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Contribution to the knowledge of the genus *Lithostege* Hübner, 1825 (Lepidoptera, Geometridae) with confirming the bona species status of *Lithostege amseli* Wiltshire, 1967 and descriptions of two new species from Central Asia

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ABSTRACT. Recent research on the genus *Lithostege* Hübner, 1825 has raised questions about the taxonomic status of *Lithostege amseli* Wiltshire, 1967. Examination of the recently rediscovered holotype confirms its validity as a distinct species. Furthermore, we have now clarified the taxonomy of *Lithostege amoenata* Christoph, 1885, a species that was previously misinterpreted. Additionally, two new species of the genus *Lithostege* from Afghanistan and Tajikistan are described here (*L. hausmanni* sp. n. and *L. viidaleppi* sp. n.). The wing patterns and genitalia structures of the discussed species are illustrated, and their diagnostic characteristics are discussed.

Keywords: Afghanistan, Chesiadini, Iran, Tajikistan

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INTRODUCTION

The Genus *Lithostege* Hübner, 1825 encompassing 56 species globally (Scoble, 1999; Scoble & Hausmann, 2007; Rajaei et al., 2022) belongs to the tribe Chesiadini Pierce, 1914 (Viidalepp, 2011; Rajaei et al., 2019). Compared to other Chesiadini genera, *Lithostege* species are characterized by narrower forewings and greatly reduced hindwings. Their forewings feature two areoles; the anal vein of hindwings in males is short and concealed in an elongated basal pocket (this pocket is absent in females) (see Rajaei et al., 2011). Additionally, this genus is distinguished by the more enlarged femora and the markedly short tibiae on the forelegs; distal tooth-like projections on the fore-tibia; male genitalia of many species possess a rib-like sclerite extending from below the uncus to the hemitransstilla (Viidalepp, 1990; Rajaei et al., 2011; Rajaei & Stüning, 2013).

Lithostege has a Holarctic distribution, with its greatest species diversity found in the Palaearctic, particularly in the Middle East and Central Asia (Rajaei & Xue, 2012; Rajaei et al., 2019). A mysterious species within this genus, *Lithostege amseli*, was described by Wiltshire (1967) from eastern Afghanistan (Herat). This species was described based on a male holotype collected in 1956 by H. G. Amsel (the former curator of the State Museum of Natural History Karlsruhe, Germany, see: Rajaei et al., 2023a). Wiltshire (1967) published a photo of the holotype's wings, but he did not examine its genitalia. Numerous researchers, including the first author of this paper, have attempted to locate this single

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specimen in various collections over the years, all in vain (e.g., Rajaei et al., 2011; László, 2018). Due to the absence of *L. amseli* material, Rajaei et al. (2011) after examining specimens from the Middle East and Central Asia with similar wing patterns to the holotype depicted by Wiltshire (1967: Pl. I, fig. 3), have been convinced that *L. amseli* might be a synonym of *L. amoenata*. They remarked: "... there is a high probability that *amseli* is just a junior synonym of *amoenata*, but we were unable to prove this in the absence of the type specimen. Besides the latter, fresh material from the type locality of *amseli* and subsequent molecular studies would help to solve this open question." (Rajaei et al., 2011: 5).

Recently, we succeeded in locating the holotype of *Lithostege amseli* among some other mixed material in the State Museum of Natural History Karlsruhe (Germany). Examination of this specimens genitalia clearly confirmed its status as a valid species, and we provide the first description and illustration of the genitalia of this species here. Additionally, while examining new material from Afghanistan, Iran and Tajikistan, we identified two previously undescribed species, which are described in this paper. These two new species have been incorrectly interpreted as *L. amoenata* by Rajaei et al. (2011).

MATERIAL AND METHODS

Examined specimens were loaned or deposited in the following collections (acronyms after Evenhuis, 2024):

HMIM–Hayk Mirzayans Insect Museum at the Iranian Research Institute of Plant Protection (former Plant Pests and Diseases Research Institute, PPDR);
 IZBE–Estonian Institute of Zoology and Botany, Tartu, Estonia;
 MfN–Museum of Natural History, Berlin, Germany;
 SMNK–State Museum of Natural History Karlsruhe, Germany;
 SMNS–State Museum of Natural History Stuttgart, Germany;
 ZFMK– Zoological Research Museum Alexander Koenig, Bonn, Germany;
 ZIAT–Zoological Institute, Academy of Sciences of Turkmenistan, Ashkhabad;
 ZISP–Zoological Institute, Russian Academy of Sciences, St. Petersburg, Russia;
 ZMKU–Zoological Museum, Kyiv Shevchenko University, Ukraine;
 ZSM–Bavarian Natural History Collection, Munich, Germany (SNSB/ZSM).

Morphological examinations. The genitalia structures were examined and photographed in their natural positions (Figs 14c & 15c), allowing us to identify multiple diagnostic characters (for detailed methods, see Wanke & Rajaei, 2018; Wanke et al., 2019, 2021). The specimens were photographed with an Olympus® digital camera (model: E3) prior to dissection. For genitalia dissections, standard protocol (e.g. Robinson, 1976) was followed. Dissected genitalia structures were stained using a Chlorazol Black and Mercurochrome solution in 75% ethanol. Genitalia structures were mounted on microscope slides embedded in Euparal as permanent slides. Genitalia slides were photographed by using a Keyence® digital microscope (model: VHX-5000). Preparations are marked in the text with the abbreviation 'g. prep.' or 'gen. prep.'. Image processing was done using Adobe Photoshop (version: CS5).

Distribution map. Geographical coordinates were traced using 'Google Earth Pro', and were subsequently plotted and prepared in QGIS. For the preparation of the elevation profile in QGIS, Global Multi-resolution Terrain Elevation Data 2010 (GMTED2010) was used (Downloaded from USGS).

RESULTS

Taxonomic hierarchy

Class Insecta Linnaeus, 1785

Order Lepidoptera Linnaeus, 1785

Family Geometridae Leach, 1815

Subfamily Larentiinae Duponchel, 1845

Tribe Chesiadini Pierce, 1914

Genus *Lithostege* Hübner, 1825

Type species: *Geometra griseata* Denis & Schiffermüller, 1775.

Diagnosis. The genus can be diagnosed by the following synapomorphic characters (Rajaei et al., 2011; Rajaei & Stüning, 2013; Rajaei et al., 2019): the forewing is slightly elongated and features two areoles in its venation. The hindwing is oval, narrow and reduced in size, with a shorter anal vein in males and a longer one in females. The foreleg has a significantly thickened femur; the tibia of the foreleg is extremely short and ends distally with a massive, forked projection that includes a longer internal and a shorter external tooth (see Rajaei & Stüning, 2013: fig. 2). Additionally, the foreleg's epiphysis is small; the mid-tibia has one pair of spurs and the hind tibia has two pairs of spurs. The male genitalia of most species feature a harpe, a process arising from the basal centre of valva, which is divided into the basal part and a dorsal arm. The female genitalia of most species possess a membranous diverticulum attached to the corpus bursae.

