



## A systematic revision of the genus *Gnophopsodos* Wehrli, 1945, with description of two new species (Lepidoptera: Geometridae)

SVEN ERLACHER<sup>1</sup> & JOSEPHA ERLACHER

Museum für Naturkunde, Moritzstraße 20, D-09111 Chemnitz, Germany. E-mail: [erlacher@naturkunde-chemnitz.de](mailto:erlacher@naturkunde-chemnitz.de)

<sup>1</sup>Corresponding author

### Abstract

In a comprehensive morphological study besides results of DNA barcoding the genus *Gnophopsodos* Wehrli, 1945 is taxonomically revised. The taxon comprises nine species. Diagnostic characters are depicted and a key to the species based on the morphology of male genitalia is provided. Males and females (if available) of each species and their genitalia are illustrated. The distribution of all species is described and figured on maps. *Gnophopsodos hilmari* **spec. nov.** from Uzbekistan and Kyrgyzstan, *Gnophopsodos sabine* **spec. nov.** and *Gnophopsodos ravistriolaria pantherinus* **subspec. nov.**, both from the Russian part of the Altai Mountains, are described as new. *Gnophopsodos puengeleri* (Bohatsch, 1910) **stat. rev.** is re-established as a separate species. The following synonyms are recognized: *Chelegnophos* Wehrli, 1951 **syn. nov.** of *Gnophopsodos* Wehrli, 1945; *Chelegnophos alaianus* Viidalepp, 1988 **syn. nov.** of *Gnophopsodos puengeleri* (Bohatsch, 1910), *Psodos altissimaria* Oberthür, 1913 **syn. nov.** of *Gnophopsodos gnophosaria* (Oberthür, 1893), and *Gnophos orbicularia* Püngeler, 1904 **syn. nov.** of *Gnophopsodos stemmataria* (Eversmann, 1848) **comb. nov.** The latter is transferred from the genus *Gnophos* Treitschke, 1825 to the genus *Gnophopsodos*.

**Key words:** Asia, *Charissa*, *Chelegnophos*, DNA barcoding, *Gnophos*, morphology, new species, synonyms, taxonomy

### Introduction

As in most *Gnophos* Treitschke, 1825 and *Charissa* Curtis, 1826 the adults of the genus *Gnophopsodos* Wehrli, 1945 are perfectly adapted to rocks on which they rest during daytime, that results in strong convergence of wing pattern even in different geometrid genera. This makes them hard to tell apart on habitus. For that it is often necessary to study their genitalia, but even with that, finding differences between species is sometimes difficult.

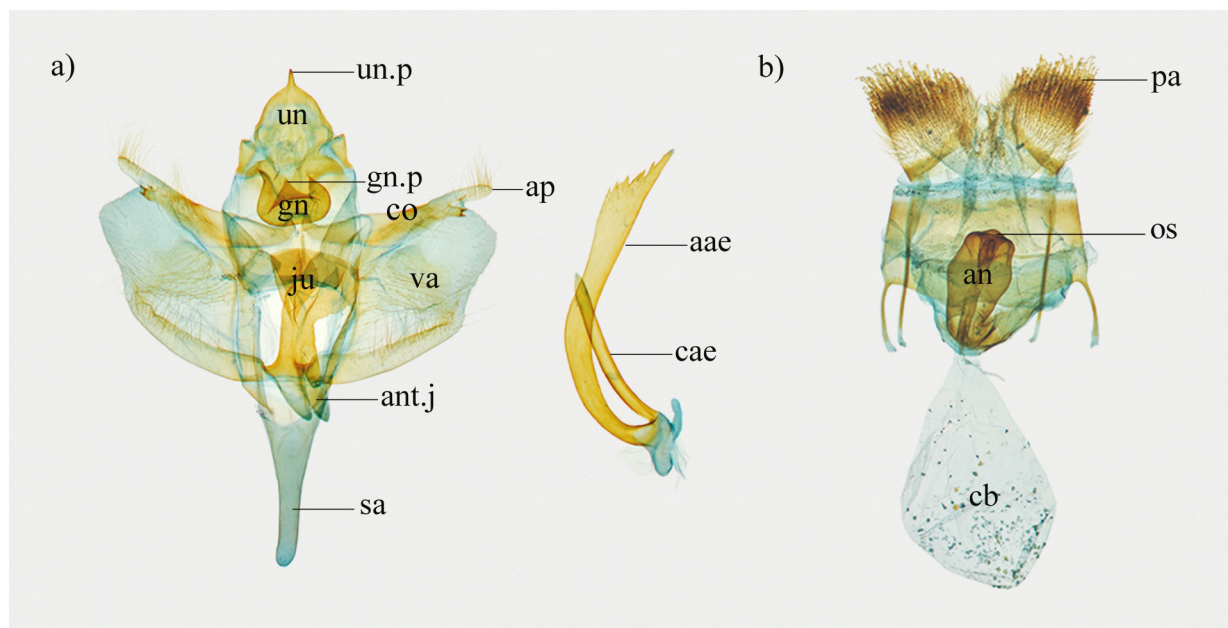
The taxon *Gnophopsodos* was introduced as a genus by Wehrli (1945), while *Chelegnophos* was proposed as a subgenus of *Gnophos* by Wehrli (1951). Afterwards both were again proposed by translating his former French article into German and by publishing it in Wehrli (1953). Whereas Wehrli (1951, 1953) treated *Gnophopsodos* as a link between *Gnophos* and *Psodos* Treitschke, 1825 he obviously overlooked the conformity to *Chelegnophos* in the structure of male genitalia. Since that publication there has not been a revision of this group. In his phylogenetic study of the *Gnophos*-group Sauter (1990) treated *Chelegnophos* as a subgenus of *Charissa*. Later Kaila *et al.* (1996) and Viidalepp (1996) considered *Chelegnophos* as a separate genus. Finally, Parsons *et al.* (1999) retained *Chelegnophos* as subordinate to *Gnophos* and listed it as junior synonym of the latter as they did with all priorly described subgenera without giving any reasons.

Recent collections of some “*Gnophos*” and “*Charissa*” from the Russian part of the Altai Mountains and the discovery of two unknown species from there as well as from Uzbekistan and Kyrgyzstan revealed several taxonomic problems which necessitated a revision of *Chelegnophos* and *Gnophopsodos*. The present paper deals with the diagnostic characters of each species in detail and provides a key for determination of all species. Two species and one subspecies are described as new. Furthermore, results of DNA barcoding were used to give additional support.

## Methods

**Morphology.** The taxonomic assignment of the species was made on the basis of external and internal morphological characters. Genitalia preparation was conducted as described in Trusch & Erlacher (2001). The photographs of the genitalia were taken with a Nikon D90 camera connected to the stereomicroscope Nikon SMZ1000. Several images of different focus planes were combined using the freely available software CombineZP in order to obtain optimally focused images. Photographs were enhanced and arranged to plates with Adobe® Photoshop® software. External measurements of the available specimens were conducted by using a sliding calliper. Internal measurements were made on photographs of the genitalia by means of the software Motic Images Plus (version 2.0). The following external characters were measured: wingspan (widest distance between forewing margins in set specimens); forewing length (length of the costa from the base to the apex); forewing width (longest line of the forewing parallel to the body).

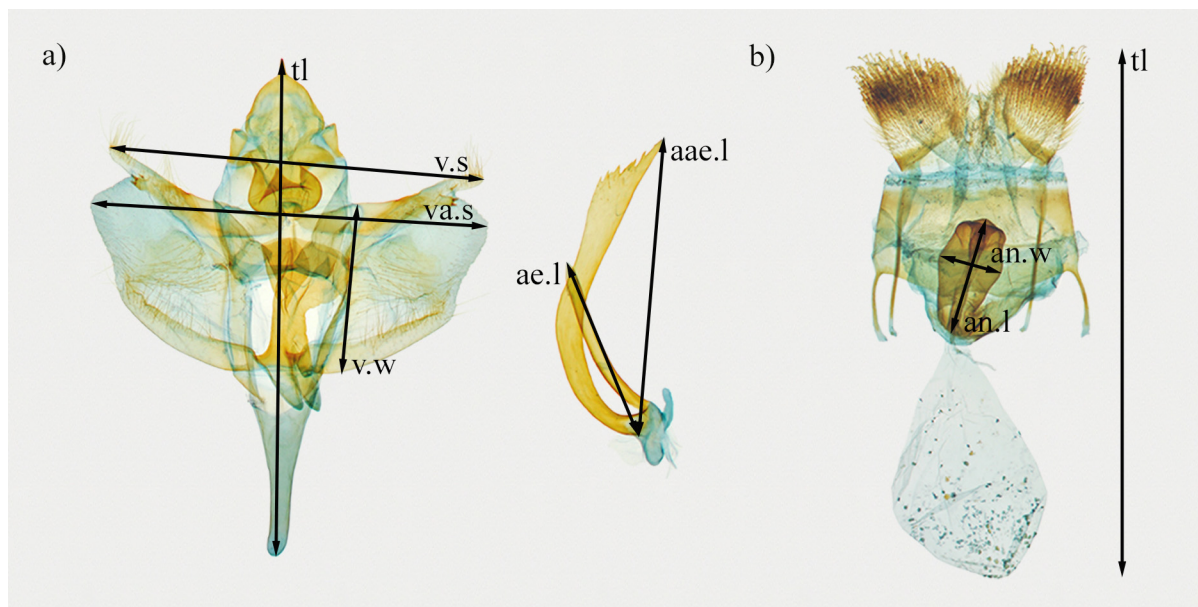
Terminology of male and female genitalia are explained in Fig. 1. Following genitalia characters were measured (see Fig. 2): in the male genitalia—total length (distance from the most caudal part of the uncus to the end of the saccus); valvae span (line between apices of valvae spread out on the slide); valvulae span (distance between the apices of valvulae); valvae width (distance between base of the costa and ventral valvae margin); aedeagus length (distance from the base of the appendix aedeagi to the distal end of the corpus aedeagi); length of appendix aedeagi (longest straight distance between the base of the appendix aedeagi and the distal end of the appendix aedeagi); in the female genitalia—total length (distance from an imaginary horizontal line along the posterior end of the papillae anales to the anterior end of the corpus bursae); antrum length (distance from the ostium to the anterior end of the strongly sclerotized antrum); antrum width (distance between the widest lateral extension of the antrum).



**FIGURE 1.** Structures of the genitalia in the genus *Gnophopsodos*, on the sample of *G. sabine* spec. nov. a)—male, b)—female. **a.e.**: appendix aedeagi; **an**: antrum; **ant.ju**: anterior juxta appendices; **ap**: apex of costa; **c.a.e.**: corpus aedeagi; **cb**: corpus bursae; **co**: costa; **gn**: gnathos; **gn.p**: gnathos peak; **ju**: juxta; **os**: ostium; **pa**: papillae anales; **sa**: saccus; **un**: uncus; **un.p**: uncus peak; **va**: valvula.

**DNA analysis.** DNA sequencing was performed at the Canadian Centre for DNA Barcoding (CCDB) following standard high-throughput protocols (Ivanova *et al.* 2006; deWaard *et al.* 2008). PCR amplification with a single pair of primers consistently recovered a 658 bp region near the 5' end of the mitochondrial cytochrome c oxidase I (COI) gene that included the standard 648 bp barcode region for the animal kingdom (Hebert *et al.* 2003). DNA extracts are stored at the CCDB. Complete specimen data including images, voucher deposition, barcode identification number, sequence process ID, barcode index number (BIN), GPS coordinates, sequence and trace files can be accessed in the Barcode of Life Data (BOLD) System (Ratnasingham & Hebert 2007; Ratnasingham

2016) in the public data set DS-GNOPHOPS (<http://dx.doi.org/10.5883/DS-GNOPHOPS>). Sequence distances for the barcode region and a neighbor joining tree (Saitou & Nei 1987) with all barcoded species of this article were calculated using the Kimura 2 Parameter model (Kimura 1980) as implemented in BOLD (<http://www.boldsystems.org>). Genetic distances between species are reported as minimum pairwise distances.



**FIGURE 2.** Measured genitalia structures a)—male, b)—female. **aae.l**: length of appendix aedeagi; **ae.l**: aedeagus length; **an.l**: antrum length; **an.w**: antrum width; **lt**: total length; **va.s**: valvulae span; **v.s**: valvae span; **v.w**: valvae width.

**Abbreviations.** The examined material is deposited in the institutional and private collections as listed below. The abbreviations of institutional insect collections follow Parsons *et al.* (1999) and Evenhuis (2016), with priority to Parsons *et al.* (1999).

