



New geometrid moths from Iraqi Kurdistan (Lepidoptera, Geometridae: Sterrhinae, Larentiinae)

FARHAD A. KHUDHUR^{1,2} & AXEL HAUSMANN³

¹Department of Forest Ecology, Faculty of Forestry and Wood Technology, University of Mendel, Brno, Czechia.

²Department of Biology, College of Science, University of Sulaimani, Sulaymaniyah, Kurdistan Region, Iraq.

✉ farhad.khudhur@univsul.edu.iq; <https://orcid.org/0000-0001-5267-6334>

³SNSB—Zoologische Staatssammlung München Münchhausenstr. 21D-81247 Munich, Germany.

✉ hausmann.a@snsb.de; <https://orcid.org/0000-0002-0358-9928>

Abstract

A large number of geometrid moths was collected by the first author in Iraqi Kurdistan including several undescribed species and subspecies. In this paper we describe three new geometrid taxa: *Idaea medianocturna walaila* **ssp. nov.**, *Lulavia mahwii* **sp. nov.** and *Protorhoe drechseli nebuloides* **ssp. nov.** We present differential diagnoses and images of adult moths and genitalia.

Key words: *Idaea*, *Lulavia*, *Protorhoe*, fauna

Introduction

Iraqi Kurdistan with its topographical variability hosts a rich and variable Lepidopteran fauna and the area deserves wide-ranging surveys extending from its lowlands, plains and semi-deserts, to the foothills and mountainous regions (Khudhur 2022). The primary focus of the doctoral study project undertaken by the first author of this article is to survey and compare the insect fauna in various forest fragments, using Macro-Lepidoptera (Geometridae and Noctuidae) as a model organism. The discovery of new taxa is one of the anticipated outcomes of this project.

In the framework of this study, we detected several specimens of an undescribed species of the megadiverse genus *Idaea*. Molecular and morphological analysis confirmed this species belongs to the *Idaea nocturna* species group, which was recently revised by Hausmann (2020). The pronounced sexual dimorphism, with very dark males and much paler females, further confirmed the affinity of this species to this species group. In this article, we describe the new species and include it in the integrative taxonomic analysis of the entire species group.

Furthermore, interesting specimens of the genus *Lulavia* were investigated which was regarded as monotypic, so far. *Lulavia multipunctata* (Staudinger 1898) was recently presented as parts of the fauna of Jordan (Hausmann 1991), Israel (Hausmann *et al.* 2020) and south-western Iran (Lehmann *et al.* 2009; Rajaei *et al.* 2023). Strongly diverging DNA barcodes of the Kurdish populations suggested them to be different at species rank from *L. multipunctata* and belong to an undescribed species which is described here.

Another larentiine, *Protorhoe drechseli* was recently described by Rajaei *et al.* (2017) from south-eastern Turkey. Diverging DNA barcodes of the Kurdish populations suggested them to be different at subspecies rank from the nominotypical populations. Wing pattern and genitalia clearly differ from neighboring Iranian populations of *P. tangaba* (Wiltshire 1952).

Material and Methods

Abbreviations

BIN = Barcode Index Number

BOLD = Barcode of Life Data System

COI = mitochondrial cytochrome c oxidase I gene, region near the 5' terminus ('DNA barcode', 658 bp)
RCDS = Research collection of Dirk Stadie (Rossleben), later in SNSB-ZSM
ZSM = SNSB – Bavarian State Collection of Zoology, Munich (Zoologische Staatssammlung München)

Sampling and morphological analysis

Altogether about 100 specimens of the *Idaea nocturna* species group, the species pair *Lulavia multipunctata* / *L. mahwii* and *Protorhoe drechseli* were examined at the ZSM. Dissection and preparation of genitalia slides were performed applying standard protocols (cf. Robinson 1976), the genitalia are embedded in Euparal. Measurements were done with a reticule in a Wild M3Z microscope.

DNA Analysis

DNA sequencing was performed at the 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' terminus 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. All sequences are deposited also in GenBank according to the iBOL data release policy. Complete specimen data including images, voucher deposition, GenBank accession numbers, GPS coordinates, sequence and trace files can be accessed in the Barcode of Life Data System (Ratnasingham & Hebert 2007; Ratnasingham 2017) in the public datasets DS-NOCTURNA (doi: <https://dx.doi.org/10.5883/DS-NOCTURNA>) and DS-GEOMIRAQ (doi: <https://dx.doi.org/10.5883/DS-GEOMIRAQ>).

Data Analysis

Sequence divergences for the barcode region were calculated using the Kimura 2 Parameter model, employing the analytical tools on BOLD. Genetic distances between species are reported as minimum pairwise distances. Species delimitation was investigated using the BIN (barcode index number) system as implemented on BOLD (Ratnasingham & Hebert 2013).