Lithostege amseli Wiltshire, 1967 *bona* sp.

Lithostege amseli Wiltshire, 1967: 150, pl. 1, fig. 3. Holotype (♂) in coll. SMNK (examined here) (Figs 1, 11, 20).

Type material. **Holotype** ♂, Afghanistan, Herat, 970 m, 15.4.1956, H. G. Amsel leg.; ex. coll. Prof. H. G. Amsel, SMNK; E. Lep. 17a; *Lithostege amseli* Wilts. Holotype; gen. prep. 2753/2023 H. Rajaei (SMNK).

Taxonomic note. Wiltshire (1967: 150) described this species based solely on external characteristics of the male holotype. He indicated that the specimen was deposited in ZM [ZSM]; however, it could not be located in the ZSM or any other collection prior to this study (see: Rajaei et al., 2011). The absence of the holotype caused long-term misinterpretation of this taxon by Rajaei et al. (2011), who tentatively suggested it might be a junior synonym of *L. amoenata*. This misinterpretation was subsequently repeated by other authors (e.g. László, 2018). Recently the holotype of *L. amseli* was discovered among miscellaneous specimens in SMNK collection by the second author of this paper. Since this specimen was collected by H. G. Amsel, it is clear that Wiltshire (1967: 150) borrowed this specimen directly from Amsel but mistakenly cited ZSM as the depository. Wiltshire returned the holotype (along with many other loaned specimens) to SMNK after his study. Examination of the holotype's genitalia clearly confirms that *L. amseli* is a distinct species, not to be confused with any other described *Lithostege*. Additionally, based on the wing pattern and genitalia structure, this species does not belong to the *amoenata* species-group (as wrongly suggested by Rajaei et al., 2011) but to the *bosporaria* species-group. It is closely related to *L. wiltshirei* László, 2018; *L. samandooki* Rajaei, 2011 and *L. dissocyma* Prout, 1938 (see below).

Diagnosis. *Lithostege amseli* belongs to the *bosporaria* species-group, characterized in the male genitalia by the plate-like sclerotized valvae, with a harpe situated centrally and extended into a smooth dorsal projection; a triangular saccus; and a short aedeagus with scobinate or shortly dentate vesica. Females in the *bosporaria*-group have a deeply incised ventral margin of the antrum. Externally, *L. amseli* resembles *L. wiltshirei* (Figs 4 & 20; also see László, 2018: Pl. 46, figs 36–39 & gen. fig. 11), *L. samandooki* and *L. dissocyma* (Figs 2–3). However, these four allopatric species can be distinguished by their geographic distribution pattern and genitalia characteristics. *Lithostege amseli* is known only from East Afghanistan (Herat), *L. wiltshirei* from its type locality in Quetta (Pakistan), *L. samandooki* from southern Iran and *L. dissocyma* is known from eastern Iraq to southern Iran. In terms of wingspan, *L. amseli* (23 mm) is very similar to *L. wiltshirei* (23–25 mm) (Fig. 4) but differs from *L. samandooki* (25–26 mm) (Fig. 2) and *L. dissocyma* (29–31 mm) (Fig. 3). The antemedial lines of *L. amseli* feature two parallel white lines that are right-angled outwards (similarly in *L. samandooki*), while in *L. wiltshirei* and *L. dissocyma*, these lines are acutely angled; see Figs 1–4). *L. amseli*'s postmedial lines consist of two parallel white lines, separated by a brown line, forming two outward projections (three projections in *L. samandooki*, one in *L. dissocyma* and *L. wiltshirei*).

Remarks. During this study, a female specimen of *L. amseli* could not be traced, nor was a male specimen of *L. wiltshirei* found, preventing direct comparison of their genitalia. However, the male genitalia of *L. amseli* are easily distinct from those of *L. samandooki* and *L. dissocyma*: in *L. amseli* (Fig. 11),



Figures 1-10. Wing pattern. **1.** *Lithostege amseli*, holotype, male (Afghanistan, Herat, 970 m), **2.** *L. samandooki*, male (Iran, prov. Kerman, Omrudoieh); **3.** *L. dissocyma*, male (Iran, prov. Fars, S Jahrom); **4.** *L. wiltshirei*, HT, female (Pakistan, Quetta); **5-6.** *L. amoenata*: **5.** Syntype, Female (Turkmenistan, Ashkhabat); **6.** Male (Iran, Prov. Khorasan-e Shomali, Kopet-Dagh Mts); **7-8.** *L. hausmanni* sp. n.: **7.** Holotype, male (Afghanistan, Dasht-i-Nawar, NW v. Ghazni), **8.** Paratype, female (SE Afghanistan, Safed Koh, S-Seite, Kotkai); **9-10.** *L. viidaleppi* sp. n. (Tajikistan, 6 km from Nikolajevsky pass): **9.** Holotype, male, **10.** Paratype, female. a, upperside; b, underside.

the uncus is finger-shaped, moderately long; the valva is broad and apically rounded; the basal part of the harpe is digitiform and not hooked, the dorsal arm of the harpe is thin, short and running parallel to the uncus; the sacculus part of valva is broadly thickened without any ornamentation; and the saccus is long, distally pointed (the uncus is much longer in *L. samandooki* and *L. dissocyma*, hook-shaped in *L. samandooki*; the valva is elongated in *L. samandooki*, and broad in *L. dissocyma*; the basal part of the harpe is hooked, the dorsal arm of the harpe is thin, long and running parallel to the valva in *L. samandooki*;

the harpe of *L. dissocyma* is more similar to that of *L. amseli* but the dorsal arm of the harpe is running parallel to the valva; the sacculus of *L. samandooki* is strongly sclerotized, broadly thickened basally, and narrower distally with a flat, elongated, triangular projection on the subapical part of the valva; the sacculus of *L. dissocyma* is more similar to that of *L. amseli*; the saccus is long and distally rounded in both *L. samandooki* and *L. dissocyma*; Figs 12–13).

Distribution. This species is known only from its type locality in Herat (Afghanistan) (Fig. 21).

Lithostege amoenata Christoph, 1885 (Figs 5–6 & 14, 17, 21)

Type material. **Lectotype** ♀, [Turkmenistan] Ashkhabat, Coll. Great Knjaz Nikolaj Mikhajlovich, 23.5.82 Amoenata Chr., Lectotypus *Lithostege amoenata* Christoph, 1885, Design. V. Mironov 2017. in ZISP. Paralectotypes, 1 ♀, 1 ♂, same data as Lectotypus, but 5.6.82, in ZISP.