Institutional collections:

BMNH	Natural History Museum, London, United Kingdom
IZBE	Institute of Zoology and Botany, Tartu, Estonia
MNC	Museum für Naturkunde (coll. S. Erlacher), Chemnitz, Germany
MNHU	Museum für Naturkunde, Berlin, Germany
SMNK	Staatliches Museum für Naturkunde, Karlsruhe, Germany
ZFMK	Zoologisches Forschungsinstitut und Museum Alexander Koenig, Bonn, Germany
ZRAS	Zoological Institute, Russian Academy of Sciences, St. Petersburg, Russia
ZSM	Zoologische Staatssammlung, Munich, Germany

Private collections:

GJK	J. Gelbrecht, Königs Wusterhausen, Germany
KTD	T. Karisch, Dessau, Germany
LHS	H. Löbel, Sondershausen, Germany
MBB	B. Müller, Berlin, Germany
RUK	U. Ratzel, Karlsruhe, Germany
SBD	B. Schacht, Dahlewitz, Germany
SDE	D. Stadie, Eisleben, Germany
SMM	M. Sommerer, Munich, Germany
SPV	P. Skou, Vester Skerninge, Denmark

Further abbreviations: barcode id. = barcode identification number; BIN = barcode index number of BOLD systems; E = east of; env. = environment; gen. = genitalia; gen. prep. = genitalia slide number; lux = light-trap; m = meters above sea level; N = north of; prov. = province; S = south of.

## Results

Our studies have led us to conclude that *Chelegnophos* is a synonym of *Gnophopsodos* which now altogether comprises nine species. All of them occur in the Palaearctic region, mainly in North, Central and East Asia.

### Checklist of the genus *Gnophopsodos*

*Gnophopsodos* Wehrli, 1945

= *Chelegnophos* Wehrli, 1951 **syn. nov.**

1. *Gnophopsodos badakhshanus* (Wiltshire, 1967)
2. *Gnophopsodos fractifasciaria* (Püngeler, 1901)
3. *Gnophopsodos gnophosaria* (Oberthür, 1893)  
= *Psodos altissimaria* Oberthür, 1913 **syn. nov.**
4. *Gnophopsodos hilmari* **spec. nov.**
5. *Gnophopsodos puengeleri* (Bohatsch, 1910) **stat. rev.**  
= *Chelegnophos alaianus* Viidalepp, 1988 **syn. nov.**
6. *Gnophopsodos ravistriolaria* (Wehrli, 1922)  
*Gnophopsodos ravistriolaria ravistriolaria* (Wehrli, 1922)  
*Gnophopsodos ravistriolaria pantherinus* **subspec. nov.**
7. *Gnophopsodos sabine* **spec. nov.**
8. *Gnophopsodos stemmataria* (Eversmann, 1848) **comb. nov.**  
= *Gnophos orbicularia* Püngeler, 1904 **syn. nov.**
9. *Gnophopsodos tholeraria* (Püngeler, 1901)

### Key to *Gnophopsodos* species (male genitalia structures)

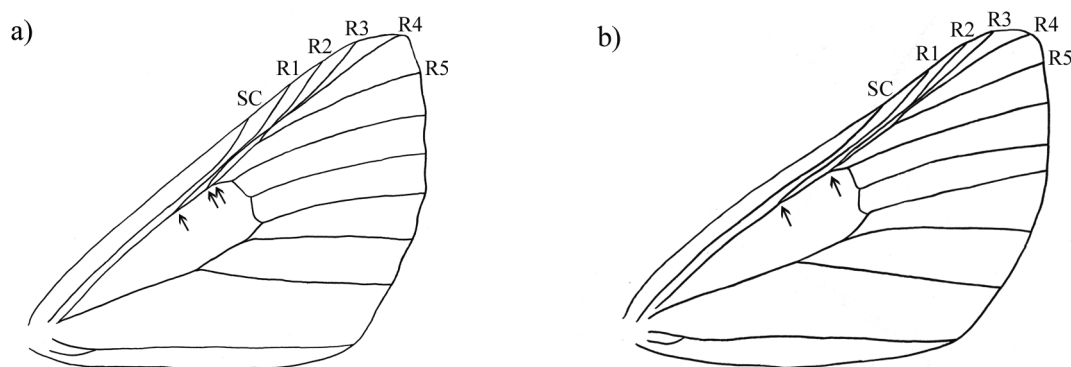
- |   |  |                           |
|---|--|---------------------------|
| 1 | Appendix aedeagi tubular and blunt, slightly shorter than corpus aedeagi               | 2                         |
| - | Appendix aedeagi not tubular, clearly longer than corpus aedeagi                       | 3                         |
| 2 | Anterior appendices of juxta remarkably slender and cusp-like, about 6–8 costal thorns | <i>G. badakhshanus</i>    |
| - | Anterior appendices of juxta moderately pointed, about 15–20 costal thorns             | <i>G. hilmari</i>         |
| 3 | Appendix aedeagi pincer-like incised   | 4                         |
| - | Appendix aedeagi sometimes serrate but not incised                                     | 5                         |
| 4 | Juxta rabbit ear-shaped incised  | <i>G. ravistriolaria</i>  |
| - | Juxta keyhole-shaped, saccus remarkably short  | <i>G. tholeraria</i>      |
| 5 | Appendix aedeagi spoon-shaped broadened with terminal peak                             | <i>G. stemmataria</i>     |
| - | Appendix aedeagi with other characteristics  | 6                         |
| 6 | Juxta broadly u-shaped incised   | <i>G. gnophosaria</i>     |
| - | Juxta undivided, caudally broadened  | 7                         |
| 7 | Saccus thick and straight  | <i>G. sabine</i>          |
| - | Saccus thin, clearly bent  | 8                         |
| 8 | Appendix aedeagi with smooth margin  | <i>G. fractifasciaria</i> |
| - | Appendix aedeagi margin at caudal end finely serrate                                   | <i>G. puengeleri</i>      |

### Genus *Gnophopsodos* Wehrli, 1945

*Gnophopsodos* Wehrli, 1945, *Mitteilungen der Schweizerischen entomologischen Gesellschaft*, 19: 334.—Type species: *Psodos gnophosaria* Oberthür, 1893.

*Chelegnophos* Wehrli, 1951 **syn. nov.**, *Lambillionea*, 51: 27.—Type-species: *Gnophos ravistriolaria* Wehrli, 1922.

**Description.** Medium sized moth species with a range of colors from whitish-gray or cream to dark brownish-gray; wing pattern with medial lines and discal spot often distinct; hindwing termen in most species slightly curved; wing venation variable within the group, R2 either freely arising from the discoidal cell (Fig. 3a) or R2 pediculate with R3–5 (Fig. 3b) (see Sauter 1990).



**FIGURE 3.** Types of wing venation patterns in *Gnophopsodos*. a)—*G. stemmataria*: R2 freely arising from the discoidal cell and b)—*G. ravistriolaria*: R2 pediculate with R3–5. Arrows pointing at the roots of veins arising from the discoidal cell.

**Male genitalia.** Bifurcate aedeagus, with appendix aedeagi being variable in form and length; uncus and gnathos strongly sclerotized, both terminating in a peak or hook-like structure; costal thorns developed (with exception of *G. tholeraria*) occasionally pooled to a subterminal cactus-like structure; valvae with more or less distinct lobe-like widening; juxta variable, mostly undivided and ventrally broadened (with exception of *G. gnophosaria* and *G. ravistriolaria*) with paired dorsal appendices, always without thorns.

**Female genitalia.** Bursa copulatrix remarkable hyaline, without signum or sclerotizations. Antrum compact, cylindrical or oval-shaped, strongly sclerotized, ostium funnel-like with or without bulges.

**Diagnosis.** The genus *Gnophopsodos* is characterised by the following autapomorphic character states:

- Aedeagus bifurcate
- Valvae with more or less distinct valvulae
- Bursa copulatrix hyaline, membranous, without signum or sclerotizations
- Antrum compact, strongly sclerotized, cylindrical, medially domed, area around ostium curved

On appearance, moths of *Gnophopsodos* are externally similar to those of *Gnophos* and *Charissa*. Most of the species of *Gnophopsodos* may possibly be identified by a cuspidate, i.e. well developed acute-angled postmedial line (except *G. badakhshanus*, *G. gnophosaria*, *G. hilmari* spec. nov., and *G. ravistriolaria*) which is more rounded in *Gnophos* and *Charissa* (except subgenus *Kemtrognophos* Wehrli, 1951). One species, *G. gnophosaria*, can be confused with some *Psodos*, but possesses a yellowish-white underside of wings, which is more brownish in *Psodos*.

Unlike of external characters, the species of *Gnophopsodos* can clearly be recognized by their unique male and female genitalia (see list of autapomorphies).

**Distribution.** The genus *Gnophopsodos* comprises species occurring across central Asia with a west-to-east-extension from the eastern parts of Afghanistan to central China. In the North, species were sporadically found in mountains of southern Siberia. Species of this genus are mainly montane and live up to altitudes of 4300 m.

Distribution of the species are mapped in Figs 3 and 4, respectively.

**Biology.** Larval stages and food plants are unknown.

**Remarks.** DNA barcoding analyses with BOLD (<http://www.boldsystems.org>) strengthen the assumption that *Gnophopsodos* is a genus related with *Charissa*, nevertheless, the systematic position of *Gnophopsodos* remains uncertain.

A Neighbor joining tree for all analyzed species of *Gnophopsodos* based on DNA barcoding is depicted in Fig. 6.

Genetic distances to the nearest neighbor of four examined species of the genus *Gnophopsodos* resulting from an analysis of DNA barcodes are shown in Tab. 1.

**TABLE 1.** Genetic distances (minimum pairwise distances, Kimura 2 parameter) to the nearest neighbor of four examined species of the genus *Gnophopsodos* resulting from an analysis of full-length barcode fragments (COI 5', 658 bp).

	<i>G. sabine</i> spec. nov.	<i>G. puengeleri</i>	<i>G. hilmari</i> spec. nov.
<i>G. fractifasciaria</i>	5.78%	4.77%	7.25%
<i>G. hilmari</i> spec. nov.	9.16%	6.9%	
<i>G. puengeleri</i>	6.28%		

### 1. *Gnophopsodos badakhshanus* (Wiltshire, 1967)

(adults Pl. 1, Figs 1a, 1b; male gen. Pl. 3, Fig. 1c; female gen. Pl. 5, Fig. 1d)

*Gnophos* (*Chelegnophos*) *badakhshanus* Wiltshire, 1967, *Beiträge zur naturkundlichen Forschung in SW-Deutschland*, 26: 167, Pl. 3, figs. 37, 41; Pl. 16, Fig. 73.—Locus typicus: Afghanistan, Badakhshan, Sarekanda, 4200 m. Deposition of holotype ♂: ZSM? (It should be kept in coll. J. Klapperich, ZSM, but could not be found). Not examined.

**Material examined.** Type material. Paratypes 3♂: **Afghanistan:** 1♂, Badakhshan, Anjuman Mountains, Anjuman pass, 4200 m, 12.viii.1952, leg. J. Klapperich, gen. prep. SE-604; 1♂, Badakhshan Mountains, Sarekanda, 4200 m, 31.vii.1953, leg. J. Klapperich; 1♂ (Pl. 1, Fig. 1a; Pl. 3, Fig. 1c), same locality, 4100 m, 01.viii.1953, leg. J. Klapperich, ZFMK.—Further material. **Afghanistan:** 1♂, Badakhshan Mountains, Anjuman, 3000 m, 10.viii.1963, leg. K. Omoto, barcode id. SE-MNC-Lep-00867; 1♂, Panjshir Valley, ca 3500 m, 12.–14.viii.1963, leg. K. Omoto, barcode id. SE-MNC-Lep-00866; 1♂, Anjuman pass, 3900–4300 m, 08.–12.viii.1963, leg. K. Omoto, gen. prep. SE-653, barcode id. SE-MNC-Lep-00868, ZSM. 1♂, North-East Afghanistan, Badakhshan, Anjuman Mountains, Anjuman pass, 4000 m, 11.viii.1952, leg. J. Klapperich; 1♀ (Pl. 1, Fig. 1b; Pl. 5, Fig. 1d), North-East Afghanistan, Badakhshan Mountains, Sarekanda, 4200 m, 31.vii.1953, leg. J. Klapperich, gen. prep. SE-660, SMNK. **Tajikistan:** 1♂, East Pamir, Muzkol, Tshetshekty, 22.vii.1982, SPV.

**Description.** Adults (Pl. 1, Figs 1a,b).

Measurements. Wingspan: 30–33 mm (♂), 31 mm (♀); forewing length: 12–18 mm (♂), 16 mm (♀); forewing width: 11–12 mm (♂), 11 mm (♀).

Wings. Upper side whitish-gray, powdered with grayish-brown scales, particularly along costa; lines and discal spots very vague; underside similar to upper side but a shade paler and faintly marked; fringes dirty white.