Results

Systematic account

Sterrhinae

***Idaea nocturna* species group**

Diagnostic characters : Adults with dark ground coloration (especially in males) and diffuse wing pattern. Frons flat, brown. Male antennae with dentate or bipectinate flagellum. Male hindtibia without pencil, tarsus shortened, tarsomeres appearing as fused. Male genitalia with broad uncus and one stout cornutus in the aedeagus. Female genitalia with long ductus bursae, corpus bursae with spinules ('lamina dentata') and appendix bursae (cf. Hausmann 2020).

Genetic data (Fig. 1): In an analysis of the COI gene of all *Idaea* species worldwide, the *nocturna* species group belongs to a common cluster in a separate position to other representatives of *Idaea* (Hausmann 2020).

Idaea nocturna (Staudinger 1892) is distributed in the adjacent territories of the "Ferghana basin": easternmost Uzbekistan (locus typicus), central and south-western Kyrgyzstan, possibly also Tadzhikistan.

Its sister species *Idaea zoferata* Kaila & Viidalepp, 1996 occurs at the northern edge of the Tian Shan mountain chain: northernmost Uzbekistan, northernmost Kyrgyzstan, south-eastern Kazakhstan (locus typicus). *Idaea beata* Hausmann, 2020 is, so far, only known from northern Israel (locus typicus), *Idaea millesima* Hausmann & Prochazka, 2020 only from Greece, southern Peloponnese peninsula (locus typicus).

Idaea medianocturna Hausmann, 2020 is distributed in south-eastern Turkey (locus typicus).

Further information on the morphology and genetic data of all members of this species-group see Hausmann (2020).

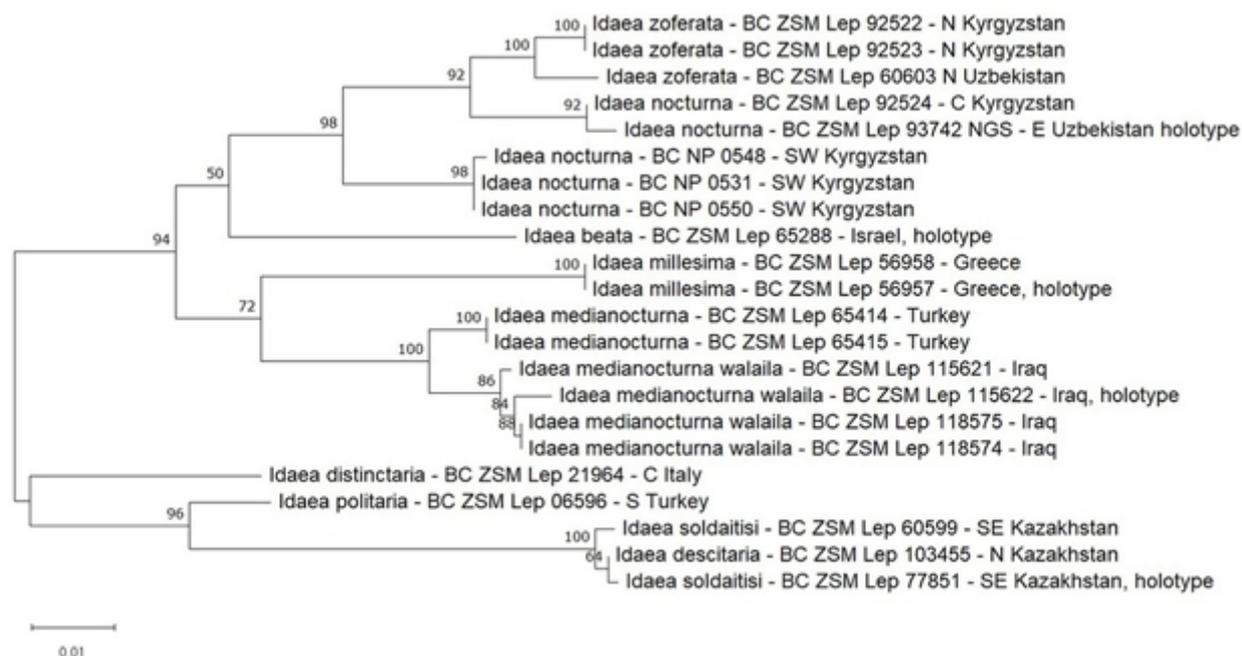


FIGURE 1. Maximum Likelihood Tree generated from COI barcode sequences for representatives of the *Idaea nocturna* species group s.l. and two outgroup species (*Idaea distinctaria* Boisduval, 1840; *I. politaria* (Hübner, 1799)); sequence lengths considered from 500bp to 658bp but holotypes of *Idaea nocturna* (Staudinger 1892) (277bp) and *I. soldaitisi* Herbulot, 1994 (164bp) with shorter sequences; 50 bootstrap replications, Tamura-Nei model, uniform rates, built with MEGA11 software (Tamura *et al.* 2013; scale bar = 1 %); original data see <https://dx.doi.org/10.5883/DS-NOCTURNA>.

Idaea medianoctrurna walaila Khudhur & Hausmann, ssp. nov.

Figs 4, 5

Type locality and repository: Iraq, Kurdistan, Sulaymaniyah, Zoologische Staatssammlung München (ZSM).

Type material: Holotype: Male, Iraq, Kurdistan Region, Sulaymaniyah, Dukan, Gechina, 13.IV.2022, leg. Farhad A. Khudhur, (gen.prp. ZSM G 22562; DNA barcode: BC_ZSM_Lep_115622). **Paratypes:** All Iraq, Kurdistan Region, Sulaymaniyah, leg. Farhad A. Khudhur, coll. ZSM: 2 males, Sharbazher, Gmo Mt, Hazarkanian, #6e, 35°54'44" N, 45°33'42" E, 3.VI.2023 (DNA barcode: BC_ZSM_Lep_118573). 1 female, Qara Dagh, Sagma Mt, 3.25km NW Jafaran vill., #3f, 35°18'37" N, 45°17'37" E, 19.V.2023. 2 females, Dukan, Zewe vill., Piramagroon Mt. #5a, 35°45'36" N, 45°14'24" E, 25.V.2023. - 1 female, Dukan, Zewe vill., Piramagroon Mt. #5a, 35°45'36" N, 45°14'24" E, 25.V.2023 (gen.prp. ZSM G 22563; DNA barcode: BC_ZSM_Lep_118574). - 1 female, id., #5b (DNA barcode: BC_ZSM_Lep_118575). 3 females, Gapilon, Maloma vill., 1.V.2022 (DNA barcode: BC_ZSM_Lep_118724). 1 female, Dukan, Zarzi vill., 13.IV.2022 (DNA barcode: BC_ZSM_Lep_115621).

Description. Adult, male (Fig. 4): Wingspan 14.5–16.5 mm. Ground colour of the wings is blackish brown. Wing pattern almost invisible, fringe blackish. Frons black brown, vertex paler grey brown. Palpi bushy, length 0.4–0.6 mm, i.e. 0.9–1.1 times diameter of eye. Antennae with dentate flagellum, shortly bipectinate with paired, ciliate, sub-triangular branches on each antennomere, length of branches 1.0–1.5 times width of flagellum. Hindtibia slender, length 1.0–1.2 mm, hindtarsus fused, length 0.5–0.6 mm, i.e. tarsus half length of tibia.

Female (Fig. 5): Wingspan 15.5–18.5 mm. Sexual dimorphic, females much paler than males, grey with a beige tinge. Transverse lines better marked than in male, but vague. Terminal line of all wings is fine, blackish, fringe pale beige, with small blackish fringe dots. Length of palpi 1.2 times diameter of eye.

Male genitalia (Fig. 8): Uncus truncate at tip. Saccus short, broad. Valva long, narrowing to tip, at tip narrowly and shortly bilobous. Length of aedeagus 1.2 mm, of cornutus 1.0 mm (0.8 times length of aedeagus), cornutus narrow.

Female genitalia (Fig. 11): Antrum truncate. Ductus bursae longitudinally furrowed, length 1.2 mm, ductus seminalis arising from junction with corpus bursae. Minute spinules in the lateral part of corpus bursae, covering 3/4 of length.

Differential diagnosis: Slightly smaller than nominotypical *Idaea medianoctrurna*, wing coloration of males darker, pectination of male antennae slightly longer. Male genitalia of nominotypical *Idaea medianoctrurna* with tip of valva shortly bifurcate with dorsal projection longer than the ventral one. Female genitalia of nominotypical *Idaea medianoctrurna* with much less spinules, covering approx. 1/3 of corpus bursae.

Genetic data (Fig. 1): BIN: BOLD:AEU7115. Diverging from nominotypical *Idaea medianoctrurna* by 1.68–2.15%.

Distribution: Only known from Iraq, not listed for the fauna of Iraq (Wiltshire 1957), nor for the adjacent provinces of Iran (Rajaei *et al.* 2023).

Etymology: The name alludes to the names of the closely allied taxa (*Idaea nocturna*, *I. medianoctrurna*, *I. millesima*), their Latin names meaning „nightly“, „mid-nightly“ and „the 1000th“, thus all three in a certain way referring to the Middle Eastern tales of 1001 nights (“Alf Laila Wa-Laila“ in Arabic language), wa-laila meaning “and one night” or “one more night”.

Larentiinae

Lulavia mahwii Khudhur & Hausmann, sp. nov.

<http://zoobank.org/urn:lsid:zoobank.org:pub:0CC7C28F-10D5-44E8-B964-4D135570255E>

Figs 6

Type locality and repository: Iraq, Kurdistan, Sulaymaniyah, Zoologische Staatssammlung München (ZSM).

Type material: Holotype: Male, Iraq, Kurdistan Region, Sulaymaniyah, Dukan, Chamy Razan Valley, 4.II.2022, leg. Farhad A. Khudhur, coll. ZSM (genitalia slide Nr. ZSM G 22561, Barcode sample ID: BC_ZSM_Lep_115624).

Paratypes: All Iraq, Kurdistan Region, Sulaymaniyah, leg. Farhad A. Khudhur, coll. ZSM: 8 males, Sangaw, Zhallay, Darband vill., #2d, 35°26′01″N 45°07′28″E, 16.I.2023. - 6 males, id., #2a, 35°25′45″N 45°06′39″E. - 1 male, id., #2c, 35°25′18″N 45°05′18″E. - 1 male, id., #2b, 35°25′31″N 45°06′34″E. - 2 males, id., #2b, 35°26′05″N 45°08′05″E. - 1 male, Garmyan, Maydan, Horen vill. #1e, 34°53′21″N 45°40′18″E, 28.I.2023. - 7 males, Bakrajo, Hazar Merd, Dekon vill., 35°29′52″N 45°18′57″E, 02.II.2023.

Description: Adult, male (Fig. 6): Wingspan 22.5–27 mm. Ground colour of forewing dark sand-coloured, distad of medial area two zig zagging postmedial fasciae, the inner one pale, the distal one darker, on veins some dark grey spots, forewing costa dark grey; forewing termen with elongate terminal streaks. Hindwing is much paler, almost without pattern. Frenulum developed as a stout bristle. Frons bulbed, brown with some beige scales. Palpi dark brown, length 0.6–0.7 mm, i.e. 1.0–1.1 times diameter of eye. Proboscis developed. Antennae ciliate-fasciculate, length of cilia 2.5–3 times width of flagellum. Spur formula of legs 0-2-4, foretibia short with short pencil on the inner side, first tarsomere of foreleg elongate.

Female: Unknown. For the potentially related populations of the Iran see remarks.

Male genitalia (Fig. 9): Uncus long, narrow, rounded at tip. Saccus broad, sub-rectangular. Valva broad, rounded at tip. Juxta developed as broad sclerite with two small patches of setae, posteriorly with paired sclerotized, truncate projections. Transtilla with paired sclerites both bearing a very short setose lobe (‘labides’) and a short spine towards the centre. Length of aedeagus 1.1 mm, of cornutus (bundle of microspinules) 0.5 mm (i.e. ca half length of aedeagus).

Differential diagnosis: In wing coloration and pattern no significant difference from Israeli *Lulavia multipunctata* (Staudinger, 1898). Male genitalia are very similar to those of *L. multipunctata*, but transtilla sclerites of the latter rounded towards the centre, less projecting, cornutus (bundle of microspinules) shorter: 0.3–0.4 mm.

Genetic data (Fig. 2): BIN: BOLD:AAJ2041. One barcoded specimen (BC_ZSM_Lep_115624) from Iraq diverging by 4.40% from barcoded specimens of *Lulavia multipunctata* from Israel (BIN: BOLD:AAJ2041; n=2). Distance from one southern Iranian (province Fars) specimen 3.59% (BIN: BOLD:AAX5919), the latter (coll. RCDS) requiring further study.

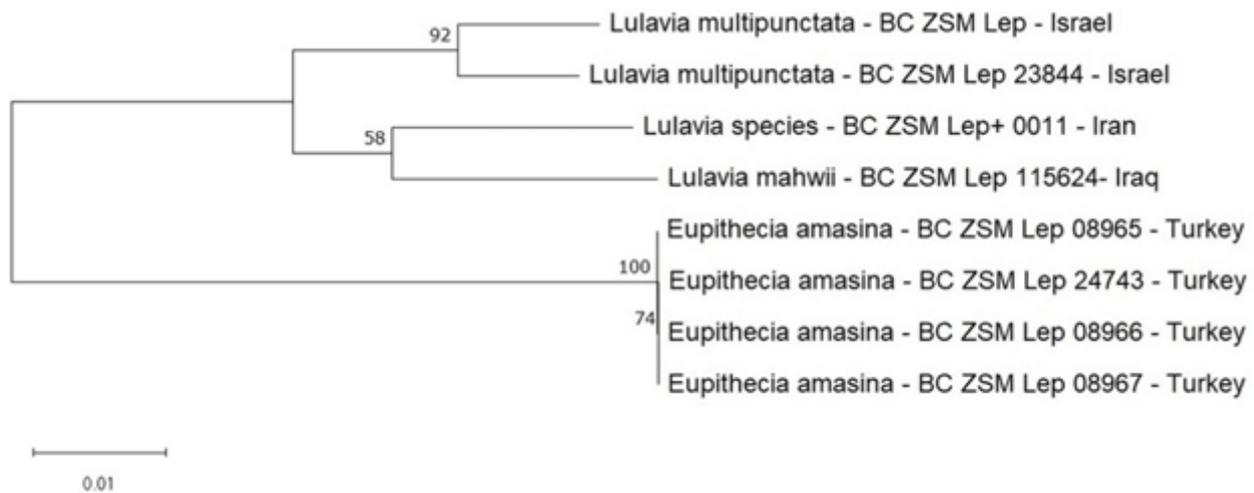


FIGURE 2. Maximum Likelihood Tree generated from COI barcode sequences for representatives of the genus *Lulavia* and the nearest neighbor from its closest (though probably unrelated) Palaeartic genus as outgroup species (*Eupithecia amasina* Bohatsch, 1893); sequence lengths considered from 500bp to 658bp; 50 bootstrap replications, Tamura-Nei model, uniform rates, built with MEGA11 software (Tamura *et al.* 2013; scale bar = 1 %); original data see <https://dx.doi.org/10.5883/DS-GEOMIRAQ>.

Distribution: Only known from Iraq, not listed for the fauna of Iraq (Wiltshire 1957), nor for the adjacent provinces of Iran (Rajaei *et al.* 2023). Populations from the more southern provinces Bushehr, Fars and Hormozgan (Lehmann *et al.* (2009) are recorded under the name *Lulavia multipunctata* (Staudinger, 1898) requiring further integrative taxonomic analysis to investigate potential conspicuity (see under genetic data).

Etymology: The species is named after Mahwi who was one of the most prominent classical Kurdish poet and Sufis from Kurdistan. Mahwi was always using “Parwana – in Kurdish” meaning “Moth” as moth and flame metaphor in his poems.

Remarks: Wingspan of females from the doubtfully conspecific Iranian populations (see above) slightly more than half of the male wingspan (Lehmann *et al.* 2009).

Protorhoe drechseli nebuloides Khudhur & Hausmann, ssp. nov.

Fig. 7

Type locality and repository: Iraq, Kurdistan, Sulaymaniyah, Zoologische Staatssammlung München (ZSM).

Type material: Holotype: Male, Iraq, Kurdistan Region, Sulaymaniyah, Dukan, Zewe vill., Pirmagroom Mt., #3e; 35°46'49"N 45°22'28"E, 9.IV.2023, leg. Farhad A. Khudhur, (genitalia slide nr. ZSM G 22571, Barcode sample ID: BC_ZSM_Lep_118589). **Paratype:** 1 male, same data as holotype (ZSM).

Description: Adult, male (Fig. 7): Wingspan 25–25.5 mm. Ground colour of wings sand-coloured, hindwing slightly paler than forewing. Forewing with basal area, medial and postmedial fascia brown, thinly bordered blackish at both sides. suffused by a few brownish scales. Forewing costa with five brown spots. Both wings with diffuse, brown postmedial fasciae. Postmedial fascia slightly zigzagging. Areas between fascia and terminal area much paler, unicolorous, just the terminal area with a vague, paler, zigzagging subterminal line. Forewing discal spot absent. Hindwing almost without any pattern. Frenulum developed as a single stout bristle. Frons slightly convex, brown, with a few beige scales. Proboscis well developed. Palpi bushy, grey-brown, length 0.55 mm, i.e. 0.9 times diameter of eye. Antennae very shortly ciliate-setose, setae ca 1/4 width of flagellum. Hindtibia narrow, with four spurs.

Female unknown.

Male genitalia (Fig. 10): Uncus long and narrow, sub-apically dilated. Juxta with two short posterior projections. Valva comparatively broad, costa sclerotized, apically tapered. Length of aedeagus 1.05 mm, without cornutus, vesica granulose at tip.

Differential diagnosis: In wing coloration and pattern similar to that of the nominotypical subspecies, but with paler ground colour and less dark suffusion. Clearly differing from Iranian *P. tangaba* (Wiltshire, 1952), ground colour of the latter much darker, forewing discal spots better marked, terminal area and the area between basal and medial fascia with many dark scales. In male genitalia similar to those of nominotypical *P. drechseli*, but valva broader, costa of valva much more tapered at tip.

Genetic data (Fig. 3): BIN: BOLD:AAF1595. New DNA barcode for BOLD (sample ID: BC_ZSM_Lep_118589), diverging by 2.50% from the nominotypical populations of Turkish *P. drechseli* (Rajaei, Stadie & Hausmann 2017) with BIN: BOLD:AAF1588; diverging by 4.12% from the Iranian *P. tangaba* (Wiltshire, 1952) with BIN: BOLD:AAF1594.

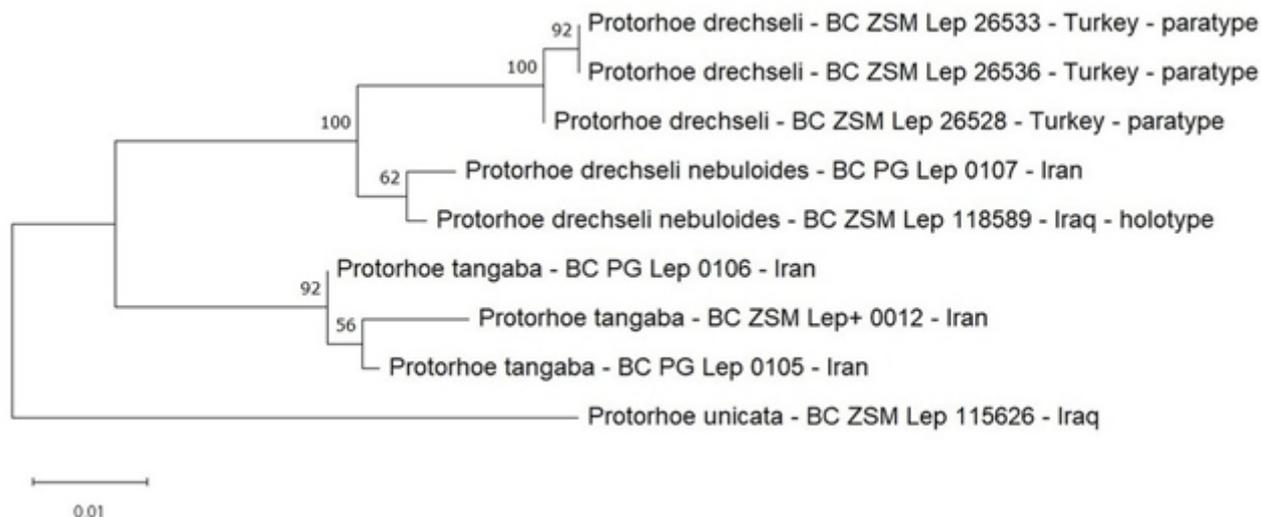
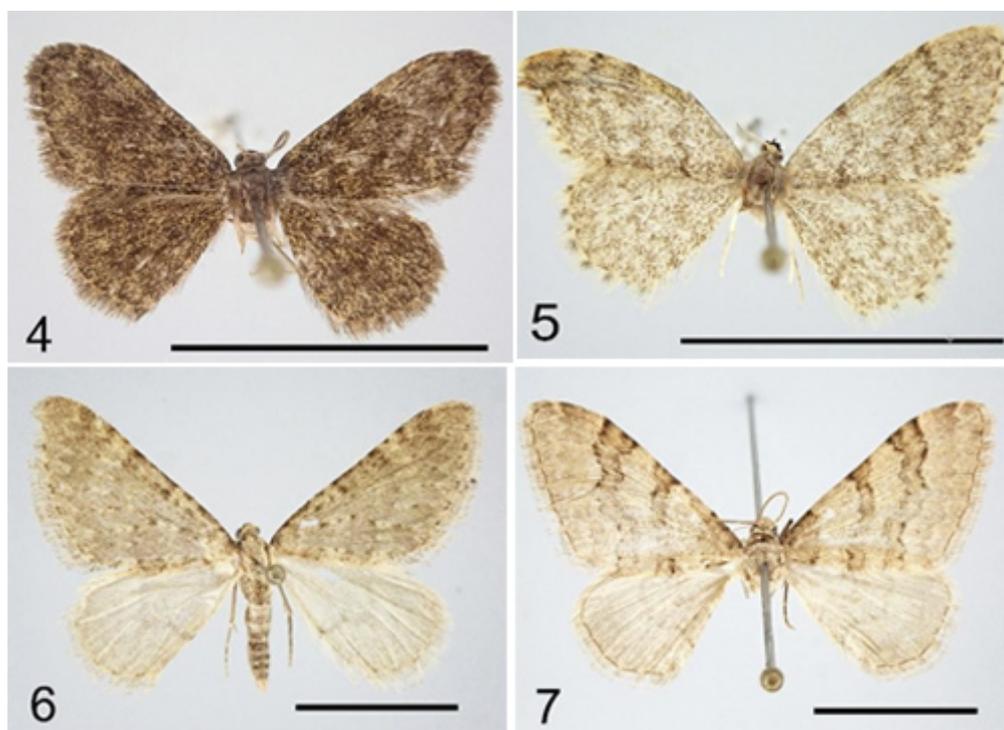
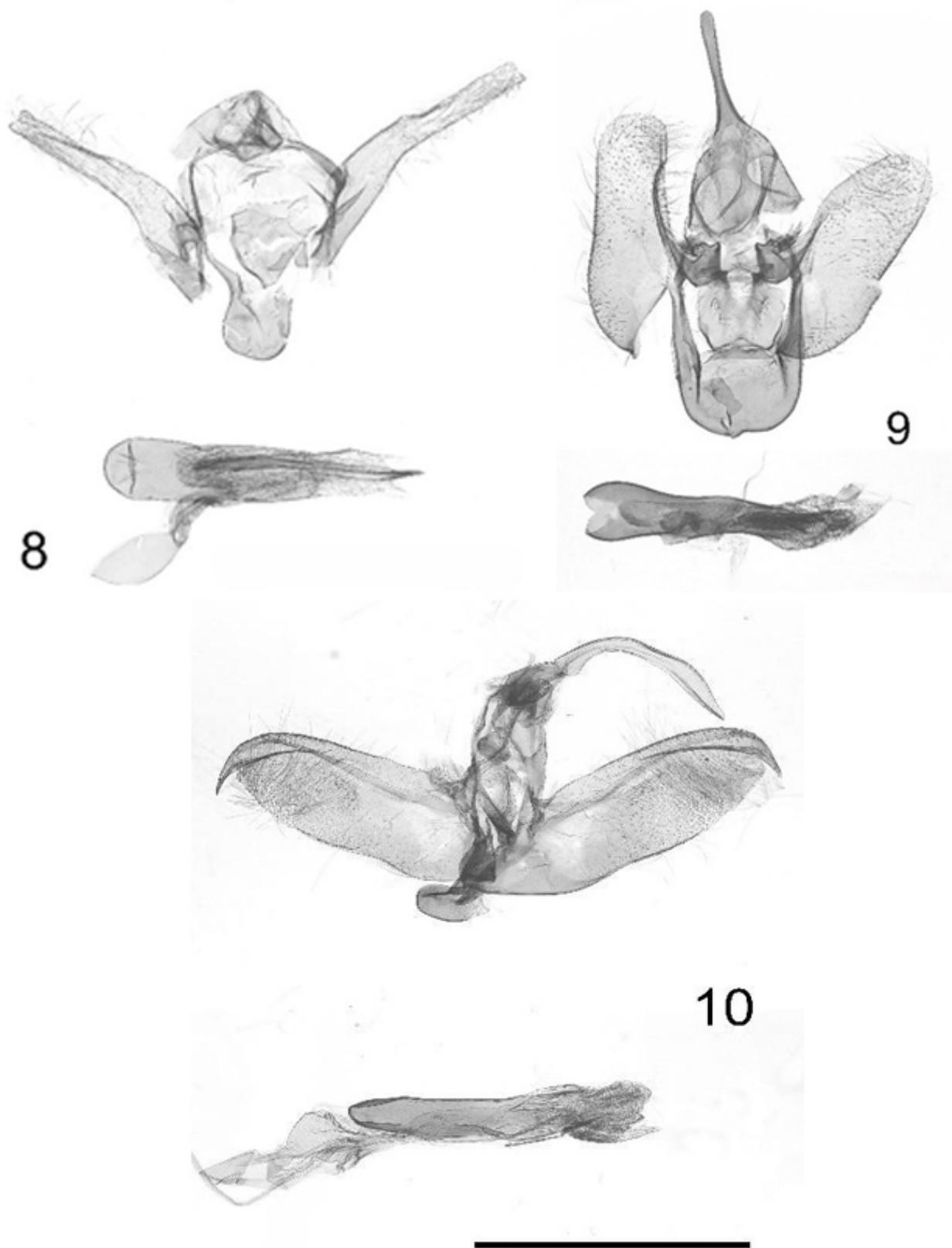


FIGURE 3. Maximum Likelihood Tree generated from COI barcode sequences for allied representatives of the genus *Protorhoe*; sequence lengths considered from 500bp to 658bp; 50 bootstrap replications, Tamura-Nei model, uniform rates, built with MEGA11 software (Tamura *et al.* 2013; scale bar = 1 %); original data see <https://dx.doi.org/10.5883/DS-GEOMIRAQ>.



FIGURES 4–5. *Idaea medianocturna walaila* ssp. nov., holotype, male and paratype female. Fig. 6: *Lulavia mahwii* sp. nov., paratype, male. Fig. 7: *Protorhoe drechseli nebuloides* ssp. nov., holotype, male. Scale bar = 10 mm.



FIGURES 8–10. Male genitalia: Fig. 8: *Idaea medianoctrurna walaila* **ssp. nov.**, holotype. Fig. 9: *Lulavia mahwii* **sp. nov.**, holotype. Fig. 10: *Protorhoe drechseli nebuloides* **ssp. nov.**, holotype. Scale bar = 1 mm.



FIGURE 11. Female genitalia: *Idaea medianoctrurna walaila* **sp. nov.**, paratype. Scale bar = 1 mm.

Distribution: Not listed in Wiltshire (1957), new for Iraq. One barcoded specimen from adjacent province in Iran diverging by 0.61% (see Fig. 3) and well corresponding in external appearance. The Iranian specimen was misidentified (tentative, preliminary identification) as “*P. turkmenaria*” in Rajaei *et al.* (2017: Fig. 41).

Etymology: The name alludes to the external similarity with the larentiine genus *Nebula*.

Discussion

Based on these interesting findings of this paper, plains and forests of Iraqi Kurdistan might be considered as attractive biodiversity spots for investigation of different taxa of Lepidoptera. Biogeographically, the region is the median southernmost of Irano-Tauranian region which southerly and westerly has a direct transition from mountainous-foothill topography to the Mesopotamian shrub desert, and this situation makes it as a semi-isolated biogeographical spot for hosting taxa that characterized by variable range of divergence in DNA barcodes . The region with its diversity in ecosystems and topography, giving chances for potential discoveries of lepidoptera species groups for future works, especially this trend is enhanced by poor and scarce investigation attempts during past decades due to instability and political conflicts and scarcity of specimens and museum deposited materials from this region.

Acknowledgements

Our gratitude to Dr. Vladimir Hula, the supervisor of the first author's doctoral study from Mendel University, Brno, Czechia for his valuable scientific and practical advice for light trap preparation. We appreciate the support and facilities of the department of Forest Ecology in the Faculty of Forestry and Wood Technology, Mendel University, Brno, Czechia. Our gratitude to Dr. Karzan G. Khudhur from University of Sulaimani, Sulaymaniyah Iraq and Ing. Dr. Kristína Dziváková, from Mendel University, Brno, Czechia, for their support and facilitation in sending and transporting the specimens from Iraq to the deposit destination. We are very grateful to the staff at the Canadian Centre for DNA Barcoding for sequence analysis. Paul D.N. Hebert and many other colleagues of the Barcode of Life project (Biodiversity Institute of Ontario, Guelph, Canada) contributed to the success of this study. The data management & analysis system BOLD was provided by Sujeevan Ratnasingham (BIO, Guelph).

References

- deWaard, J.R., Ivanova, N.V., Hajibabaei, M. & Hebert, P.D.N. (2008) Assembling DNA barcodes: analytical protocols. *In: Martin C (Ed.), Methods in molecular biology: environmental genetics*. Humana Press, Totowa, N.J., pp. 275–293.
https://doi.org/10.1007/978-1-59745-548-0_15
- Hausmann, A. (2020) Revision of the West Palaearctic *Idaea nocturna* species group (Lepidoptera, Geometridae, Sterrhinae). *Mitteilungen der Münchner Entomologischen Gesellschaft*, 110, 71–80.
- Hausmann, A., Müller, G.C. & Kravchenko, V.D. (2020) Vol. 3, Geometridae. *In: Müller, G.C., Kravchenko, V.D., Hausmann, A., Speidel, W., Mooser, J.† & T.J. Witt † (Eds.), The Lepidoptera of Israel. Proceedings of the Museum Witt München*, 9, 1–256.
- Hebert, P.D.N., Cywinska, A., Ball, S.L. & deWaard, J.R. (2003) *Biological identifications through DNA barcodes. Proceedings of Royal Society of London B*, 270, 313–321.
<https://doi.org/10.1098/rspb.2002.2218>
- Ivanova, N.V., deWaard, J.R. & Hebert, P.D.N. (2006) An inexpensive, automation-friendly protocol for recovering high-quality DNA. *Molecular Ecology Notes*, 6, 998–1002.
<https://doi.org/10.1111/j.1471-8286.2006.01428.x>
- Kaila, L. & Viidalepp, J. (1996) *Idaea zoferata*. *In: Kaila, L., Viidalepp, J., Mikkola, K. & Mironov, V. (Eds), 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.
- Kemal, M. & Koçak, A.Ö. (2016) On the Geometridae fauna of Bahçesaray district, together with some morphological and ecofaunistic notes (Van Province, East Turkey) (Lepidoptera). *Priamus*, 14 (2), 76–119.
- Khudhur, F.A. (2022) Faunistic study of butterflies (Lepidoptera, Papilionoidea) of Sulaymaniyah Province, Kurdistan-Iraq. *Biodiversity Data Journal*, 10, e82612.
<https://doi.org/10.3897/BDJ.10.e82612>
- Lehmann, L., Stadie, D. & Zahiri, R. (2009) Zum Winteraspekt der Makrolepidopterenfauna Südirans mit Anmerkungen zur Biologie einiger Arten (Lepidoptera: Bombycoidea, Papilionoidea, Geometroidea, Noctuoidea). *Nachrichten des Entomologischen Vereins Apollo*, 30 (3), 105–119.
- Rajaei, H., Aarvik, L., Arnscheid, W.R., Baldizzone, G., Bartsch, D., Bengtsson, B. Å., Bidzilya, O., Buchner, P., Buchsbaum, U., Buszko, J., Dubatolov, V.V., Erlacher, S., Esfandiari, M., Freina, J. de, Gaedike, R., Gyulai, P., Hausmann, A., Haxaire, J., Hobern, D., Hofmann, A., Ignatev, N., Kaila, L., Kallies, A., Keil, T., Kiss, Á., Kitching, I. J., Kun, A., László, G. M., Leraut, G., Mally, R., Matov, A., Meineke, J-U., Melichar, T., Mey, W., Mironov, V., Müller, B., Naderi, A., Nässig, W. A., Naumann, S., Nazari, V., Nieuwerkerken, E. J. van, Nuss, M., Pöll, N., Prozorov, A.M., Rabieh, M.M., Rákósy, L., Rindoš, M., Rota, J., Rougerie, R., Schintlmeister, A., Shirvani, A., Sihvonen, P., Simonsen, T. J., Sinev, S. Yu., Skou, P., