteroventrally (Fig. 27). Male genitalia as in Figs 28–29. Distribution: Pamirs, Alai. .... *R. dimorpha* Smirnov, 1924
- Metafemur with long pile anteroventrally (Figs 8, 24, 26). .... 4
- 4 Metafemur with long erect pale pile anteroventrally, as long as width of metafemur (Fig. 26). Male genitalia as in Figs 30–32: in lateral view, surstyli with broad basal part and strong curvature medially (Fig. 31); in dorsal view, surstyli broad basally, narrows towards apical part (Fig. 30). Distribution: Tian Shan, Kyrgyz Kashgaria, Dzungarian Alatau. .... *R. montivaga* Violovitsh, 1984
- Metafemur with some long pale pile anteroventrally, shorter than width of metafemur (Figs 8, 24). Male genitalia not as above (Figs 9–14). .... 5
- 5 Surstylus in lateral view with long, curved posterodorsal lobe (Fig. 13), in dorsal view with posterodorsal lobe bent in apical third (Fig. 12). Distribution: West Pamir. .... *R. khakimovi* Barkalov, sp. nov.
- Surstylus in lateral view with slightly curved, medially narrowed posterodorsal lobe (Fig. 10), in dorsal view with posterodorsal lobe not bent (Fig. 9). Distribution: Ladakh. .... *R. bella* Mengual, sp. nov.
- 6 Face without vittae of grey pollinosity, OR at most with triangular maculae of grey pollinosity on dorsal part of face, joint with pollinosity along eye margin (Fig. 33). Black fascia on posterior margin of abdominal terga 3–4 narrows and sometimes completely peters out towards lateral margin. Distribution: European Alps, northern Caucasus, Altai, Sayan. .... *R. alpina* Sack, 1938
- Face with two longitudinal vittae of grey pollinosity, from frons to mouth edge (Figs 7, 23, 34). Black maculae or fascia on posterior margin of abdominal terga broadened towards lateral margin (Figs 4, 5, 20, 21). .... 6
- 6 Frons with grey pollinose vittae widen dorsally, forming triangular macula on each side (Figs 23, 35). .... *R. khakimovi* Barkalov, sp. nov.
- Frons with grey pollinose vittae narrow, not forming triangular maculae (Figs 7, 34, 36). .... 7
- 7 Distribution: Pamirs, Alai. .... *R. dimorpha* Smirnov, 1924
- Distribution: Tian Shan, Kyrgyz Kashgaria, Dzungarian Alatau. .... *R. montivaga* Violovitsh, 1984
- Distribution: Ladakh. .... *R. bella* Mengual, sp. nov.



Figs 25–27. 25 – *Rohdendorfia alpina* Sack, 1938, male (ZFMK-DIP-00019928), proleg, lateral view. 26 – *Rohdendorfia montivaga* Violovitsh, 1984, male (ZFMK-DIP-00019929), metaleg, lateral view. Scale bars = 0.5 mm. 27 – *Rohdendorfia dimorpha* Smirnov, 1924, male (ZFMK-DIP-00019931), lateral view. Scale bars = 1 mm.



Figs 28–32. Male genitalia. 28–29 – *Rohdendorfia dimorpha* Smirnov, 1924 (adapted from BARKALOV & NIELSEN 2010). 28 – epandrium, dorsal view; 29 – epandrium, lateral view. 30–32 – *R. montivaga* Violovitsh, 1984 (adapted from BARKALOV & NIELSEN 2010). 30 – epandrium, dorsal view; 31 – epandrium, lateral view; 32 – hypandrium, lateral view.



Figs 33–36. 33 – *Rohdendorfia alpina* Sack, 1938, female (ZFMK-DIP-00019933), head, frontolateral view. 34 – *R. dimorpha* Smirnov, 1924, female (ZFMK-DIP-00019932), head, frontolateral view. 35 – *R. khakimovi* Barkalov, sp. nov., female, head, dorsal view. 36 – *R. montivaga* Violovitsh, 1984, female, head, dorsal view. Scale bars = 0.5 mm.