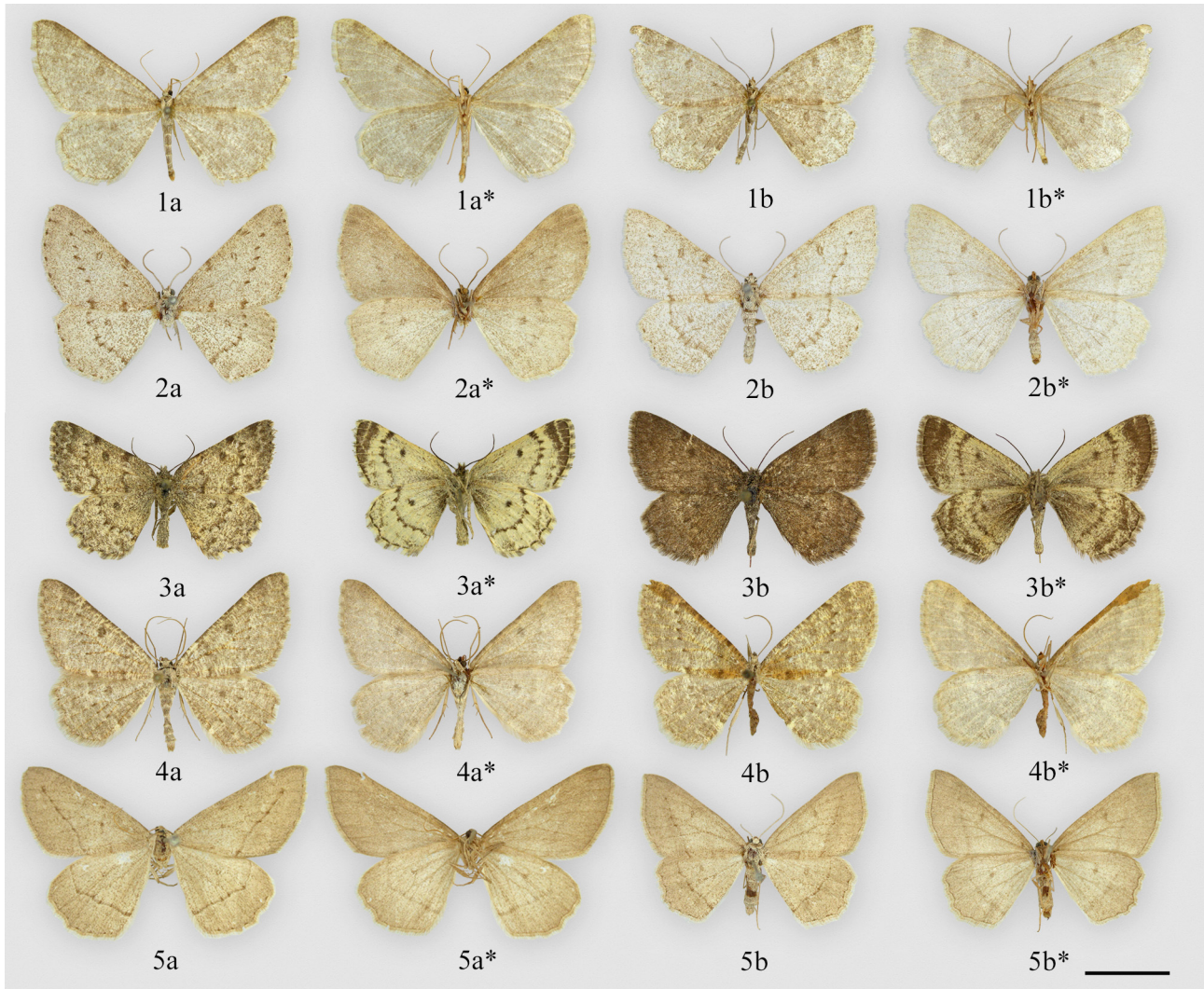
Male genitalia (Pl. 3, Fig. 1c). Total length: 1.57 mm; valvae span: 1.43 mm; valvulae span: 1.34 mm; valvae width: 0.56 mm. Costa with about 6–8 short and thick costal thorns, apex covered with strong setae; uncus strongly sclerotized, slenderly triangular-shaped with blunt peak; gnathos strongly sclerotized, slender, laterally not compressed, evenly tapered, distinctly pointed; juxta small, inconspicuous, not bifurcate or broadened; aedeagus length: 0.59–0.65 mm; appendix aedeagi: 0.47–0.54 mm.

Female genitalia (Pl. 5, Fig. 1d). Total length: 3.03 mm; antrum length: 0.25 mm; antrum width: 0.27 mm; antrum miniaturized.

**Diagnosis.** The wing-form of *G. badakhshanus* resembles those of *G. hilmari* and *G. ravistriolaria pantherinus*, but the basic coloration of *G. badakhshanus* is remarkably whitish and may only occur in faded specimens of the mentioned species, at least regarding the examined material. Additionally, *G. ravistriolaria pantherinus* has a yellowish ground color with a rather distinct blackish-gray pattern, while the wings of *G. badakhshanus* are just vaguely marked with grayish-brown. To distinguish *G. badakhshanus* from *G. hilmari* might be more difficult assuming unusual dark specimens of the former or light ones of the latter. Details are given in the diagnosis of *G. hilmari*. Genitalia structures of *G. ravistriolaria pantherinus* clearly differ from those of *G. hilmari* and *G. badakhshanus*, making it impossible to confuse them: besides the u-shaped incised juxta of *G. ravistriolaria pantherinus* it is most of all the pincer-like appendix aedeagi that makes this species unique; for in both, *G. hilmari* and *G. badakhshanus*, appendix aedeagi is tubular and undivided and the juxta undivided as well.

**Distribution** (Fig. 4). Examined specimens of *G. badakhshanus* originate from Afghanistan where they were found in the mountains of the province Badakhshan (West Pamir). The species was mentioned by Viidalepp (1988) also from Khorugh (Tajikistan). The species occurs at an altitude range from 2300 m to 4300 m.

**Biology.** The flight period lasts from mid-July to mid-August.



**PLATE 1.** Adults of *Gnophopsodos*. 1—*G. badakhshanus*: 1a—paratype ♂, 1b—♀; 2—*G. fractifasciaria*: 2a—holotype ♂, 2b—♀; 3—*G. gnophosaria*: 3a—holotype ♂, 3b—♂; 4—*G. hilmari* spec. nov.: 4a—holotype ♂, 4b—paratype ♂; 5—*G. puengeleri*: 5a—lectotype ♂, 5b—paralectotype ♀. Undersides of specimens are denoted by '\*'. Scale bar: 10 mm.

## 2. *Gnophopsodos fractifasciaria* (Püngeler, 1901)

(adults Pl. 1, Figs 2a, 2b; male gen. Pl. 3, Fig. 2c; female gen. Pl. 5, Fig. 2d)

*Gnophos fractifasciaria* Püngeler, 1901, *Deutsche Entomologische Zeitschrift Iris*, 14: 189, Pl. 3, Fig. 13.—Locus typicus: Kyrgyzstan, Alexander Mountains. Deposition of holotype: MNHU. Examined.

**Material examined.** Type material. Holotype ♂ (Pl. 1, Fig. 2a; Pl. 3, Fig. 2c): [**Kyrgyzstan:**] 'Asia centr[al]. | Alexandergebirge | Rückbeil 1899', 'Type | fractifasciata Püng[eler]. | ♂', 'SE-594 ♂ | gen. prep. | Erlacher, 2014', MNHU.—Further material. **Kazakhstan:** 1♂, mountains Terskey Alatau, river Orta Kokpak, 42°42'N / 79°46'E, 2400 m, 09.vii.1993, leg. V. Murzin, coll. C. Herbulot, gen. prep. SE-654, barcode id. SE-MNC-Lep-00852, BIN BOLD:ABA8683; 1♂, same locality, 05.vii.1993, leg. V. Murzin, coll. C. Herbulot, barcode id. SE-MNC-Lep-00853, BIN BOLD:ABA8683; 1♂, same data, barcode id. SE-MNC-Lep-00854, BIN BOLD:ABA8683, ZSM. **Kyrgyzstan:** 1♂, Issyk Kul, leg. W. Rückbeil, MNHU. **China:** 2♂, Saichin mountain chain N Korla, 1902, leg. W. Rückbeil; 1♀ (Pl. 1, Fig. 2b; Pl. 5, 2d), same data, gen. prep. SE-592, MNHU.

**Description.** Adults (Pl. 1, Figs 2a, 2b).

**Measurements.** Wingspan: 30–33 mm (♂), 33 mm (♀); forewing length: 17–19 mm (♂), 18 mm (♀); forewing width: 12–14 mm (♂), 12 mm (♀).

Wings. Upper side whitish to brownish light-gray; antemedial line often indistinct; postmedial line distinctly visible, spotted or continuous; marginal line spotted, sporadically absent.

Male genitalia (Pl. 3, Fig. 2c). Total length: 2.40 mm; valvae span: 1.62 mm; valvulae span: 1.83 mm; valvae width: 0.81 mm. Costa padded, sparse costal thorns pooled to a subterminal cactus-like structure; uncus broadly rounded with intense and slender peak; gnathos bulb-like, laterally strongly compressed, ventrally pointed; juxta caudally spoon-shaped broadened; aedeagus length: 0.58–0.67 mm; appendix aedeagi: 1.11–1.12 mm.

Female genitalia (Pl. 5, Fig. 2d). Total length: 3.30 mm; antrum length: 0.74 mm; antrum width: 0.35 mm.

**Diagnosis.** Due to variability of coloration and line-pattern *G. fractifasciaria* can resemble *G. puengeleri*, *G. sabine* or *G. tholeraria*. For distinction between *G. fractifasciaria* and *G. sabine* see diagnosis of *G. sabine*. As implied by the name “*fractifasciaria*” the species typically has disconnected ante- and postmedial lines, which are rather continuous in *G. puengeleri*. But this characteristic is still quite variable and hardly useful for a distinction between the species. However, postmedial lines of *G. puengeleri* proceed remarkably straight towards the apex while line-proceeding of *G. fractifasciaria* is less directed and additionally, post- and antemedial lines of *G. fractifasciaria* diverge less towards the costa than those of *G. puengeleri*. External distinction between *G. fractifasciaria* and *G. tholeraria* should mostly be possible by paying attention to the more slender wing-form of *G. tholeraria* and the patches of grayish-brown scales that are scattered over the wings, whereas the wings of *G. fractifasciaria* are rather smoothly colored. Internally, *G. fractifasciaria* is characterized by a slightly broadened appendix aedeagi with smooth margin and distinct peak, whereas the appendix aedeagi of *G. puengeleri* has no peak and the caudal margin is finely serrate. According to male genitalia there is no possibility of confusing *G. fractifasciaria* and *G. tholeraria* because of the keyhole-shaped juxta, the short saccus and the spoon-shaped and divided appendix aedeagi of the latter.

**Distribution** (Fig. 4). Three specimens of *G. fractifasciaria* originate from China in a mountain chain north of Korla. The holotype was found in the Alexander Mountains in Kyrgyzstan. Kaila *et al.* (1996) listed the species from the Issyk–Kul and Kaindy. Another known occurrence is in South–East Kazakhstan in the Terskey Alatau Mountains, where three males were collected in 1993. The species occurs at an altitude of about 2400 m.

**Biology.** So far as is known the flight period is from the beginning to the middle of July (see Kaila *et al.* 1996).

**Remarks.** Based on available molecular data the nearest species of *G. fractifasciaria* is *G. puengeleri* with a COI distance of 4.77% (see also Tab. 1 and Fig. 6).

### 3. *Gnophopsodos gnophosaria* (Oberthür, 1893)

(adults Pl. 1, Figs 3a, 3b; male gen. Pl. 3, Fig. 3c)

*Psodos gnophosaria* Oberthür, 1893, *Études d'Entomologie*, 18: 28, Pl. 3, Fig. 45.—Locus typicus: China, Sichuan, Kangding (formerly Ta–Tsien–Lou). Deposition of lectotype: ZFMK. Examined.

*Psodos altissimaria* Oberthür, 1913 syn. nov., *Études de Lépidoptérolologie comparée*, 7: 326, Pl. 184, Fig. 1809, 1810.—Locus typicus: China, Tibet (in “Explication des Planches, p. 669: “Tibet oriental”). Deposition of holotype: ZFMK. Examined.

**Material examined.** Type material. Lectotype ♂ of *Psodos gnophosaria* (Pl. 1, Fig. 3a; Pl. 3, Fig. 3c) (hereby designated): [**China:**] ‘Thibet | Ta–tsien–lou | Mai, Juin 1892’, ‘*Psodos Gnophosaria* | Ob[er]th[ü]r (Étud d' Entom. | XVIII <unreadable> Pl. 3 | Fig. 45’, ‘SE–614 ♂ | gen. prep. | Erlacher, 2014’, ZFMK.

Holotype ♂ of *Psodos altissimaria* (Pl. 1, Fig. 3b): [**China:**] ‘Chasseurs Thibétains | 1897 | ex R. P. Déjean’, ‘[fig.] 1809 | [sketch upper side]’, ‘[fig.] 1810 | [sketch underparts]’, ‘*Psodos altiβimaria* | Ob[er]th[ü]r—type’, ‘SE–613 ♂ | gen. prep. | Erlacher, 2014’, ZFMK.—Further material. **China:** 1♂, prov. Sichuan, Kangding (formerly Ta–Tsien–Lou), 1899; 1♂, same locality, 1893, gen. prep. Wehrli–7576; 1♂, same locality, 1910; 1♂, same data, gen. prep. Wehrli–7577, ZFMK. 1♂, prov. Sichuan, Xiaolou (formerly Siao–Lou), 1900, BMNH.

**Description.** Adults (Pl. 1, Figs 3a, 3b).

Measurements. Wingspan: 26–29 mm (♂); forewing length: 14–15 mm (♂); forewing width: 9–10 mm (♂).