Additional material. (9 ♀, 17 ♂): 1 ♂, [Iran] Khorasan, Kopetdagh-Allahakbar, 1950 m, 16.6.1974, leg. Radj [abi], Paz [ouki], g. prep. 1065/2010 H. Rajaei; 1 ♀, [Iran, Khorasan e Shomali] Sarekhs [Sarakhs], 21.v.[19]73, [leg.] Abai; both in HMIM. 1 ♀, Nord Iran, Elbursgebirge östl. Shemshak, 50 km nördl. Tehran, 2100–2500 m, 8.–24.6.1973, leg. G. Junge, g. prep. 1024/2010 H. R.; 6 ♂, Iran, Prov. Khorasan[-e Shomali], Kopet-Dagh Mts., 40 km N of Qucan, 2000 m, 4–5.vi.2010, leg. B. Benedek & T. Hác; 1 ♂, Iran, Prov. Khorasan[-e Shomali], Kopet-Dagh Mts., 65 km N of Qucan, 2000 m, 5.vi.2010, leg. B. Benedek & T. Hác, g. prep. (♂) 2757/2024 H. Rajaei; 8 ♂, Iran, Prov. Khorasan[-e Shomali], Binalud Mts., 40 km SW of Mashad, Moghan-Pivejan Site, 2000–2500 m, 6–7.VI.2010, leg. B. Benedek & T. Hác, g. prep. (♂) 2757/2024 H. Rajaei; 1 ♂, [Turkmenistan], Merv; 1 ♂, [Turkmenistan], Ashkhabad, 8 Mai; all in SMNK. 1 ♀, Iran, Prov. Khorasan[-e Shomali], Kopet-Dagh Mts., 65 km N of Qucan, 2000 m, 5.vi.2010, leg. B. Benedek & T. Hác, g. prep. 2768/2024 H. Rajaei; 4 ♂, Iran, Prov. Khorasan[-e Shomali], Kopet-Dagh Mts., 40 km N of Qucan, 2000 m, 4–5.vi.2010, leg. B. Benedek & T. Hác, g. prep. 2769/2024 H. Rajaei; 1 ♂, Iran, Prov. Khorasan[-e Shomali], Binalud Mts., 40 km SW of Mashad, Moghan-Pivejan Site, 2000–2500 m, 6–7.VI.2010, leg. B. Benedek & T. Hác, g. prep. 2762/2024 H. Rajaei; all in SMNS. 1 ♂, [Turkmenistan], Kopet-Dagh, Suljukli, 25.05.1923, Shestoperov leg; all in ZIAT. 1 ♂, [Turkmenistan], Asia centr. (Tekke); 1 ♀, [Turkmenistan] Ashkhabad; both in MfN; 1 ♀, Turkmenia, West Kopet-dagh, gorge Aidere, 1.v.1983, A. Deviatkin [leg.]; in ZMKU.

Taxonomic note. *Lithostege amoenata* has been consistently misinterpreted in the past (e.g., Rajaei et al., 2011; Viidalepp, 2011; László, 2018), primarily due to highly external similarity to *L. hausmanni* sp. n. and *L. viidaleppi* sp. n., as well as the absence of the holotype of *L. amseli*. Rajaei et al. (2011) suggested that *L. amseli* might be a synonym of *L. amoenata*, but deferred the formal act of synonymization pending further studies. László (2018) recognized this misinterpretation, noting that Rajaei et al. (2011) had mistakenly depicted specimens as *L. amoenata* that were not collected near the type locality of this species. Upon studying the holotype of *L. amseli* and extensive material from across the Middle East and Central Asia, we have gained a better understanding of the morphology of the *amoenata* species-group, leading to the discovery of two new species: *L. hausmanni* sp. n. and *L. viidaleppi* sp. n. (see below). Here we examine and illustrate the type specimens of *L. amoenata*, as well as additional specimens from northeastern Iran, particularly the Kopet-Dagh Mountains.

Diagnosis. The wingspan: 28–31 mm. Externally, *L. amoenata* closely resembles the allied species, *L. hausmanni* sp. n. and *L. viidaleppi* sp. n., described herein (Figs 7–10). These three species have allopatric distribution: *L. amoenata* is found in southwestern Turkmenistan and northeastern Iran; *L. hausmanni* sp. n. is known only from central and southeastern Afghanistan and North Iran; and *L. viidaleppi* sp. n. is distributed in southern Tajikistan. Additionally, they can be easily distinguished in the characters of male and female genitalia. In *L. amoenata* (Fig. 14) both the apical and costal valval processes are of the same size; The juxta is elongated, with its apical part is narrower than the basal; the aedeagus is short and not curved (in *L. hausmanni* sp. n. (Fig. 15) the apical process of the valva is very long, the costal process is reduced to a series of small teeth; the juxta is elongated, with basal narrower than the apical; and the aedeagus is short and subapically curved; in *L. viidaleppi* sp. n. (Fig 16) the apical process of the valva is long, the costal process forms a stout projection, slightly shorter than the apical one; the juxta is

elongated, with the basal section narrower than the apical; and the aedeagus is long and subapically curved). The female genitalia of *L. amoenata* (Fig. 17) include a very short antrum, with a lip-shaped ventral margin; a tubular and thick ductus bursae; and a spherical corpus bursae fully covered with dense spicules (*L. hausmanni* sp. n. (Fig. 18) has a short, triangular antrum, with a short V-shaped incision into the ventral margin; a curved, narrow ductus bursae; and a spherical corpus bursae half covered with small spicules; *L. viidaleppi* sp. n. (Fig. 19) features a bowl-shaped antrum with a U-shaped incision into the ventral margin; a tubular and short ductus bursae; and a spherical corpus bursae, with only the dorsal third covered with loose spicules).

Bionomics. *L. amoenata* appears to be bivoltine, with specimens collected from May to July and at the end of September, at the altitude ranging from 1950 to 2500 m.

Distribution. This species is distributed in southern Turkmenistan, northern and northeastern Iran (Fig. 21).

***Lithostege hausmanni* sp. n. (Figs 7–8 & 15, 18, 21)**

<https://zoobank.org/urn:lsid:zoobank.org:act:DC380493-68E2-4343-AD79-C4B836FE7ABA>