## Discussion

Two new species of *Rohdendorfia* are described from Central Asia, one of the highest regions on Earth. The studied type specimens of *R. bella* Mengual sp. nov. are the first records of the genus *Rohdendorfia* for India and for the state of Jammu and Kashmir. From the Indian state of Jammu and Kashmir, including the former Indian administered areas now under the Chinese and Pakistani control and the highlands of Ladakh, GHORPADÉ (2014) listed a total of 92 species, plus four species likely to be present. In his checklist, *Rohdendorfia dimorpha* was listed from this Indian state based on CLAUSSEN (1988), but later GHORPADÉ (2015) questioned the presence of *R. dimorpha* from Jammu and Kashmir as there is no verified record from this Indian state. CLAUSSEN (1988) only summarized the ideas of LAMBECK & BRINK (1973), who considered *R. dimorpha* a faunal element of the Pamirian oreal centre. The only records of *R. dimorpha* from Central Asia are given by DOESBURG (1955) and BAŃKOWSKA (1968). DOESBURG (1955) reported three female specimens of *R. dimorpha* from the Aghil Mountains (5220 m a.s.l.), northern Karakorum in the Xinjiang Uyghur Autonomous Region of China, and BAŃKOWSKA (1968) reported one female from Sarekanda (4200 m a.s.l.), Badakhshan Province in northeastern Afghanistan, and two more females from a pass near Kabul (1740 m a.s.l.), eastern Afghanistan. As stated by BARKALOV & NIELSEN (2010), without male specimens from this region it is not possible to confirm the occurrence of *R. dimorpha* in these territories.

*Rohdendorfia* females are difficult to be distinguished as they present many variable characters (CLAUSSEN 1988, BARKALOV & NIELSEN 2010). The distribution or the presence of conspecific males may help with the identification, but we support the use of molecular characters in these cases to link sexes. DNA barcoding has been already used to link sexes (JORDAENS et al. 2015) and life stages (ANDRIĆ et al. 2014). Thus, we have sequenced a few genes (COI, 28S and 18S rRNA) from the holotype of *R. bella* Mengual sp. nov. and from some paratypes of *R. bella* Mengual sp. nov. and *R. khakimovi* Barkalov sp. nov. to help with further identifications of this genus based on molecular characters, especially females. When we compared the COI sequences of the two new species with the sequences published in GenBank for

this genus (*R. alpina*, accession number KF919082), we did not find a very broad uncorrected pairwise distance among them as the three species differ from 0.463% to 1.235% (see Table 1). There is another published COI sequence for *R. alpina* (GenBank accession number EF127338), but it refers to the 3'end of the COI gene and it cannot be compared with the barcode sequences of the 5'end of the COI gene. Nevertheless, it is interesting to point out that the two published COI sequences for *R. alpina* (KF919082 and EF127338) present many nucleotide changes in the region where they overlap and this deserves further study.

Regarding the two rRNA genes sequenced in the present study, we think they can be of little use to distinguish species due to their conservative nature, although the number of published sequences is very low and their use might improve with higher numbers of sequences. There is only one published 28S rDNA sequence of *R. alpina* (GenBank accession number EF127420) and another one for *R. dimorpha* (GenBank accession number EF127395), which do not differ from one another, but both differ in two nucleotides from the two obtained sequences of *R. bella* Mengual sp. nov., which are identical. For the 18S gene, its use for distinguishing species is also limited by its conservative nature and the low number of published sequences; only one 18S rDNA sequence for *R. alpina* is published (GenBank accession number EU431552). The 18S rDNA sequence of *R. alpina* has only one nucleotide change compared with the two identical 18S rDNA sequences here obtained for *R. bella* Mengual sp. nov.

Albeit the differences among different species for the studied genes (COI, 18S and 28S rRNA) are small, we think it is worth to obtain and publish new sequences of *Rohdendorfia* to help with the identification of males and females, either from the DNA-barcoding region or from other genes that can provide a better resolution at species level.

*Rohdendorfia* species are high alpine taxa occurring in the highest mountains on Earth, such as the Alps, Caucasus, Altai, Sayan, Tian Shan, Kashgar, Dzungarian Alatau, Pamirs, Alai and Ladakh. Their abundance may be locally high, as the type series of *R. bella* Mengual sp. nov. and *R. khakimovi* Barkalov sp. nov. prove, but usually they are not abundant in collections. LAMBECK & BRINK (1973) presented *R. dimorpha* as an oreal species of the Pamir. VARGA (1996) defined the oreal fauna as the fauna from non-arboreal

Table 1. COI (5'end of the gene, 648 bp) uncorrected pairwise distances (% similarity) among *Rohdendorfia* specimens (GenBank accession numbers in brackets).