Wings. Upper side grayish, diffused with dark grayish-brown scales to dark gray-brown; discal spot dark gray or gray-brown, depending on the background coloration more or less distinct; postmedial line dark-gray, dentate, distinct in brighter specimens, mingling with basic coloration in dark brownish specimens; underside remarkably bright, grayish-white or a shade darker regarding specimens with overall dark basic coloration; antemedial line missing; postmedial line dark-gray, dentate, clearly in contrast to background; marginal line dashed; apex and margin of forewing blackish-gray; discal spot distinct; fringes with smoothly alternating dark and bright patches.



Male genitalia (Pl. 3, Fig. 3c). Total length: 2.14–2.5 mm; valvae span: 1.74–1.97 mm; valvulae span: 1.7–2.01 mm; valvae width: 0.77–0.98 mm. Apex densely covered with strong setae, costal thorns short and thick, distributed over subterminal costa surface; uncus strongly sclerotized, blunt; gnathos strongly sclerotized, long and beak-like with strong peak; juxta strongly sclerotized, broadly u-shaped incised; saccus short, medially turned down; aedeagus length: 0.71–0.86 mm; appendix aedeagi: 1.34–1.44 mm.

**Diagnosis.** Within the genus *G. gnophosaria* has unique characteristics. Externally, the species can be definitely determined by its remarkably bright and contrasty underside of the wings with dark apex and forewing margin and distinct postmedial lines and discal spots on both, fore- and hindwings.

**Distribution** (Fig. 4). *Gnophopsodos gnophosaria* was found in the Tibetan part of China in the province Sichuan, with exception of one specimen, for which the only given information is that it was collected by “Chasseurs Thibétains”. Although there are no data about the altitudes at which they were found, due to the locality it can be surmised that the vertical distribution range extends from about 600 m to 2900 m.

**Biology.** No records are available regarding the flight period.

**Remarks.** *Psodos altissimaria* Oberthür, 1913 is recognized to be conspecific with *Gnophopsodos gnophosaria* (Oberthür, 1893).

#### 4. *Gnophopsodos hilmari* spec. nov.

(adults Pl. 1, Figs 4a, 4b; male gen. Pl. 3, Fig. 4c)

Locus typicus: Uzbekistan, western Tian Shan, Tschatkalski Chrebet, 70 km E Tashkent, Bolshoy Chimgan Mountain, 2800 m.  
Deposition of holotype: MNC.

**Material examined.** Type material. Holotype ♂ (Pl. 1, Fig. 4a; Pl. 3, Fig. 4c): [Uzbekistan:] ‘UdSSR/ Usbekische SSR | westl. TIENSHAN | Tschatkalski Chrebet | Bolschoi Tschimgan 2800 m | TASCHKENT 70 km O | 12. Juli 1984 | leg. Dr. B. Mueller Berlin’, ‘SE-451 ♂ | gen. prep. | Erlacher, 2011’, <red label> ‘HOLOTYPE ♂ | *Gnophopsodos hilmari* | Erlacher & Erlacher, 2016’, MNC.

Paratypes 2♂: **Kyrgyzstan:** 1♂ (Pl. 1, Fig. 4b), Tian Shan, Ala-Artscha national park, 3500–4000 m, 10.vii.1979, leg. L. & Kr. Krušek, gen. prep. SE-489, barcode id. SE-MNC-Lep-01278, BIN BOLD:ABW1867, SMM. **Uzbekistan:** 1♂, 70 km E Tashkent, Bolshoy Chimgan Mountain, 41°17’N / 69°58’E, 2800 m, 12.vii.1984, leg. B. Müller, gen. prep. SE-652, barcode id. BMB-Lep-00358, MBB.

**Description.** Adults (Fig. Pl. 1, Figs 4a, 4b).

Measurements. Wingspan: 30 mm (♂); forewing length: 18 mm (♂); forewing width: 12 mm (♂).

Wings. Upper side yellowish-cream, densely powdered with dark gray scales; discal spot gray, faintly in contrast to the background; antemedial line gray, faintly visible, blurring with background; postmedial line rather indistinct, occasionally mingling with the basic coloration, darkened on veins, giving an interrupted impression; marginal line faintly implied or absent; underside pale yellowish-cream; discal spot rather indistinct, light-gray; postmedial line slightly visible, shadow-like; marginal line missing; fringes yellowish, darker on vein ends.

Male genitalia (Pl. 3, Fig. 4c). Total length: 2.02–2.34 mm; valvae span: 1.41–1.43 mm; valvulae span: 1.33–1.38 mm; valvae width: 0.66–0.77 mm. Costa covered with about 15–20 short and thick costal thorns; uncus strongly sclerotized, slenderly triangular-shaped with blunt peak; gnathos strongly sclerotized, slender, laterally not compressed, intensely pointed; juxta small, unremarkable, not bifurcate or broadened; aedeagus length: 0.70–0.77 mm; appendix aedeagi: 0.64–0.68 mm.

**Diagnosis.** *Gnophopsodos hilmari* closely resembles *G. badakhshanus* in wing-form and type of coloration, but *G. badakhshanus* is conspicuously whitish whilst *G. hilmari* bears a more yellowish-brown or cream basic color. But relying solely on external characters should not lead to a firm determination of the species. Using genitalia characteristics attention should be given to the number of costal thorns and the form of the anterior appendices of the juxta: the costa of *G. badakhshanus* bears about 6–8 short and thick costal thorns, which is about half the number of thorns on the costa of *G. hilmari*. The anterior appendices of the juxta of *G. badakhshanus* terminate typically cusp-like, while in *G. hilmari* appendices are moderately pointed. The aedeagi of both species are extremely similar in form, but the aedeagus of *G. hilmari* is clearly longer (0.70–0.77 mm) than that of *G. badakhshanus* (0.59–0.65 mm).

**Distribution** (Fig. 4). Of the three known specimens of *G. hilmari* two originate from the Bolshoy Chimgan Mountain (2800 m) in Uzbekistan and the third one was collected in the Ala–Artscha National Park (3500 m–4000 m) in Kyrgyzstan.

**Biology.** All examined specimens were collected at the beginning of July. No further records are available.

**Remarks.** Based on available molecular data the nearest species of *G. hilmari* is *G. puengeleri* with a COI distance of 6.9% (see also Tab. 1 and Fig. 6), whereas the morphology of male genitalia indicates a relationship of *G. hilmari* and *G. badakhshanus*.

**Etymology.** The new species is dedicated to the Chemnitz performer, mime artist, philosopher, and father of the co-author, Hilmar Messenbrink.

### 5. *Gnophosodos puengeleri* (Bohatsch, 1910) stat. rev.

(adults Pl. 1, Figs 5a, 5b and Pl. 2, Fig. 5c; male gen. Pl. 3, Figs 5d, 5e; female gen. Pl. 5, Fig. 5f)

*Gnophos puengeleri* Bohatsch, 1910, *Jahresbericht des Wiener Entomologischen Vereins*, 20: 164.—Locus typicus: Uzbekistan, Fergana region, Alai Mountains. Deposition of lectotype: MNHU. Examined.

*Chelegnophos alaianus* Viidalepp, 1988 syn. nov., *Fauna pyadenits gor Srednei Azii [Geometridae fauna of the Central Asian mountains]*: 159, Pl. 3, Fig. 15, text-Pl. 37, figs. 2–5.—Locus typicus: Kyrgyzstan, northern slope of the Alaiski mountain range, River Terek, Darvaza, 2600 m. Deposition of holotype: ZRAS. Examined.

**Material examined.** Type material. Lectotype 1♂ of *Gnophos puengeleri* Bohatsch, 1910 (Pl. 1, Fig. 5a; Pl. 3, Fig. 5d) (hereby designated): [Kyrgyzstan:] ‘Asia centr[al]. | Fergane, Alai | M. Korb’, ‘Type | Püngeleri Bohatsch ♂’, ‘Genit. Unters. | Nr. 5395 | Zool[ogisches]. Mus[eum]. Berlin’, MNHU.

Paralectotype 1♀ of *Gnophos puengeleri* Bohatsch, 1910 (Pl. 1, Fig. 5b; Pl. 5, Fig. 5f) (hereby designated): **Kyrgyzstan:** Fergana region, Togus–torau, 1901, leg. W. Rückbeil, gen. prep. SE–591, MNHU.

Holotype 1♂ of *Chelegnophos alaianus* Viidalepp, 1988: [Kyrgyzstan:] <in Russian> ‘Alayskiy khr[ebet], sev[ernyi] sklon, | r[eka] Terek, uroch[ishche] Darvaza [Alai Range, northern slope, river Terek, tract Darvaza] | 20.7.1968, 2600 m, [leg.] Bundel’, ‘Chelegnophos | alaianus Viid.’, ‘2624 ♂’, ‘Holotypus’, ‘IZBE | IZBE0096325 | Insecta Generale | LepPal–26225’, ZRAS.—Further material. **Kazakhstan:** 1♂ (Pl. 2, Fig. 5c; Pl. 3, Fig. 5e), SE Kazakhstan, Almaty, Bolshaya Almatinka, 2600 m, 10.–20.vii.1994, leg. A. Saldaitis, gen. prep. SE–588, barcode id. SE–MNC–Lep–00856, BIN BOLD:ABU6743; 1♀, SE Kazakhstan, Transili–Alatau, valley of Alma–Atinka river, 0.5 km S Medeo, 28./29.viii.1990, lux, leg. T. Karisch, gen. prep. SE–590, barcode id. SE–MNC–Lep–00857, KTD.

**Description.** Adults (Pl. 1, Figs 5a, 5b and Pl. 2, Fig. 5c).

Measurements. Wingspan: 31–34 mm (♂), 26–29 mm (♀); forewing length: 14–17 mm (♂), 15–17 mm (♀); forewing width: 12 mm (♂), 10–13 mm (♀).

Wings. Upper side ash-gray to brownish; antemedial line slightly visible or absent; postmedial line rather continuous; discal spot occasionally indistinct.

Male genitalia (Pl. 3, Figs 5d, 5e). Total length: 1.91–1.99 mm; valvae span: 1.15–1.36 mm; valvulae span: 1.37–1.59 mm; valvae width: 0.60–0.64 mm. Costa padded, sparse costal thorns pooled to a subterminal cactus-like structure; uncus medium–broad, rounded with slender peak; gnathos strongly sclerotized, bulb-like, laterally compressed, moderately pointed and roof-shaped; juxta weakly sclerotized, caudally broadened; aedeagus length: 0.68–0.81 mm; appendix aedeagi: 0.93–1.08 mm.

Female genitalia (Pl. 5, Fig. 5f). Total length: 2.83–3.18 mm; antrum length: 0.60–0.62 mm; antrum width: 0.30–0.33 mm.

**Diagnosis.** The following species appear to be similar to *G. puengeleri*: *G. fractifasciaria*, *G. sabine*, and *G. stemmataria*. For distinction see diagnoses of the respective species.

**Distribution** (Fig. 5). Two of the examined specimens of *G. puengeleri* originate from the so called “Fergana region” in Kyrgyzstan: the lectotype (male) from the Alai Mountains and the paralectotype (female) from the province Naryn (Togus–Torau, about 2000 m). Two further specimens were captured in South–East Kazakhstan: there is a male from around Almaty (2600 m) and a female originating from the Transili–Alatau south of Medeo (about 2000 m). *G. puengeleri* was also recorded (as *G. alaianus*) from Kyrgyzstan (river Terek, northern slope of the Alaiski mountain range), and from Transalai Mountains, Tshatkal, south–east of lake Issyk–Kul (Viidalepp

1988), east of Naryn in Kyrgyzstan, and from the Alma–Ata National Park in Kazakhstan at altitudes between 1700 m and 2900 m (Kaila *et al.* 1996).

**Biology.** The flight period lasts from early July to the end of August (see Viidalepp 1988, Kaila *et al.* 1996).

**Remarks.** *Gnophos puengeleri*, that has been considered to be synonym of *Chelegnophos stemmataria* (= *orbicularia*) since Parsons *et al.* (1999) is herewith reinstated as bona species. *Chelegnophos alaianus* Viidalepp, 1988 is recognized to be conspecific with *Gnophopsodos puengeleri* (Bohatsch, 1910).

Based on available molecular data the nearest species of *G. puengeleri* is *G. fractifasciaria* with a COI distance of 4.77% (see also Tab. 1 and Fig. 6).

## 6. *Gnophopsodos ravistriolaria* (Wehrli, 1922)

(adults Pl. 2, Figs 6a–6c; male gen. Pl. 4, Figs 6d, 6e)

For material examined, description, distribution, and biology see below under subspecies.

**Diagnosis.** *Gnophopsodos ravistriolaria* can resemble *G. tholaria* in wing-pattern and type of coloration but the yellowish basic color of *G. ravistriolaria* is more distinctive. Internally, the species is characterized by its unique, slender u-shaped incised juxta and the smooth-margined pincer-like appendix aedeagi.

### *Gnophopsodos ravistriolaria ravistriolaria* (Wehrli, 1922)

(adults Pl. 2, Fig. 6a; male gen. Pl. 4, Fig. 6d)

*Gnophos ravistriolaria* Wehrli, 1922, *Deutsche Entomologische Zeitschrift Iris*, 36: 23, pl. 1, fig. 23, pl. 2, fig. 35, 51.—Locus typicus: Russia / Mongolia, Sajan Mountains, Munko–Sardyk, 3400 m. Deposition of holotype: ZFMK. Examined.