Material examined. Holotype ♂, Afghan.[Afghanistan], Dasht-i-Nawar, NW v. Ghazni, 3000 m, 8–10.vi.1965, [leg.] Kasy & Vartian; ex. Ausbeuten G. Ebert, SMNK, E-Lep 22; gen. prep. 2760/2023 H. Rajaei; in SMNK. **Paratypes** (12 ♂, 10 ♀): 1 ♂, same data as holotype, gen. prep. 1025/2010 H. Rajaei; 2 ♂, Afghanistan, SO Afghanistan, Safed Koh, S-Seite, Kotkai, 2350 m, 23.vi.1967, M. Müller leg.; ex. Ausbeuten G. Ebert, SMNK, E-Lep 22; gen. prep. ♂ 2758/2023 H. Rajaei; 3 ♀, same data, 30.vi.1968; 1 ♀, same data, 25.vi.1968, gen. prep. 988 I. Kostjuk; 1 ♂, 3 ♀, same data, 14–23.vi.1966, leg. G. Ebert, gen. prep. ♂ 2764 /2023 H. Rajaei; 1 ♀, same data, 21.vi–1.vii.1969, leg. G. Ebert; 4 ♂, Z-Afghanistan, Oberlauf d. Helmand, Mullah-Jaqub-Pass, 3000 m, 16.vii.1966, leg. G. Ebert, gen. prep. 989 I. Kostjuk; 1 ♀, E-Afghanistan, prov. Bamian, vic. Panjao, 2300 m, 27.vi.70, leg. C. Naumann, coll. Nr. 1083; all in SMNK. 1 ♂, 1 ♀, Afghanistan, SO Afghanistan, Safed Koh, S-Seite, Kotkai, 2350 m, 2.vi.1967, M. Müller leg.; ex. Ausbeuten G. Ebert, SMNK, E-Lep 22; gen. prep. ♀ 2759; ♂ 2758/2023 H. Rajaei; 1 ♀, same data, 14–23.vi.1966, leg. G. Ebert, gen. prep. ♀ 2765/2023 H. Rajaei; 1 ♂, Z-Afghanistan, Oberlauf d. Helmand, Mullah-Jaqub-Pass, 3000 m, 16.vii.1966, leg. G. Ebert; all in SMNS.

Additional material. Two additional specimens were also identified as *L. hausmanni* (not included in the type material): 2 ♂, N Iran, 2400 m, Demavend, 25.–26.IX.1965, [leg.] E. & A. Vartian, ZSM Genital prep. No. 4530 and 4531 [dissected by A. Hausmann], both in ZSM. *Note.* The geographic location of these two specimens does not match the distribution pattern of *L. hausmanni* sp. n., and it cannot be ruled out that the specimens are mislabeled or a confusion of their locality data happened during dissection. Further field works are required to prove the presence or absence of this species in North Iran.

Etymology. This new species is named after Dr. Axel Hausmann, head of lepidoptera section at the Bavarian State Collection for Zoology (ZSM). Axel Hausmann is the founder of the scientific initiative “Forum Herbulot”, and has played a prominent role in the taxonomic studies of the family Geometridae in the last few decades. He is a senior author of numerous monographs on this moth family, including the book series “Geometrid Moths of Europe”, where he also served as editor-in-chief.

Diagnosis. *Lithostege hausmanni* sp. n. belongs to the *amoenata* species-group (the defining characteristics of which are discussed under *L. amoenata*). Externally this new species could be mistaken for *L. amoenata* and *L. viidaleppi* sp. n. (Figs 5–10), but it is clearly distinguishable by the genitalia structures in both sexes. In the male genitalia of *L. hausmanni* sp. n. (Fig. 15), the apical process is very long and the costal process is reduced into a series of small teeth; the juxta is elongated with its basal part narrower than the apical; the aedeagus is short and subapically curved (in *L. amoenata* (Fig. 14) both apical and costal processes of the valva are equal in length; the juxta is elongated, but its apical part is narrower than the basal; and the aedeagus is short and not curved; in *L. viidaleppi* sp. n. (Fig. 17) the apical process of the valva is roughly twice longer than the stout costal process; the juxta is elongated, which its basal section narrower than the apical; the aedeagus is long, subapically curved).

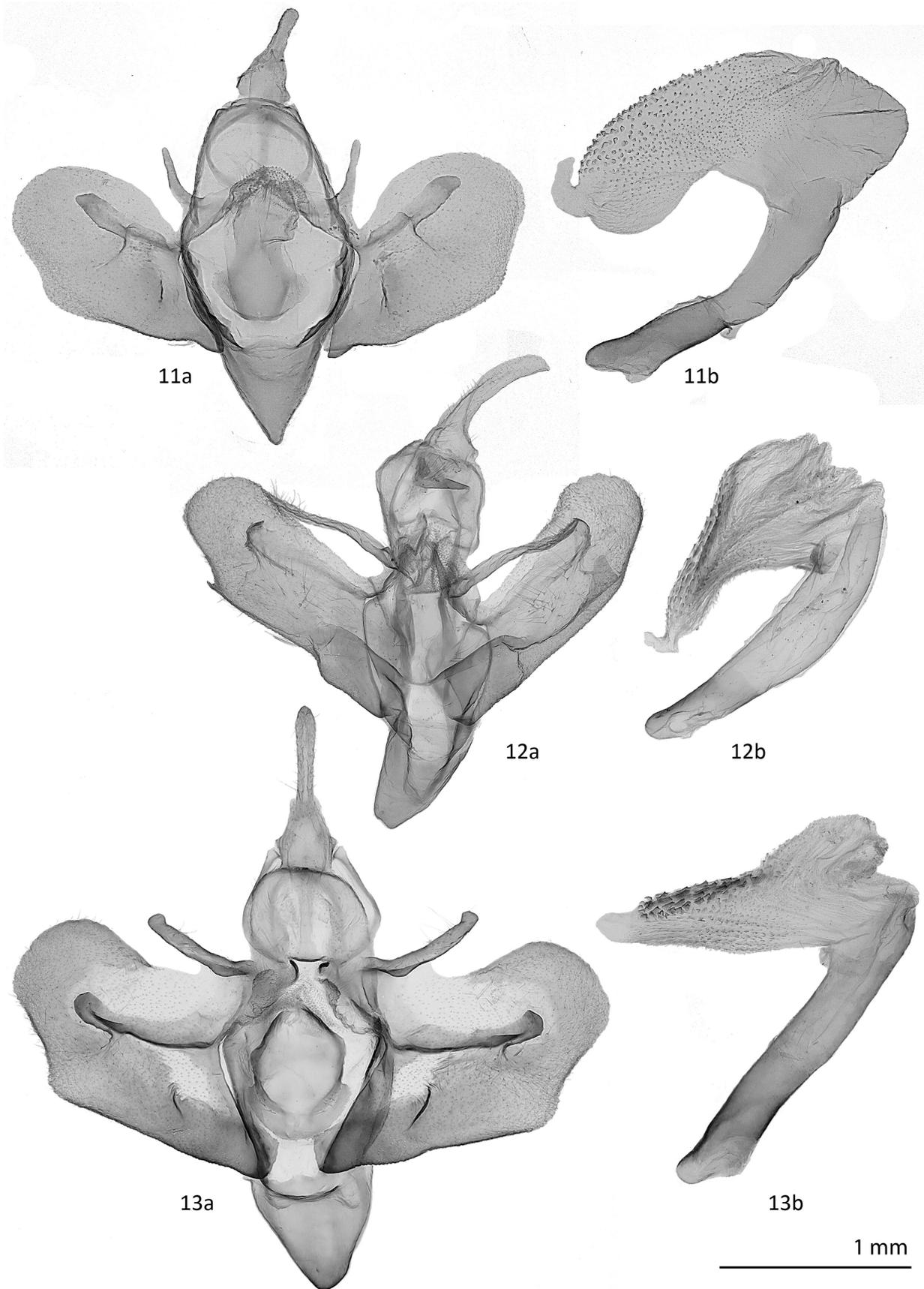


Figure 11-13. Male genitalia. **11.** *Lithostege amseli*, Holotype (Afghanistan, Herat, g. prep. 2753/2024 H. Rajaei); **12.** *L. samandooki*, holotype (Iran, Omrudieh, g. prep. 2201/2019 H. Rajaei); **13.** *L. dissocyma* (Iran, prov. Ilam, Chavar, Banvizeh, g. prep. 2203/2019 H. Rajaei). a, genitalia capsule; b, aedeagus.