	1	2	3	4	5	6	7
<i>R. bella</i> Mengual, sp. nov. [MH282897]	1	–	99.846	100	100	99.537	99.383
<i>R. bella</i> Mengual, sp. nov. [MH282898]	2	99.846	–	99.846	99.846	99.383	99.228
<i>R. bella</i> Mengual, sp. nov. [MH282899]	3	100	99.846	–	100	99.537	99.383
<i>R. bella</i> Mengual, sp. nov. [MH282900]	4	100	99.846	100	–	99.537	99.383
<i>R. khakimovi</i> Barkalov, sp. nov. [MK415827]	5	99.537	99.383	99.537	99.537	–	99.846
<i>R. khakimovi</i> Barkalov, sp. nov. [MK415828]	6	99.383	99.228	99.383	99.383	99.846	–
<i>R. alpina</i> Sack, 1938 [KF919082]	7	99.383	99.228	99.383	99.383	98.92	98.765

biomes (regions with low level of primary production, i.e. less than 25 q/ha per year) caused by orography without a zonal nature like tundra, for instance. Usually, the oreal elements occur in spot-like, “insular”, often highly endemic or widely separated areas (VARGA 1996), exactly as it seems the case of *Rohdendorfia*. According to LATTIN (1967), the oreal elements of the Palaearctic may have emerged from an ancient Palaearctic oreal fauna with a formerly wider distribution, which probably also applies to the *Rohdendorfia* species (CLAUSSEN 1988).

All specimens of *R. bella* Mengual sp. nov. were collected over 5000 m a.s.l. and the individuals of *R. khakimovi* Barkalov sp. nov. in a mountain range close to 4500 m a.s.l. The authors only know a few other species collected at this altitude in Central Asia and in the Andes in South America. High mountain ecosystems can be seen as oceanic islands, where climate warming may result in reduction and increased variability of precipitation, and consequently in reduction in snow-cover, changes in biophysical characteristics of rivers and mountain lakes, and shifts in the distribution and phenology of many species of plants and animals along elevation gradients (ZAMORA et al. 2017). TERZİOĞLU et al. (2015) predicted an upward shift in the tree line, which would probably threaten the plant diversity of the alpine grassland areas as forests may cover them. These habitats with long periods of being covered by snow are endangered by the global warming, and the species of the genus *Rohdendorfia* might be also endangered if these kinds of ecosystems disappear. Another factor that alters these high mountain ecosystems and leads to long-term degradation is human activity, which in the case of Tajikistan was caused by overgrazing by goats, sheep and cows. More studies on the dynamics of these ecosystems, as well as the paramos around the globe, and the impact of overgrazing are urgently needed to understand and preserve their unique biota.

### Acknowledgements

Our most sincere thanks are due to Inés Abela-Hofbauerová for letting us study the dipterans she collected in the Ladakh Region. We thank Tore Nielsen for sharing his opinions and suggestions on the new species and Trevor O. Burt for drawing Figs 9–11. We thank Claudia Etzbauer for her invaluable help in the molecular lab. The work of A.V. Barkalov was conducted with the financial support of the Russian Foundation for Basic Research, grant No. 16-04-00194-a, and the Federal Fundamental Scientific Research Programme for 2013–2020, grant No. AAAA-A16-116121410121-7.

### References

- ANDRIĆ A., ČIKOPARIJA B., OBREHT D., ĐAN M, PRERADOVIĆ J., RADENKOVIĆ S., PÉREZ-BAÑÓN C., & VUJIĆ A. 2014: DNA barcoding applied: identifying the larva of *Merodon avidus* (Diptera: Syrphidae). *Acta Entomologica Musei Nationalis Pragae* **54**: 741–757.
- BAŃKOWSKA R. 1968: Materialen zur Kenntnis der Syrphidae (Diptera) von Afghanistan. *Fragmenta Faunistica* **14(9)**: 195–208.
- BARKALOV A. V. & NIELSEN T. R. 2010: Revision of the genus *Rohdendorfia* Smirnov, 1924 (Diptera, Syrphidae). *Norwegian Journal of Entomology* **57**: 154–161.
- BROWN R. W. 1956: *Composition of scientific words, a manual of methods and a lexicon of materials for the practice of logotechnics*. Published by the author, Baltimore, 882 pp.
- CLAUSSEN C. 1988: Zur Kenntnis der Gattung *Rohdendorfia* Smirnov 1924 in Europa (Diptera: Syrphidae). *Entomologische Zeitschrift* **98(9)**: 113–128.
- DOESBURG P. H. VAN, SR. 1955: Report on the syrphid flies, collected by the “Fourth Dutch Karakorum Expedition, 1935” (Mededelingen over Syrphidae XIII). *Beaufortia* **47(5)**: 47–51.
- EVENHUIS N. L. 2009: *The insect and spider collections of the world website* [online]. Available from: <http://hbs.bishopmuseum.org/codens/> (accessed 15 January 2018).
- GHORPADÉ K. 2014: An updated check-list of the Hover-flies (Diptera—Syrphidae) recorded in the Indian subcontinent. *Colemania* **44**: 1–30.
- GHORPADÉ K. 2015: Hover-flies (Diptera—Syrphidae) documented from the Northwest Frontier of the Indian sub-continent: a circumstantial history and inclusive bibliography. *Colemania* **50**: 1–151.
- HUO K.-K. 2014: Spazigasteroides a new genus from China with a black face and scutellum in the Syrphini (Diptera: Syrphidae). *Zootaxa* **3755(3)**: 230–240.
- JORDAENS K., GOERGEN G., VIRGILIO M, BACKELJAU T., VOKAERA A. & DE MEYER M. 2015: DNA barcoding to improve the taxonomy of the Afrotropical hoverflies (Insecta: Diptera: Syrphidae). *PLoS ONE* **10(10)** (e0140264): 1–15.
- LAMBECK H. J. P. & BRINK J. M. VAN 1973: Contribution to the knowledge of the taxonomy, faunal composition and cytology of the syrphid flies (Diptera: Syrphidae) of Kashmir (India). I. Taxonomic account and faunal composition. *Genen en Phaenen* **16(3)**: 87–100.
- LATTIN G. DE 1967: *Grundriß der ZooGeographyphie*. Fischer Verlag, Jena, 602 pp.
- MENGUAL X. 2015: A taxonomic revision of the genus *Asiobaccha* Villovitsh (Diptera: Syrphidae). *Journal of Natural History* **50(41–42)**: 2585–2645.
- MENGUAL X., STÄHLS G. & ROJO S. 2008: First phylogeny of predatory flower flies (Diptera, Syrphidae, Syrphinae) using mitochondrial COI and nuclear 28S rRNA genes: conflict and congruence with the current tribal classification. *Cladistics* **24**: 543–562.
- MENGUAL X., STÄHLS G. & ROJO S. 2012: Is the mega-diverse genus *Ocyptamus* (Diptera, Syrphidae) monophyletic? Evidence from molecular characters including the secondary structure of 28S rRNA. *Molecular Phylogenetics and Evolution* **62**: 191–205.
- SHORTHOUSE D. 2010: *SimpleMappr, an online tool to produce publication-quality point maps*. Available from: <http://www.simplemappr.net> (accessed 03 July 2018).
- SPEIGHT M. C. D. 2017: *Species accounts of European Syrphidae, 2017*. Syrph the Net, the database of European Syrphidae (Diptera), vol. 97. Syrph the Net publications, Dublin, 294 pp.
- TERZİOĞLU S., TÜFEKÇİOĞLU A. & KÜÇÜK M. 2015: Vegetation and plant diversity of high-altitude mountains in eastern Karadeniz (Black Sea) region of Turkey and climate change interactions. Pp. 383–408. In: ÖZTÜRK M., HAKEEM, K. R., FARIDAH-HANUM I. & EFE R. (eds.): *Climate change impacts on high-altitude ecosystems*. Springer International Publishing, Switzerland, 696 pp.
- THOMPSON F. C. 1999: Key to the genera of the flower flies (Diptera: Syrphidae) of the Neotropical Region including descriptions of new genera and species and a glossary of taxonomic terms. *Contributions on Entomology, International* **3**: 319–378.
- THOMPSON, F. C. & ROTHERAY, G. E. 1998: Family Syrphidae. Pp. 81–139. In: PAPP, L. & DARVAS, B. (eds.): *Contributions to a Manual of Palaearctic Diptera, volume 3*. Science Herald, Budapest, 880 pp.
- THOMPSON F. C., ROTHERAY G. E. & ZUMBADO M. A. 2010: Syrphidae (flower flies). Pp. 763–792. In: BROWN B. V., BORKENT A., CUMMING J. M., WOOD D. M., WOODLEY N. E., ZUMBADO M. A. (eds.): *Manual of Central American Diptera, volume 2*. NRC Research Press, Ottawa, 728 pp.
- THOMPSON F. C. & SKEVINGTON J. H. 2014: Afrotropical flower flies (Diptera: Syrphidae). A new genus and species from Kenya, with a review of the melanostomine group of genera. *Zootaxa* **3847(1)**: 97–114.
- VARGA Z. 1996: Biogeography and evolution of the oreal Lepidoptera in the Palaearctic. *Acta Zoologica Hungarica* **42**: 289–330.
- ZAMORA R., PÉREZ-LUQUE A. J. & BONET F. J. 2017: Monitoring Global Change in High Mountains. Pp. 385–413. In: CATALAN J., NINOT J. M. & ANIZ M. M. (eds.): *High Mountain Conservation in a Changing World*. Advances in Global Change Research 62. Springer Open, 413 pp.