**Material examined.** Type material. Holotype ♂ of *Gnophos ravistriolaria ravistriolaria* Wehrli, 1922 (Pl. 2, Fig. 6a; Pl. 4, Fig. 6d): [Russia / Mongolia:] ‘Munko Sardyk | Sajan mont.’, ‘ravistriolaria | Wehrli | Gnophos | Dr. Wehrli ♂ Type’, ‘ravistriolaria | Wehrli | Gnophos | abgebildet Seitz IV | SupPl. Fig. | Dr. Wehrli Typ’, ‘582 | ♂’, ZFMK.

**Description.** Adults (Pl. 2, Fig. 6a).

Measurements. Wingspan: 30 mm (♂); forewing length: 16 mm (♂); forewing width: 10 mm (♂).

Wings. Upper side yellowish, densely cluttered with gray freckles, especially near margin; postmedial line slightly visible, blurring with freckled background; underside blurred yellowish, a shade lighter than the upper side.

Male genitalia (Pl. 4, Fig. 6d). [The description of the male genitalia is given based on the remaining fragment of the valva and the photograph of the holotype depicted by Wehrli (1922)] Costa with costal thorns condensed on a subterminal cactus-like structure; uncus strongly sclerotized, terminating in a beak-like peak.

**Diagnosis.** *Gnophopsodos ravistriolaria ravistriolaria* can be recognized by its rounded forewings and its blurred brownish wing-pattern.

**Distribution** (Fig. 4). The type specimen of *G. ravistriolaria ravistriolaria* was captured in the Sajan Mountains at Munko–Sardyk at an altitude of 3400 m. The mountain Munko–Sardyk is located north of the lake Chöwsgöl Nuur near the Russian–Mongolian border. Viidalepp & Soljanikov (1977) figured a male from river Horidulin–Gol and listed a female from upper course of river Uryngym–Gol but we did not succeed in finding the exact sites of these on maps.

**Biology.** After Viidalepp & Soljanikov (1977) a female was captured on the 6<sup>th</sup> of July 1965 and a male on the 19<sup>th</sup> of August 1966.

### *Gnophopsodos ravistriolaria pantherinus* subspec. nov.

(adults Pl. 2, Figs 6b, 6c; male gen. Pl. 4, Fig. 6e)

Locus typicus: Russia, North–West Altai, Zmeinogorsk, Tigireksky ridge, 3 km east–southeast Razrabotnaya Mountain, 51°02′40″N / 83°00′05″E, 1500 m. Deposition of holotype: MNC.

**Material examined.** Type material. Holotype ♂ of *Gnophopsodos ravistriolaria pantherinus* subsp. nov. (Pl. 2, Fig. 6b; Pl. 4, Fig. 6e): [Russia]: ‘Rußland, Altai Reg. | NW Altai, Zmeinogorsk, Tigireksky | Ridge, 3 km ESE Razra- | botnaya Mt. 1500 m | 16.–19.vii.2012 lg. | A. Volynkin, coll. Ratzel | 51°02’40’’N / 83°00’05’’[E]’, ‘Watershed of | Irkutka and Bolshoi | Tigirek rivers; | Border of subalpine | meadows and *Pinus | larix* forest’, ‘SE–606 ♂ | gen. prep. | Erlacher, 2014’, <red label> ‘HOLOTYPE ♂ | *Gnophopsodos ravistriolaria* | ssp. *pantherinus* | Erlacher & Erlacher, 2016’, MNC.

Paratypes 15♂ of *Gnophopsodos ravistriolaria pantherinus* subsp. nov.: **Russia:** 1♂ (Pl. 2, Fig. 6c), North–West Altai, Zmeinogorsk, Tigireksky ridge, 3 km east–southeast Razrabotnaya Mountain, 51°02’40’’N / 83°00’05’’E, 1500 m, 16.–19.vii.2012, leg. A. Volynkin, gen. prep. SE–612; 7♂, same data, MNC. 7♂, same data, gen. preps. SE–621, SE–622, SE–656, RUK.

**Description.** Adults (Pl. 2, Figs 6b, 6c).

Measurements. Wingspan: 28–32 mm (♂); forewing length: 15–17 mm (♂); forewing width: 10–11 mm (♂). Wings. Upper side yellowish, densely cluttered with dark gray spots and patches, distally from postmedial line darkened, occasionally forming a band-like structure, but not reaching the slightly brighter marginal area; discal spot distinct, dark-gray; antemedial line more or less distinct, dark-gray; postmedial line mostly distinct, occasionally mingling with the darker areas of the basic coloring; marginal line dark-gray, dashed or spotted; underside yellowish-white, characteristic dark-gray pattern of the upper side blurred and light-gray; discal spot distinct, light-gray; antemedial line slightly visible or absent; postmedial line if not distinct at least visible, light-gray; marginal line light-gray, dashed or spotted, occasionally missing; fringes yellowish mingled with gray.

Male genitalia (Pl. 4, Fig. 6e). Total length: 2.13–2.51 mm; valvae span: 1.51–1.78 mm; valvulae span: 1.78–2.06 mm; valvae width: 0.85–0.97 mm. Costa uneven padded, long costal thorns condensed on a subterminal bulge-like structure; uncus strongly sclerotized, terminating in a beak-like, slender peak; gnathos bulb-like, laterally compressed, terminal smoothly flattened and slightly notched, subterminal hook pointed, forming a triangular structure when observed ventrally; juxta fairly deep and slender u-shaped incised but less than halfway down, resulting in two rabbit ear-shaped lobes at the caudal end; aedeagus length: 0.89–0.92 mm; appendix aedeagi: 1.50–1.54 mm.

**Diagnosis.** *Gnophopsodos ravistriolaria pantherinus* is remarkable for its dark gray wing-pattern on yellowish ground. The wing-form is less rounded than that of the nominotypical taxon and the characteristic pattern of dark gray spots and patches as described above is lacking in the latter.

**Distribution** (Fig. 4). All specimens of the new subspecies originate from Altai Territory in Russia and were collected near Zmeinogorsk at the Tigireksky ridge at an altitude of 1500 m.

**Biology.** There are no further records available regarding the flight period apart from the four days in the mid-July when the examined specimens of *G. ravistriolaria pantherinus* were collected. The biotope was described as border of subalpine meadows and *Pinus larix* forest (U. Ratzel in lit.).

**Remarks.** We are aware of the remarkable external differences between *G. ravistriolaria ravistriolaria* and *G. ravistriolaria pantherinus* as wing-form and coloration. Besides the male genitalia of the holotype are described and figured by Wehrli (1922: pl. 2, fig. 23) his description omits parts of it (e.g. shape of juxta) and important details can’t be seen on the photograph. A drawing of the male genitalia is depicted in Viidalepp & Soljanikov (1977: 635) but for example the “peculiar prominent lobar cactus-like spiny structure at the dorsal margin” of the valvae described by Wehrli (1922: 24) is not shown at all. Unfortunately, someone before us had difficulties preparing the genitalia of the holotype of *G. ravistriolaria ravistriolaria* and destroyed many parts of it. So now it is hard to compare the remaining fragment with the genitalia of *G. ravistriolaria pantherinus*. With examination of further specimens the new subspecies may possibly be confirmed as separate species.

**Etymology.** The name of the new subspecies refers to the dark gray wing-pattern on yellowish ground, from Latin “pantherinus” (maculated).

## 7. *Gnophopsodos sabine* spec. nov.

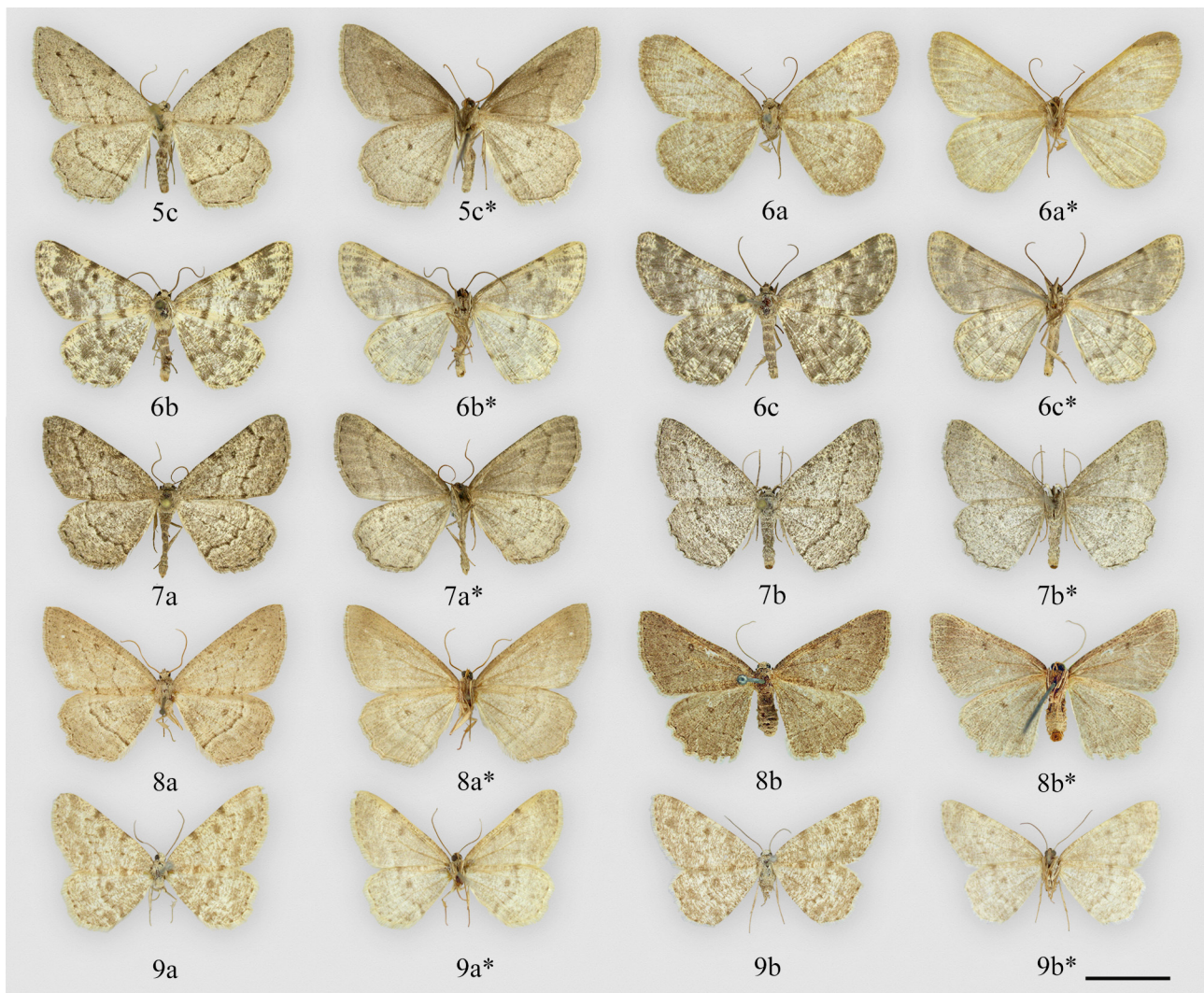
(adults Pl. 2, Figs 7a, 7b; male gen. Pl. 4, Fig. 7c; female gen. Pl. 5, Fig. 7d)

Locus typicus: Russia, Republic of Altai, env. Aktash. Deposition of holotype: MNC.

**Material examined.** Type material. Holotype ♂ (Pl. 2, Fig. 7a; Pl. 4, Fig. 7c): [Russia]: ‘Russland, Süd–Sibirien |

Republik Altai | 17.–22.VII.2009 | Umgeb. Aktasch | leg. Bernd Schacht, ‘SE–561 ♂ | gen. prep. | Erlacher, 2012’, <red label> ‘HOLOTYPE ♂ | *Gnophopsodos sabine* | Erlacher & Erlacher, 2016’, MNC.