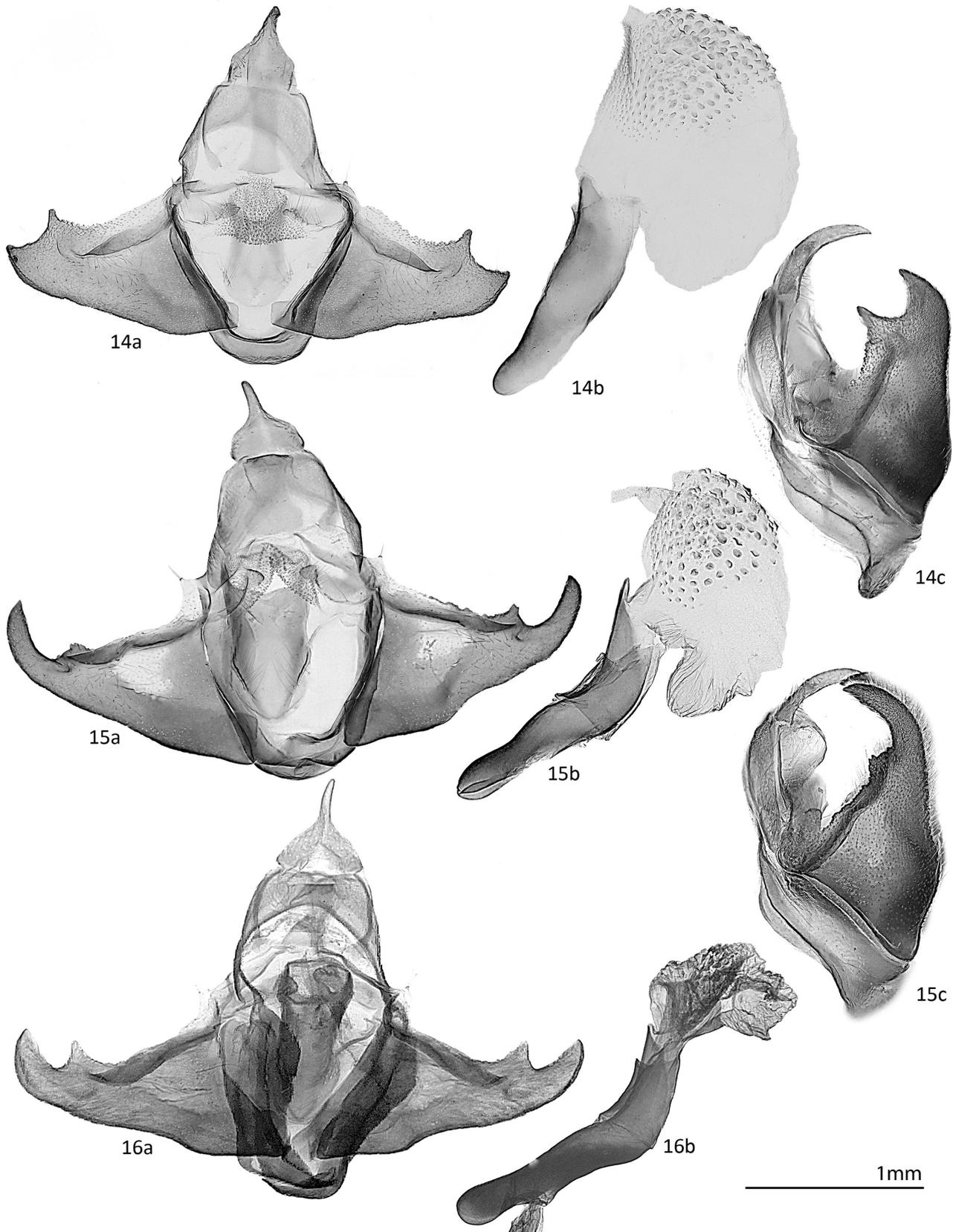


Figure 14-16. Male genitalia. **14.** *Lithostege amoenata* (Iran, Khorasan-e Shomali, Kopet-Dagh Mts., 65 km N of Qucan, g. prep. 2768/2024 H. Rajaei); **15.** *L. hausmanni* sp. n., holotype (Afghanistan, Dasht-i-Nawar, NW v. Ghazni, prep. 2760/2024 H. Rajaei); **16.** *L. viidaleppi* sp. n., holotype (Tajikistan, 6 km from Nikolajevsky pass, g. prep. 1022/2010 H. Rajaei); a, genitalia capsule; b, aedeagus; c, lateral view of the genitalia capsule.

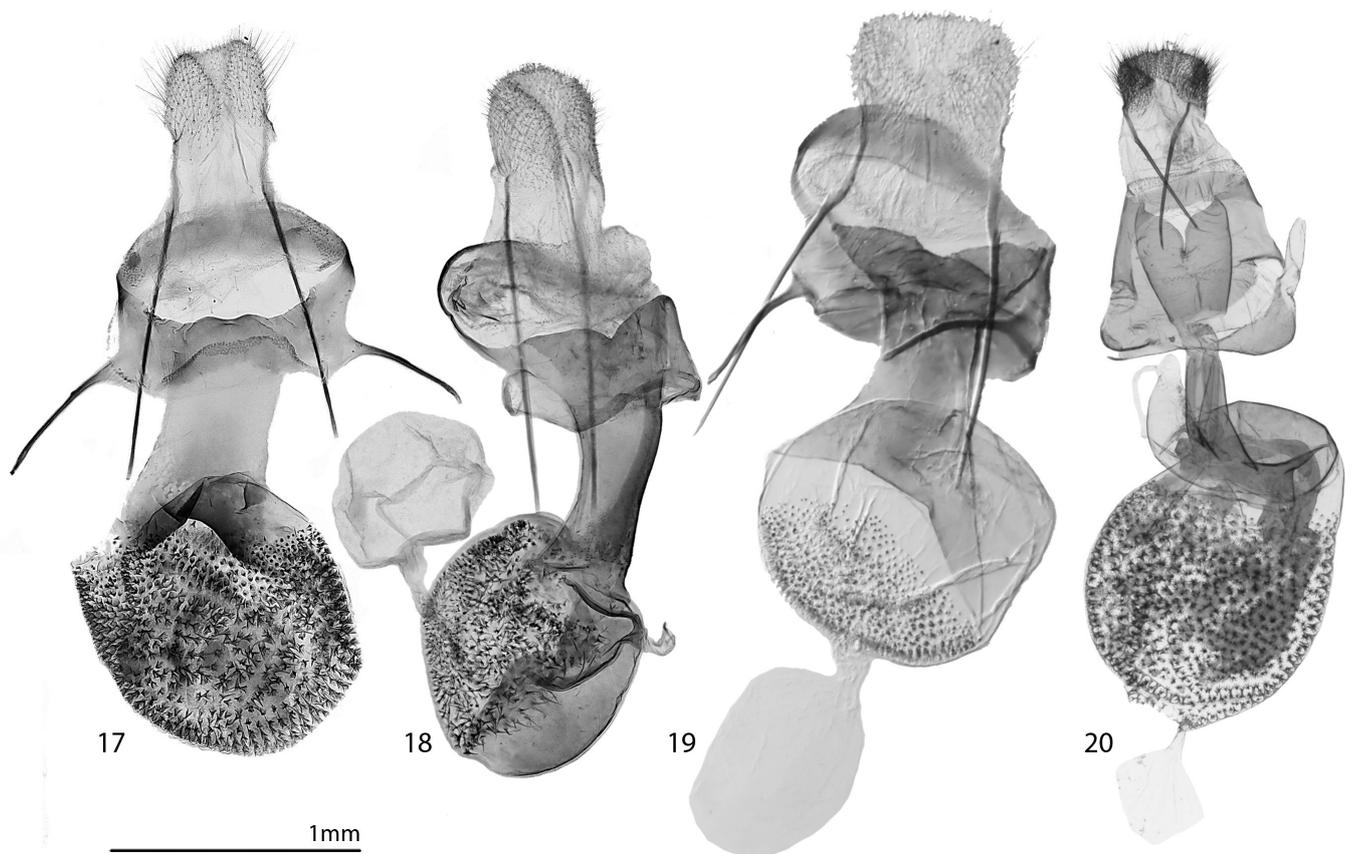


Figure 17–20. Female genitalia. **17.** *Lithostege amoenata* (Iran, Khorasan-e Shomali, Kopet-Dagh Mts., 40 km N of Qucan, g. prep. 2769/2024 H. Rajaei); **18.** *L. hausmanni* sp. n., paratype (Afghanistan, Safed Koh, Kotkai, prep. 2759/2024 H. Rajaei); **19.** *L. viidaleppi* sp. n., paratype (Tajikistan, 6 km from Nikolajevsky pass, g. prep. 1613/2010 H. Rajaei); **20.** *L. wiltshirei*, HT (Pakistan, Quetta).

In the female genitalia of *L. hausmanni* sp. n. (Fig. 18), the antrum is short and triangular, with a short V-shaped incision in the ventral margin; the narrow ductus bursae is curved; the corpus bursae is spherical, half covered with small spicules (in *L. amoenata* (Fig. 17) the antrum is very short, its ventral margin is lip-shaped; the tick ductus bursae is tubular; the corpus bursae is spherical and fully covered with dense spicules; *L. viidaleppi* sp. n. (Fig. 19) has a bowl-shaped antrum, with a U-shaped incision in the ventral margin; the short ductus bursae is tubular; the corpus bursae is spherical and with only the dorsal third covered with loose spicules).

Description. — Wingspan 24–28.5 mm (measured based on the whole type series). Wing ground colour dark-creamy to brown. Forewings with light to dark brown transverse lines; basal and antemedial lines projected towards termen on common stalk of Rs and M, angled at 80° then connected to the costal part of forewing; postmedial line brown, externally highlighted by a thick, creamy line, strongly curved towards termen on M1 and M3 and towards basis on M2; subterminal line very thin, light creamy, sometimes discontinued. There are several additional transverse lines, including a weaker basal line, a broad grey and a narrow wavy line at median area which show intraspecific variation. Fringes chequered creamy and brown. Hindwings elongate-oval, light brown to grey-ocher. Underside light creamy to light brown with traces of pattern similar to upper side.

Male genitalia (Figs 15). valva broad at base, tapering towards largely projected and pointed apex; costa of valva covered with a series of small teeth; sacculus medially curved. Uncus basally trapezoid, medially constricted, distally finger-shaped; lateral arms of gnathos present, but medially not connected;

socii at the base of uncus as tiny setose projections. Saccus short and broadly arched. Juxta elongate, its apical part shallowly notched, bowl-shaped, wider than basal part. Aedeagus short, subapically curved; vesica largely inflated with a short and broad sack-like diverticulum submedially and extensive field of sparse short teeth distally surrounding narrow tubular vesica ejaculatorius.

Female genitalia (Fig. 18). ovipositor as thick as ductus bursae; posterior apophyses three times longer than anterior apophyses; antrum triangular, its ventral margin with short V-shaped incision; ductus bursae curved, narrow; corpus bursae spherical, half covered with small spicules.

Bionomics. The known specimens were collected between the early June to mid-July, at altitudes ranging from 2350 to 3000 m.

Distribution. *Lithostege hausmanni* sp. n. is known from central and eastern Afghanistan. Two specimens from northern Iran have also been identified as *L. hausmanni* sp. n. (Fig. 21), but the presence of this species in that region requires further confirmation, as explained above.

***Lithostege viidaleppi* sp. n.** (Figs 9–10 & 16, 19, 21)

<https://zoobank.org/urn:lsid:zoobank.org:act:135EF327-7687-4148-87EE-4D36FFE7E43A>

Type material. **Holotype** ♂, Tajikistan, 6 km from Nikolajevsky pass [Nikolaev mountain pass], eastern slopes of Khozratisho Range [Khazratishoh, Khazrati-Shokh], above Chertovyj bridge, h = 2200 [m], 31.v.[19]58. meadows slope, Yu. Stshetkin, gen. prep. 1022/2010; in ZFMK; **Paratypes** (in total 4 ♂, 9 ♀): 2 ♂, 2 ♀, same as holotype; gen. preps ♂ 1611/2011, 1612/2011 and ♀ 1023/2010, 1613/2011 H. R.; all in ZFMK. 1 ♂, 2 ♀, SW Tajikistan, 60,5 km NW Shuroabad village on the road to the Pass, on wheat crops (nearby *Artemisia*), in the grass, 2050 m, 30.v.58, [leg.] Yu.L. Stshetkin; deposited in ZSM. 1 ♀, Tajikistan, 6 km from Nikolajevsky pass [Nikolaev mountain pass], eastern slopes of Khozratisho Range [Khazratishoh, Khazrati-Shokh], above Chertovyj bridge, h = 2200 [m], 31.v.[19]58. meadows slope, Yu. Stshetkin; 2 ♀, Tajikistan, Chasratishhoch-Geb., Shuroabad, 2000 m, 3.vi.58, Stshetkin; 1 ♀, Taj.[Tajikistan] SSR, in about 800 m from Shuroabad vicinity, near Khozratisho Range, 2000 m, 31.v.58, [handwriting of Yu. L. Stshetkin], g. prep. 2763/2024 H. Rajaei; all in ZSM; 1 ♂, Tadzh.[Tajikistan], 04.vii.1989, Peter I Mts., K[ishlak] Odilovot, 2000 m, U. Jürivete leg.; 1 ♀, [Tajikistan], Peter I [Mts.], Surhob [river], Odilovot, 2500 m, 04.vii.07.1989, U. Jürivete leg.; all in IZBE.

Additional material (tentatively identified as *L. viidaleppi* sp. n., but needs confirmation). 1 ♀, Afghanistan, Prov. Panjshir, Astanah N. Shava vic., 2600–2700 mNN, lux 28.vii.–9.viii.2007, leg. Einheimische Sammler via Shafiq Assad, SMNK, E-Lep. 250; gen. prep. 990/2023 I. Kostjuk.

Etymology. This new species is named after Dr. Jaan Viidalepp, senior taxonomist and scientific member of the Estonian Institute of Zoology and Botany, as well as the Estonian University of Life Sciences. He is a senior author of numerous monographs published on the family Geometridae, including “Check List of the Geometridae of the former U.S.S.R.” and the third volume of “Geometrid Moths of Europe”.

Diagnosis. *Lithostege viidaleppi* sp. n. belongs to the *amoenata* species-group (for the characteristics of this species-group, see the description under *L. amoenata*). Externally, this species (Figs 9–10) can be confused with *L. amoenata* and *L. hausmanni* sp. n. (Figs 5–7), but *L. viidaleppi* sp. n. is restricted southern Tajikistan and northeastern Afghanistan (*L. amoenata* is confined to southwestern Turkmenistan and northern and northeastern Iran; *L. hausmanni* sp. n. is known only in central and southeastern Afghanistan and northern Iran). Additionally, the male and female genitalia of this species are characteristic. In male genitalia, *L. viidaleppi* sp. n. features an apical process on the valva that is approximately twice as long as the stout costal process; the juxta is elongated, narrower at the base than the apex; aedeagus is long, subapically curved (*L. amoenata* has both apical and costal process of roughly the same size; the juxta is elongated, and narrower at the apex than the base; the aedeagus is short and not curved; *L. hausmanni* sp. n. has a very long apical process, a costal process reduced to a series of small teeth; the juxta is elongated and narrower at the base than the apex; the aedeagus is short, subapically curved). Female genitalia of *L. viidaleppi* sp. n. presents a bowl-shaped antrum with

its ventral margin featuring a U-shaped incision; the ductus bursae is tubular and short; the corpus bursae is spherical, only one-third of its dorsal part covered with loose spicules (conversely, *L. amoenata* has a very short antrum with a lip-shaped incision on its ventral margin; a tubular and thick ductus bursae; a spherical corpus bursae that is fully covered with dense spicules; *L. hausmanni* sp. n. has a short and triangular antrum with a short V-shaped incision on its ventral margin; the ductus bursae is curved and narrow; the corpus bursae is spherical, and half of it is covered with small spicules).

Description. — Wingspan 26–29 mm (measured based on the whole type series). Wing ground colour creamy to light brown. Forewing with light to dark brown transverse lines; basal and antemedial lines projected towards termen on common stalk of Rs and M, angled at 80° and then connected to forewing costa; postmedial line brown, externally highlighted with one thick and one or two very thin creamy lines, strongly curved towards termen on M1 and M3 and towards basis on M2; subterminal line light-creamy, continuous and evenly curved on upper side, zigzagged on underside. There are several additional transverse lines, including a weaker basal line, a broad grey and a narrow wavy line at median area, showing intraspecific variation. Fringes chequered creamy and brown. Hindwing elongate-oval, light-brown to grey-ochrous. Underside light creamy to light brown with reminiscent of pattern similar to upper side; only the subterminal line zigzagged on underside as opposed to evenly curved on upperside.

Male genitalia (Fig. 16). valva broad at base, tapering towards apex; apex projected and pointed; a tooth-like process present on subapical part of costa; apical process roughly twice longer than costal process; saccular part of valva medially curved. Uncus basally triangular, distally tapered, apically finger-shaped; lateral arms of gnathos present, but medially not connected; socii at the base of uncus as a tiny setose projection.

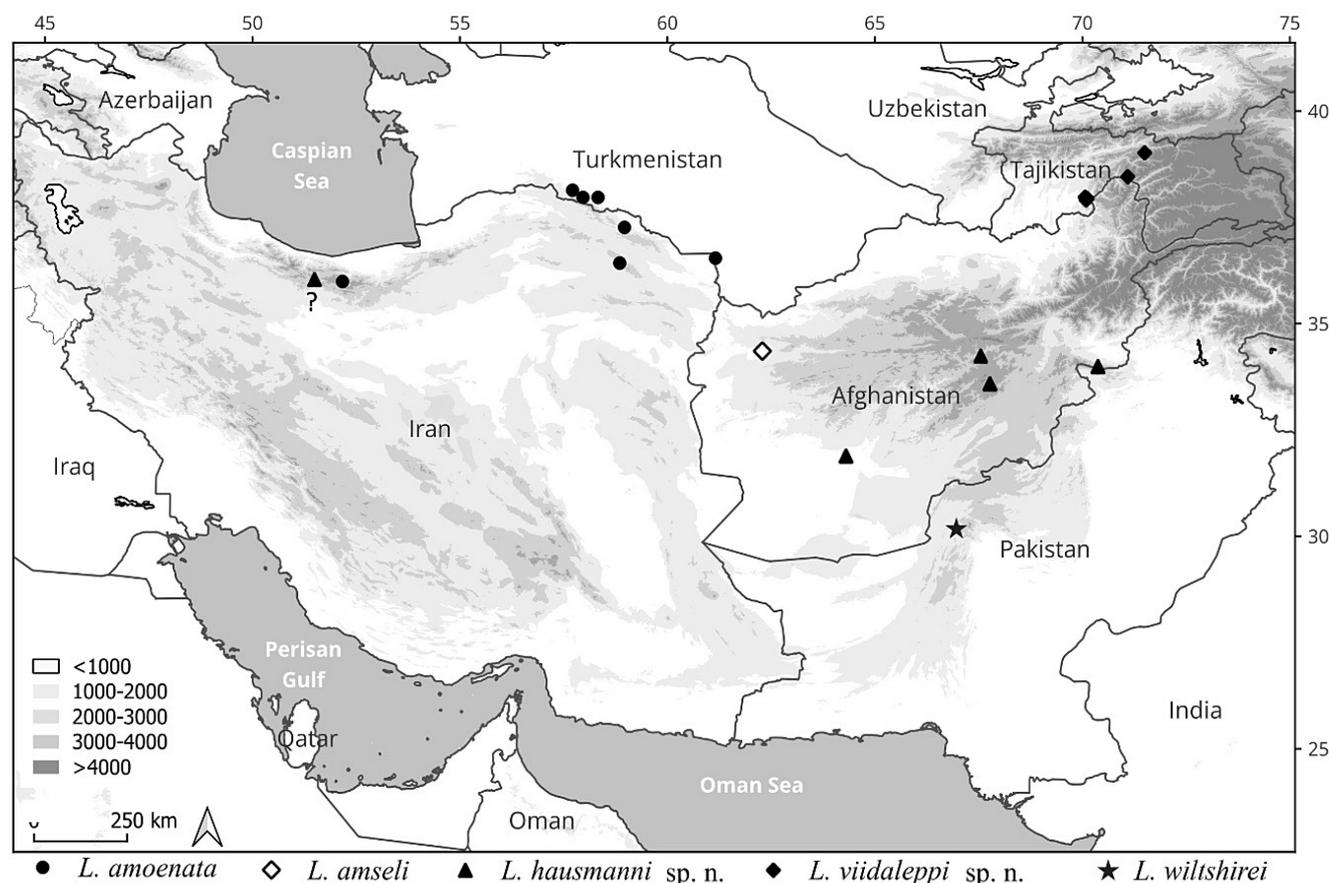


Figure 21. Distribution pattern of five *Lithostege* species in the central Asia.

Saccus very short, broad, rounded. Juxta elongate, its apical part bowl-shaped and wider than basal part. Aedeagus long, subapically curved; large vesica apically covered with very short teeth. Juxta elongate, its apical part bowl shape and wider than basal part. Aedeagus long, subapically curved; vesica largely inflated with very short and broad sack-like diverticulum submedially and extensive field of sparse short teeth distally surrounding narrow tubular vesica ejaculatorius.

Female genitalia (Fig. 19). ovipositor as thick as ductus bursae; posterior apophysis two times longer than anterior apophysis; antrum bowl-shaped, its ventral margin with U-shaped incision; ductus bursae short, tubular; corpus bursae spherical, only one third of its dorsal part covered with loose spicules.

Bionomics. The specimens of this new species were collected between the end of May to early July, at an altitude of 2000–2700 m.

Distribution. *Lithostege viidaleppi* sp. n. is restricted to southern Tajikistan and possibly northeastern Afghanistan (the latter locality needs further confirmation) (Fig. 21).

DISCUSSION

The absence of the holotype specimen of *Lithostege amseli* in previous studies led to a prolonged misunderstanding of the species within the *bosporaria* and *amoenata* species-groups (e.g., Rajaei et al., 2011; László, 2018), as well as the failure to identify several undiscovered species. This study clearly demonstrates the importance of examining type material in taxonomy. Additionally, it emphasizes the need to keep type material well-organized and accessible in reference collections. Digitizing and barcoding the type material is undoubtedly a crucial step in making these significant scientific resources available to other researchers. Additionally, this study underscores once again that the lepidopteran fauna of the Middle East is largely understudied. Landry et al. (2023) estimated that approximately half of the lepidopteran fauna of Iran remains undiscovered. Even though the genus *Lithostege* has been extensively studied and revised (e.g., Rajaei Sh. et al., 2011; Rajaei Sh. & Stüning, 2013; Rajaei et al., 2019; László, 2018), it appears that many species within this genus remain undiscovered. Within the framework of the mega-project “Lepidoptera Iranica”, a few new species of this genus have been discovered in the Middle East in recent years (Rajaei & Karsholt, 2023).

Rajaei et al. (2023b) listed 12 species of this genus from Iran; however, several additional species, whose occurrences have been noted in neighboring countries, may also be discovered in Iran (e.g., *L. excelsata* (Erschov, 1874); *L. distinctata* Christoph, 1887; *L. obliquata* Urbahn, 1971; *L. usgentaria* Christoph, 1885; *L. senata* Christoph, 1887; *L. parva* Stshetkin, 1965; *L. luminosata* Christoph, 1885 and *L. luigi* Viidalepp, 1992). This is likely true for other countries surrounding Iran as well. Filling the data gaps for the winter fauna of Middle Eastern countries may also add several new species to this genus. For example, *L. stadii* Lehmann, 2011 was recently discovered during the cold season in Iran (Lehmann, 2011).

AUTHOR'S CONTRIBUTION

The authors confirm their contribution in the paper as follows: H. Rajaei: dissected and photographed most specimens, prepared the plates, wrote the initial draft of the manuscript, and corresponded with the journal editor. I. Kostjuk: dissected and photographed several specimens and contributed to the preparation of the manuscript. Both authors have read and approved the final version of the manuscript.

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AVAILABILITY OF DATA AND MATERIAL

The specimens referenced in this study are deposited in the museums and collections detailed in the "Material and Methods" section and can be accessed upon request through the curators.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study only included plants and arthropod material, and all required ethical guidelines for the treatment and use of animals were strictly adhered to in accordance with international, national, and institutional regulations. No human participants were involved in any studies conducted by the authors for this article.

CONSENT FOR PUBLICATION

Not applicable.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interest regarding the publication of this paper.

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مطالعه تاکسونومیک جنس *Lithostege* Hübner, 1825 (Lepidoptera, Geometridae)، معرفی *Lithostege* *amseli* Wiltshire, 1967 به عنوان گونه معتبر، و توصیف دو گونه‌ی جدید از آسیای میانه

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چکیده: مطالعات اخیر بر روی جنس *Lithostege* Hübner, 1825 وضعیت تاکسونومیک گونه‌ی *Lithostege amseli* Wiltshire, 1967 را مورد سؤال قرار داده‌اند. بررسی نمونه هولوتیپ این گونه که اخیراً کشف شده، وضعیت این گونه را به عنوان گونه‌ای معتبر تأیید می‌کند. بر این اساس، اکنون درک روشن‌تری نیز از گونه *Lithostege amoenata* Christoph, 1885 داریم. این گونه نیز قبلاً به درستی شناسایی نشده بود. در ادامه‌ی این مقاله، دو گونه جدید از جنس *Lithostege* از افغانستان و تاجیکستان توصیف می‌شوند (*Lithostege viidaleppi* sp. n. و *Lithostege hausmanni* sp. n.). الگوی بال و ساختار دستگاه تناسلی تمامی گونه‌های مورد بحث در این مقاله، مصور شده و صفات تشخیصی آن‌ها مورد بررسی قرار گرفته است.

واژگان کلیدی: افغانستان، Chesiadini، ایران، تاجیکستان