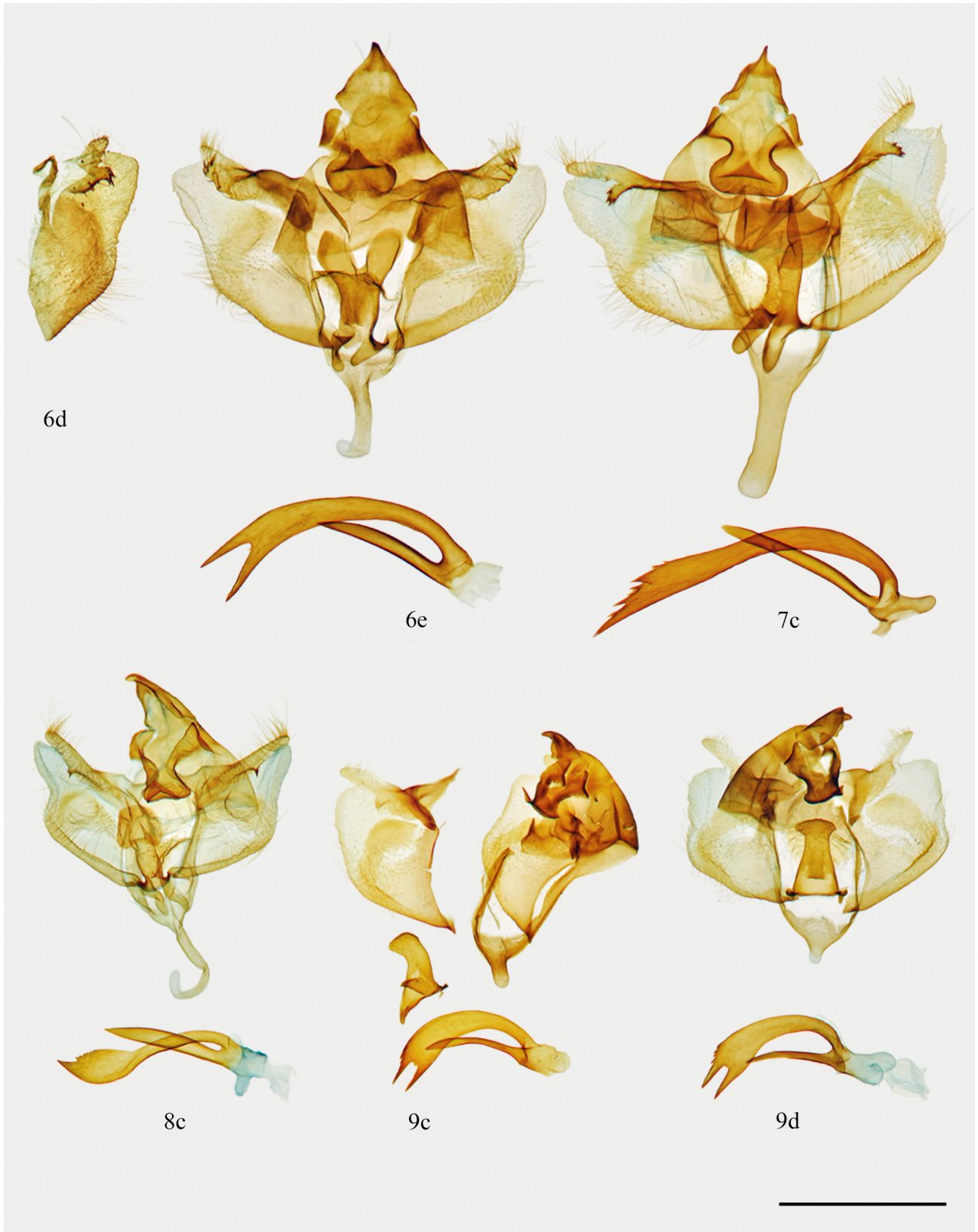
Paratypes 26♂, 2♀: **Russia:** 6♂, southern Siberia, Republic of Altai, env. Aktash, 17.–22.vii.2009, leg. B. Schacht; 1♂, same data, gen. prep. SE–657; 1♂ (Fig. 1a), same data, gen. prep. SE–396, barcode id. SE–MNC–Lep–00993, BIN BOLD:ABU7240; 1♂, same data, barcode id. SE–MNC–01071, BIN BOLD:ABU7240, SBD. 1♂, same data, gen. prep. SE–397, barcode id. SE–MNC–Lep–00971, BIN BOLD:ABU7240; 10♂, same data, LHS. 1♂, southern Siberia, Republic of Altai, env. Aktash, 15 km N village Aktash, 50°20′04″N / 87°44′38″E, 2440 m, 30.vii.2011, leg. D. Stadie, T. Drechsel & J. Gelbrecht; 1♀ (Fig. 1b; Pl. 2, Fig. 7b; Pl. 5, Fig. 7d), 3 km S Aktash, 50°18′20″N / 87°39′27″E, 1396 m, 27.–31.vii.2011, lux, leg. D. Stadie, T. Drechsel & J. Gelbrecht, gen. prep. SE–605, SDE. 1♂, Republic of Altai, Seminskiy-Pass, S Schebalino, 4 km south of the pass, 51°00′59″N / 85°37′49″E; 1560 m, 19.vii.2014, leg. J. Gelbrecht & E. Schwabe; 2♂, Republic of Altai, 6 km SE Aktash, 50°16′49″N / 87°40′07″E, 1450 m, e.o. (♀: 03.viii.2011), leg. J. Gelbrecht & E. Schwabe, GJK. 1♂, South East Altai, Ulagan (north of Aktash), Ajgulaksky Ridge, 50°19′N / 87°35′E, 1400 m, 24.v.2012, leg. A. Volynkin, ex coll. U. Ratzel; 1♂, NW Altai, Zmeinogorsk, Tigireksky Ridge, 3 km east-southeast Razrabotnaya Mountain, 51°02′40″N / 83°00′05″E, 1500 m, 16.–19.vii.2012, leg. A. Volynkin, ex coll. U. Ratzel, gen. prep. SE–662; 1♀, same data, gen. prep. SE–683, MNC.



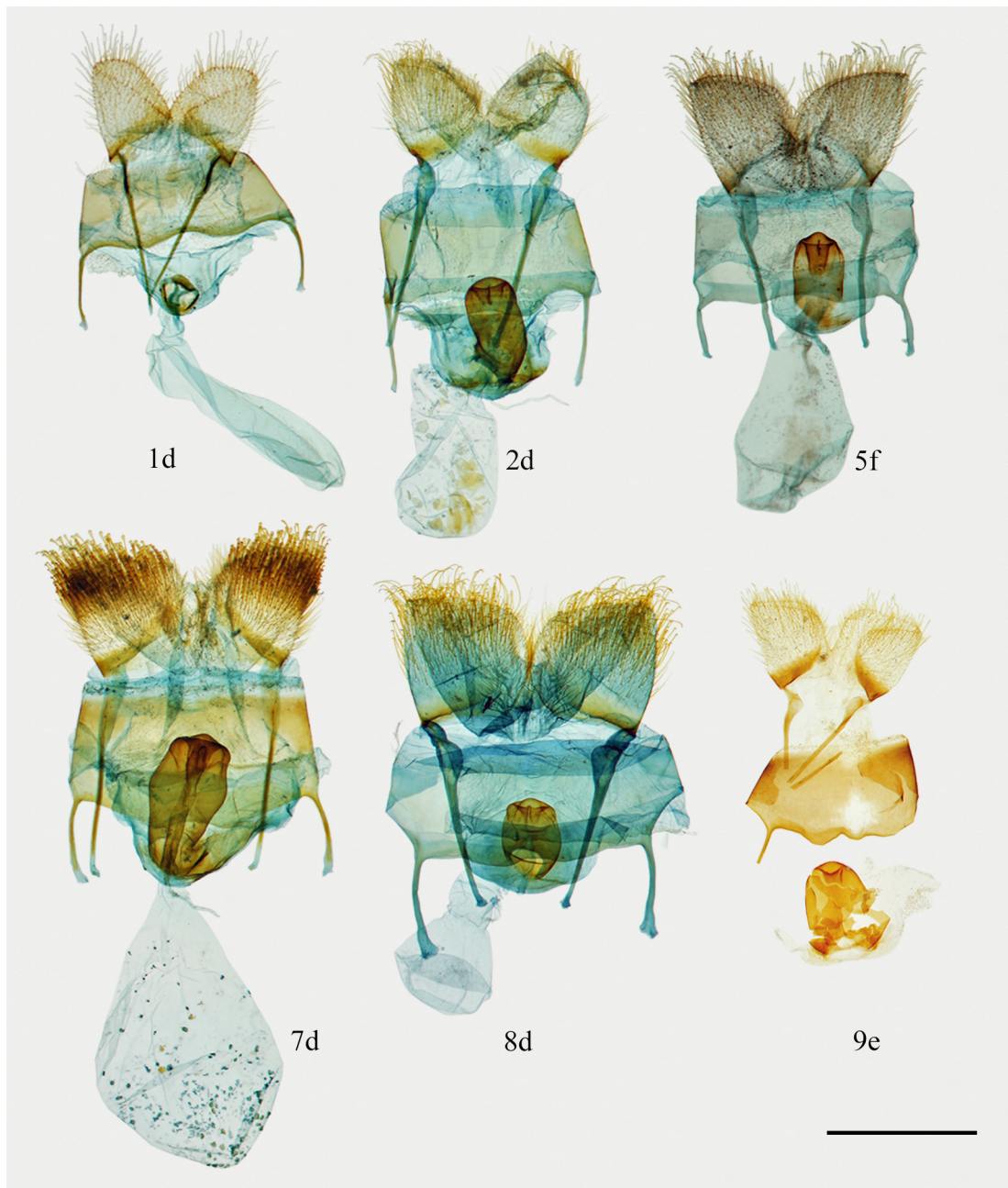
**PLATE 2.** Adults of *Gnophopsodos*. 5—*G. puengeleri*: 5c—♂; 6—*G. ravistriolaria*: 6a—*G. ravistriolaria ravistriolaria* holotype ♂, 6b—*G. ravistriolaria pantherinus* subspec. nov. holotype ♂, 6c—*G. ravistriolaria pantherinus* subspec. nov. paratype ♂; 7—*G. sabine* spec. nov.: 7a—holotype ♂, 7b—paratype ♀; 8—*G. stemmataria*: 8a—♂, 8b—holotype ♀; 9—*G. tholeraria*: 9a—lectotype ♂, 9b—paralectotype ♀. Undersides of specimens are denoted by ‘\*’. Scale bar: 10 mm.



**PLATE 3.** Male genitalia of *Gnophopsodos*; valvae and aedeagus. 1c—*G. badakhshanus* (paratype); 2c—*G. fractifasciaria* (holotype); 3c—*G. gnophosaria* (lectotype); 4c—*G. hilmari* spec. nov. (holotype); 5d—*G. puengeleri* (lectotype), 5e—*G. puengeleri*. Scale bar: 1 mm.



**PLATE 4.** Male genitalia of *Gnophopsodos*; valvae and aedeagus. 6d—*G. ravistriolaria ravistriolaria* (holotype), 6e—*G. ravistriolaria pantherinus* subsp. nov. (holotype); 7c—*G. sabine* spec. nov. (holotype); 8c—*G. stemmataria*; 9c—*G. tholeraria* (lectotype), 9d—*G. tholeraria* (paralectotype). Scale bar: 1 mm.



**PLATE 5.** Female genitalia of *Gnophopsodos*. 1d—*G. badakhshamus*; 2d—*G. fractifasciaria*; 5f—*G. puengeleri* (paralectotype); 7d—*G. sabine* spec. nov. (paratype); 8d—*G. stemmataria* (holotype); 9e—*G. tholeraria* (paralectotype). Scale bar: 1 mm.

**Description.** Adults (Pl. 2, Figs 7a, 7b).

**Measurements.** Wingspan: 28–32 mm (♂), 29–33 mm (♀); forewing length: 14–18 mm (♂), 16–17 mm (♀); forewing width: 10–12 mm (♂), 11–12 mm (♀).

**Wings.** Upper side light gray, densely cluttered with darker scales, giving an overall medium-gray impression; antemedial line more or less indistinct; postmedial line distinct, blackish-gray; marginal line dashed; underside similar to upper side but a shade lighter and blurred.

**Male genitalia** (Pl. 4, Fig. 7c). Total length: 2.52–2.59 mm; valvae span: 1.95–1.96 mm; valvulae span: 2.07–2.11 mm; valvae width: 0.85–0.88 mm. Costa smoothly padded, sparse costal thorns pooled to a subterminal cactus-like structure; uncus broadly rounded with slender peak; gnathos bulb-like, laterally compressed with subterminal pointy hook; caudal end of juxta remarkably broadened; aedeagus length: 1.02–1.06 mm; appendix aedeagi: 1.63–1.73 mm.



Female genitalia (Pl. 5, Fig. 7d). Total length: 4.01 mm; antrum length: 0.95 mm; antrum width: 0.49 mm; papillae anales densely covered with strong setae.

**Diagnosis.** Externally, *G. sabine* can be confused with grayish specimens of *G. puengeleri* or *G. fractifasciaria*. However, in contrast to *G. puengeleri* and *G. fractifasciaria*, the ante- and postmedial lines proceed rather parallel, whilst in *G. fractifasciaria* the lines diverge to the costa of the forewings and even more so in *G. puengeleri*. Yet this pattern may be slightly variable, but in most cases *G. sabine* should be distinguishable from other species of the group by its rough-looking medium-gray basic coloration diffused with darker scales, while the usual coloration of *G. puengeleri* and *G. fractifasciaria* gives a smoother impression and is lighter and rather brownish or even whitish. Regarding the male genitalia structures the most helpful characters for the determination of *G. sabine* may be the stout and straight saccus, which is singular within the genus *Gnophopsodos*. The long saw blade-shaped appendix aedeagi gives the impression of being diagonally cut, with the cutting edge being serrate, terminating in a straight peak. Only in one specimen (gen. prep. SE-662) this serration was absent. In both, *G. puengeleri* and *G. fractifasciaria*, the saccus is clearly bent and rather thin, the aedeagus appendices are shorter and either with smooth margin (*G. fractifasciaria*) or slightly serrate (*G. puengeleri*).

Except with members of the genus, *G. sabine* might be confused with *Charissa (Kemptrognophos) ambiguata* (Duponchel) and females of *Elophos vittaria* (Thunberg). Whereas the antemedial line in *G. sabine* proceeds nearly straight it is more or less serrate in *Ch. ambiguata* and *E. vittaria*. Females of the latter have a slightly convex forewing costa. Eventually, certain identification requires preparation of the genitalia.

**Distribution** (Fig. 5). The species occurs in the locality of the village Aktash at altitudes between 1400 m and 2440 m in southern Siberia in the Republic of Altai in Russia.

**Biology.** As far as is known the flight period lasts from mid-July to the beginning of August. One specimen was supposedly found in late May. The biotope was described as light, herb-rich coniferous forest, among others with larch, spruce, pine, and single rocks (J. Gelbrecht in lit.).

**Remarks.** Based on available molecular data the nearest species of *G. sabine* is *G. fractifasciaria* with a COI distance of 5.78% (see also Tab. 1 and Fig. 6). The morphology of male and female genitalia indicates relationship between these species.

**Etymology.** The new species is dedicated to Sabine Lindner, lovely mother of the co-author.

## 8. *Gnophopsodos stemmataria* (Eversmann, 1848) comb. nov.

(adults Pl. 2, Figs 8a, 8b; male gen. Pl. 4, Fig. 8c; female gen. Pl. 5, Fig. 8d)

*Cabera stemmataria* Eversmann, 1848, *Bulletin de la Société des naturalistes de Moscou*, 21: 227.—Locus typicus: Kazakhstan, Noor Saisan. Deposition of holotype: ZRAS. Examined.

*Gnophos orbicularia* Püngeler, 1903 syn. nov., *Deutsche Entomologische Zeitschrift Iris*, 16: 297, pl. 6, fig. 16.—Locus typicus: Central Asia, Kyrgyzstan, Issyk-Kul. Deposition of lectotype: MNHU. Examined.

**Material examined.** Type material. Holotype ♀ of *Cabera stemmataria* Eversmann, 1848 (Pl. 2, Fig. 8b, Pl. 5, Fig. 8d): [**Kazakhstan:**] ‘Noor-Saisan | <unreadable>’, ‘stomataria[sic!] | Ev[ers]m[ann].’, ‘Type’, ‘coll Eversmann’, ‘SE-563 ♀ | gen. prep. | Erlacher, 2013’, ZRAS.

Lectotype ♂ of *Gnophos orbicularia* Püngeler, 1903 (Pl. 2, Fig. 8a) (hereby designated): [**Kyrgyzstan:**] ‘Asia centr[al]. | Issyk-Kul | Rückbeil 1902’, ‘TYPE | orbiculata Püng[eler]. ♂ | abgebildet Iris 1903 | Püngeler’, ‘SE-603 ♂ | gen. prep. | Erlacher, 2014’, MNHU.

Paralectotype ♂ of *Gnophos orbicularia* Püngeler, 1903 (hereby designated):

**Kyrgyzstan:** Issyk Kul, 1902, leg. W. Rückbeil, MNHU.—Further material. **Kazakhstan:** 1♂, Semiretshje, ca 40 km N Dzharkent, gorge Naryn, vii.1913, leg. W. Rückbeil, gen. prep. SE-587; 1♂, Semiretshje, village Tyshkan, Sary-Saj, vii.1913, leg. W. Rückbeil, ZSM. **China:** 1♂, Tian Shan, “Syn-Tagh” mountains, 1902, leg. W. Rückbeil; 1♂, same locality, 1907, leg. W. Rückbeil junior; 1♀, Tian Shan, Iulduz (Yining), xii.1911, leg. F. Wagner, gen. prep. SE-589, MNHU. 1♂ (Pl. 4, Fig. 8c), Turkestan, Aksu, leg. R. Tancre, gen. prep. SE-618; 1♂, same data; 3♂, Tian Shan, coll. G. Merzbacher, ZSM. **Unknown country:** 1♂, Ala-tau, leg. G. Rückbeil, SE-620, ZSM.

**Description.** Adults (Pl. 2, Figs 8a,b).

Measurements. Wingspan: 24–28 mm (♂), 29 mm (♀); forewing length: 13–16 mm (♂), 15–16 mm (♀); forewing width: 8–11 mm (♂), 10 mm (♀).

Wings. Upper side grayish-brown, subtle diffused with darker scales; lines subtle but mostly distinct; underside pale grayish-brown.

Male genitalia (Pl. 4, Fig. 8c). Total length: 2.02–2.22 mm; valvae span: 1.37–1.44 mm; valvulae span: 1.56–1.62 mm; valvae width: 0.67–0.70 mm. Costa with sparse costal thorns pooled to an about medial cactus-like structure; uncus slim, beak-like pointed; gnathos bulb-like, laterally compressed and terminally flattened with moderately pointed broad hook; juxta caudally broadened, mushroom-like shape; aedeagus length: 0.70–0.75 mm; appendix aedeagi: 0.90–1.07 mm.

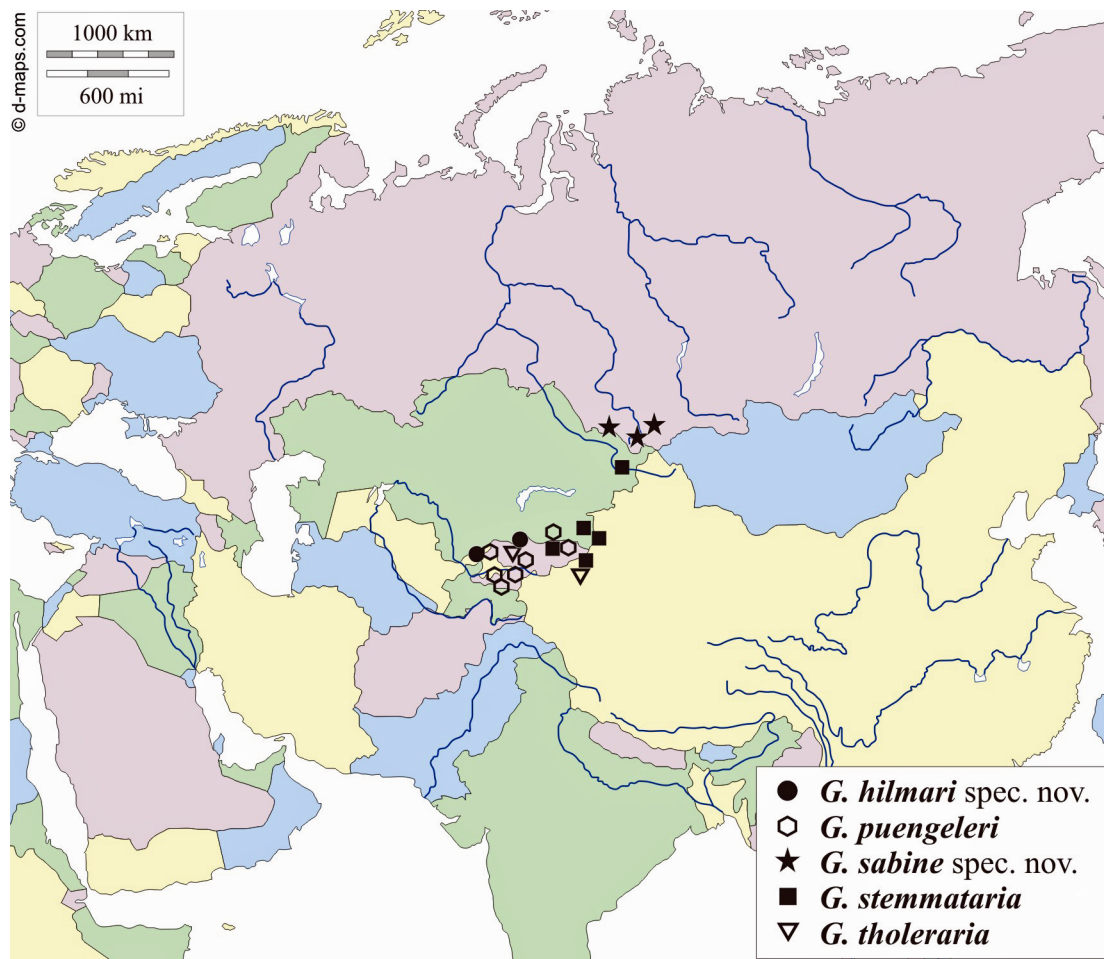
Female genitalia (Pl. 5, Fig. 8d). Total length: 2.71–3.4 mm; antrum length: 0.53–0.58 mm; antrum width: 0.28–0.38 mm; papillae anales densely covered with strong setae.

**Diagnosis.** *Gnophopsodos stemmataria* appears to be quite variable and a definite distinction on the basis of external characters, especially from *G. puengeleri*, will often not be possible. According to male genitalia structures distinction is most easily done by paying attention to the appendix aedeagi: the last third of the appendix aedeagi of *G. stemmataria* is characteristically spoon-shaped broadened with terminal peak, while the appendix aedeagi of *G. puengeleri* is smoothly broadened with the caudal margin being finely serrate but not clearly peaked.

**Distribution** (Fig. 5). As far as known *G. stemmataria* is distributed over the north-western part of China, East and South–East Kazakhstan (Noor Saisan and Semirechye) and two specimens were collected at the lake Issyk Kul in Kyrgyzstan. Of the eight specimens originating from China three were found in the Tian Shan with no particular reference to any specific locality, two were collected in proximity to Aksu, one female is from what F. Wagner called “Iuldus–area”, which is a mountain plateau in the eastern Tian Shan and two further specimens were also captured in Tian Shan, in a mountain range that is called “Syn–Tagh” by Rückbeil, but no references to this locality could be found.



**FIGURE 4.** Distribution of *Gnophopsodos* species: *G. badakhshanus*, *G. fractifasciaria*, *G. gnophosaria*, *G. ravistriolaria* *ravistriolaria*, and *G. ravistriolaria pantherinus* subsp. nov.



**FIGURE 5.** Distribution of *Gnophopsodos* species: *G. hilmari* spec. nov., *G. puengeleri*, *G. sabine* spec. nov., *G. stemmataria*, and *G. tholeraria*.

**Biology.** The flight period is July.

**Remarks.** The holotype (♀) of *Gnophos stemmataria* has been the only specimen of that species for 167 years, and although females of *Gnophopsodos* are quite difficult to determinate, due to external and internal characteristics it can be assigned to *Gnophos orbicularia*. Therefore, *G. orbicularia* is herewith established as synonym of *Gnophopsodos stemmataria*.

### 9. *Gnophopsodos tholeraria* (Püngeler, 1901)

(adults Pl. 2, Figs 9a, 9b; male gen. Pl. 4, Figs 9c, 9d; female gen. Pl. 5, Fig. 9e)

*Gnophos tholeraria* Püngeler, 1901, *Deutsche Entomologische Zeitschrift Iris*, 14: 189, pl. 3, figs. 14, 15.—Locus typicus: China, near Aksu. Deposition of Lectotype: MNHU. Examined.

**Material examined.** Type material. Lectotype ♂ (Pl. 2, Fig. 9a; Pl. 4, Fig. 9c) (hereby designated): [**China:**] ‘Ost-Turkestan | (Aksu) | Rückbeil 1900’, ‘Type | tholeraria Püng[eler] | ♂’, ‘Gnophos | tholeraria | [gen. prep.] | in Berlese-Gemisch | wasserlöslich | ♂ Holotyp. | Rezbanyai–Reser No. 26479.’, ‘Aksu | 1900’, ‘Reser–26479 ♂ | gen. prep. | Reser’, MNHU.

Paralectotypes 2♂, 1♀ (Pl. 2, Fig. 9b; Pl. 5, Fig. 9e) (hereby designated): **China:** 1♂ (Pl. 4, Fig. 9d), East Turkestan, Aksu, leg. Rückbeil 1900, gen. prep. SE–593; 1♂, same data; 1♀, East Turkestan, Aksu, leg. Rückbeil 1900, gen. prep. Reser–26480, MNHU.—Further material. **China:** 1♂, Turkestan, Aksu, leg. R. Tancre, barcode id. SE–MNC–Lep–01072; 1♂, same location, <unreadable>, 1905, SE–MNC–Lep–01073, ZSM.

**Description.** Adults (Pl. 2, Figs 9a, 9b).

Measurements. Wingspan: 27–28 mm (♂), 29 mm (♀); forewing length: 15–16 mm (♂), 15 mm (♀); forewing width: 9–10 mm (♂), 9 mm (♀).

Wings. Upper side dirty white, roughly diffused with darker patches of grayish-brown scales; medial lines grayish-brown, occasionally blurring with background coloration; underside similar to upper side, blurred; fringes yellowish-white or white.

Male genitalia (Pl. 4, Figs 9c, 9d). Total length: 1.44–1.51 mm; valvae span: 1.18 mm; valvulae span: 1.35 mm; valvae width: 0.78 mm. Costa weakly sclerotized, uneven padded, costal thorns lacking; uncus broadly rounded with moderately pointed small peak; gnathos laterally compressed, strongly pointed; juxta keyhole-shaped, caudally constricted, terminal broadened again with rounded caudal end; saccus remarkably short; aedeagus length: 0.59–0.64 mm; appendix aedeagi: 0.86–0.87 mm.

Female genitalia (Pl. 5, Fig. 9e). Antrum length: 0.7 mm; antrum width: 0.3 mm.

**Diagnosis.** Externally, the dirty white basic color diffused with patches of grayish-brown scales is characteristically for *G. tholeraria*. Internally, the species is distinctive because of the keyhole-shaped juxta, the spoon-shaped and incised appendix aedeagi and the remarkably short saccus. Therefore it can hardly be confused with any other species of the genus.

**Distribution** (Fig. 5). All examined specimens were collected near Aksu in China. Kaila *et al.* (1996) mentioned *G. tholeraria* from Kaindy in Kyrgyzstan.

**Biology.** As far as known the flight period is mid-July (Kaila *et al.* 1996).

## Acknowledgments

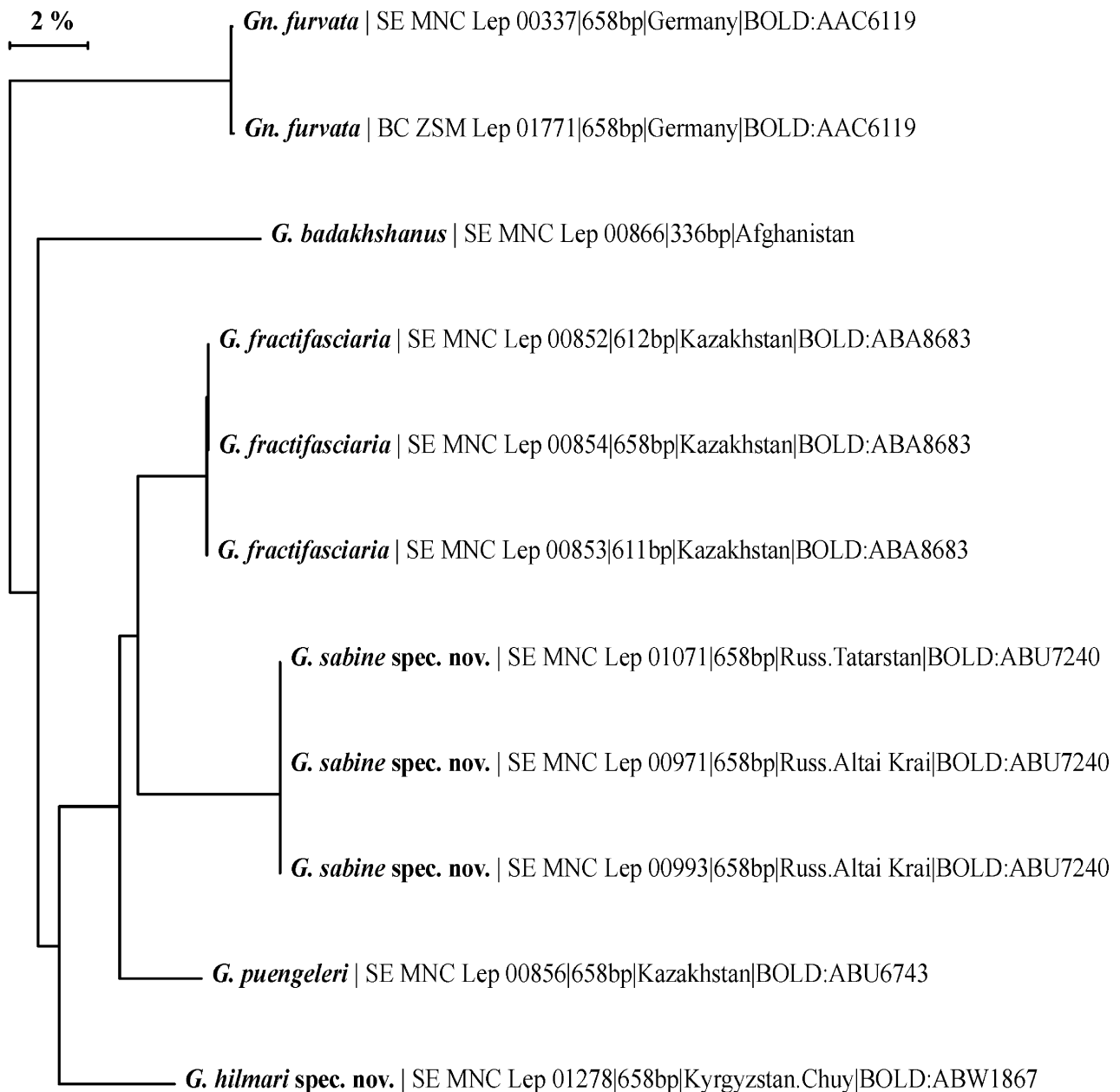
We are grateful to John Chainey, Natural History Museum, London, United Kingdom; Wolfram Mey, Museum für Naturkunde, Berlin, Germany; Robert Trusch, Staatliches Museum für Naturkunde, Karlsruhe, Germany; Dieter Stüning, Zoologisches Forschungsinstitut und Museum Alexander Koenig, Bonn, Germany; Wladimir Mironov, Zoological Institute, Russian Academy of Sciences, St. Petersburg, Russia; Axel Hausmann, Zoologische Staatssammlung, Munich, Germany; Ladislaus Reser, Natur-Museum, Luzern, Switzerland; Jörg Gelbrecht, Königs Wusterhausen, Germany; Timm Karisch, Dessau, Germany; Hans Löbel, Sondershausen, Germany; Bernd Müller, Berlin, Germany; Ulrich Ratzel, Karlsruhe, Germany; Bernd Schacht, Dahlewitz, Germany; Dirk Stadie, Eisleben, Germany; Peder Skou, Vester Skerninge, Denmark, and Manfred Sommerer, Munich, Germany, for their generosity in loan of material.

We are also grateful to Paul D.N. Hebert, Biodiversity Institute of Ontario, University of Guelph, Canada, and his competent teams at the Canadian Centre for DNA Barcoding (CCDB, University of Guelph), for sequencing and for access to the BOLD informatics platform; DNA analyses were supported by Genome Canada, the Ontario Ministry of Research and Innovation and Natural Science and Engineering Research Council of Canada (NSERC) in the framework of the International Barcode of Life (iBOL) program.

Special thanks to Laura Marrero Palma, Seville, Spain; Tina Llera Pérez, Chemnitz, Germany, as well as Axel Hausmann for giving advice and support in many situations.

We would also like to thank Jörg Gelbrecht; Bernd Müller, and especially Evgeny Beljaev, Institute of Biology and Soil Science, Laboratory of Entomology, Vladivostok, Russia; Hossein Rajaei, Staatliches Museum für Naturkunde, Stuttgart, Germany; Pasi Sihvonen, University of Helsinki, Research Affairs, Helsinki, Finland; Manfred Sommerer, and Jaan Viidalepp, Institute of Zoology and Botany, Tartu, Estonia, for their useful comments on the manuscript. Carola Baran, Stellenbosch, South Africa, and John Green, London, United Kingdom, assisted in checking the English.

This research received support from the SYNTHESYS Project ([www.synthesys.info](http://www.synthesys.info)) financed by the European Community Research Infrastructure Action under the FP6 “Structuring the European Research Area” programme.



**FIGURE 6.** Neighbor joining tree for all analyzed species of *Gnophopsodos* on the basis of DNA barcoding (Kimura 2-parameter distance model for COI-5P marker) with *Gnophos furvata* ([Denis & Schiffermüller], 1775) as outgroup. Terminal branches provided with species name, barcode id., barcode length, origin, and BIN number from BOLD.

## References

- Bohatsch, O. (1910) Neue palaearktische Macrolepidopteren. *Jahresbericht des Wiener Entomologischen Vereins*, 20, 163–164.
- deWaard, J.R., Ivanova, N.V., Hajibabaei, M. & Hebert, P.D.N. (2008) Assembling DNA Barcodes. In: Martin, C.C. (Ed.), *Methods in Molecular Biology: Environmental Genomics*. Humana Press, Totowa, N.J., pp. 275–293.  
[http://dx.doi.org/10.1007/978-1-59745-548-0\\_15](http://dx.doi.org/10.1007/978-1-59745-548-0_15)
- Evenhuis, N.L. (2016) Abbreviations for Insect and Spider Collections of the World. Available from: <http://hbs.bishopmuseum.org/codens/codens-inst.html> (accessed 14 March 2016)
- Eversmann, E. (1848) Beschreibung einiger neuen Falter Russlands. *Bulletin de la Société des naturalistes de Moscou*, 21, 205–232.
- Hebert, P.D.N., Cywinska, A., Ball, S.L. & deWaard, J.R. (2003) Biological identifications through DNA barcodes. *Proceedings of the Royal Society of London B*, 270, 313–321.

<http://dx.doi.org/10.1098/rspb.2002.2218>

- Ivanova, N.V., deWaard, J.R. & Hebert, P.D.N. (2006) An inexpensive, automationfriendly protocol for recovering high-quality DNA. *Molecular Ecology Notes*, 6, 998–1002.  
<http://dx.doi.org/10.1111/j.1471-8286.2006.01428.x>
- Kaila, L., Viidalepp, J., Mikkola, K. & Mironov, V. (1996) Geometridae (Lepidoptera) from the Tian–Shan Mountains in Kazakhstan and Kyrgyzstan, with descriptions of three new species and one new subspecies. *Acta Zoologica Fennica*, 200, 57–82.
- Kimura, M. (1980) A simple method for estimating evolutionary rates of base substitutions through comparative studies of nucleotide sequences. *Journal of Molecular Evolution*, 16, 111–120.  
<http://dx.doi.org/10.1007%2F01731581>
- Oberthür, Ch. (1893) Lépidoptères d'Asie. *Études d'Entomologie*, 18, 11–45.
- Oberthür, Ch. (1913) Suite de la Révision des Phalénites décrites par A. Guenée dans le Species Général. *Études de lépidoptérologie comparée*, 7, 237–331, pl. CLXXXIV.  
<http://dx.doi.org/10.5962/bhl.title.8792>
- Parsons, M.S., Scoble, M.J., Honey, M.R., Pitkin, L.M. & Pitkin, B.R. (1999) The Catalogue. In: Scoble, M.J. (Ed.), *Geometrid Moths of the World: A catalogue (Lepidoptera, Geometridae)*. Vol. 1 & 2. CSIRO Publishing and Apollo Books, Collingwood and Stenstrup, 1016 pp.
- Püngeler, R. (1901) Neue Macrolepidopteren aus Centralasien. *Deutsche Entomologische Zeitschrift Iris*, 14, 177–191.
- Püngeler, R. (1903) Neue palaearktische Macrolepidopteren. *Deutsche Entomologische Zeitschrift Iris*, 16, 286–301.
- Ratnasingham, S. (2016) BOLDSYSTEMS. Available from: <http://www.boldsystems.org/> (accessed 14 March 2016)
- Ratnasingham, S. & Hebert, P.D.N. (2007) The Barcode of Life Data System (<http://www.barcodinglife.org>). *Molecular Ecology Notes*, 7, 355–364.  
<http://dx.doi.org/10.1111/j.1471-8286.2007.01678.x>
- Sauter, W. (1990) Zur Systematik der *Gnophos*-Gruppe (Lepidoptera, Geometridae). *Nota lepidopterologica*, 12, 328–343.
- Saitou, N. & Nei, M. (1987) The Neighbor-joining Method: A New Method for Reconstructing Phylogenetic Trees. *Molecular Biology and Evolution*, 4, 406–425.
- Trusch, R. & Erlacher, S. (2001) *Zur Morphologie, Verbreitung, Bionomie und Identifikation der Dyscia-Arten (Lepidoptera, Geometridae: Ennominae)*. Zoologisches Forschungsinstitut und Museum Alexander König, Bonn, 115 pp.
- Viidalepp, J. & Soljanikov, V.P. (1977) On the geometrid moths (Lepidoptera, Geometridae) of the northern part of the Mongolian People's Republic. In: Kerzhner, I.M. (Ed.), *Insects of Mongolia*. Vol. 5. Nauka, Leningrad, pp. 620–641. [in Russian]
- Viidalepp, J. (1988) *Fauna pyadenits gor Srednei Azii [Geometridae fauna of the central Asian mountains]*. Nauka, Moscow, 231 pp.
- Viidalepp, J. (1996) *Check List of the Geometridae of the Former U.S.S.R.* Apollo Books, Stenstrup, 111 pp.
- Wehrli, E. (1922) Über neue schweizerische und zentralasiatische *Gnophos*-Arten und mikroskopische Bearbeitung einzelner Gruppen der Gattung. *Deutsche Entomologische Zeitschrift Iris*, 36, 1–29.
- Wehrli, E. (1945) Neue Gattungen, Untergattungen, Arten und Rassen. *Mitteilungen der Schweizerischen entomologischen Gesellschaft*, 19, 334–338.
- Wehrli, E. (1951) Une nouvelle classification du genre *Gnophos* Tr. *Lambillionea*, 51, 6–37.
- Wehrli, E. (1953) *Die Spanner des palaearktischen Faunengebietes* In: Seitz, A. (Ed.), *Die Gross-Schmetterlinge der Erde. Supplement zu Band 4*. Alfred Kernen, Stuttgart, pp. 622.
- Wiltshire, E.P. (1967) Middle East Lepidoptera XX. A third contribution to the fauna of Afghanistan. *Beiträge zur Naturkundlichen Forschung in SW-Deutschland*, 26, 137–169.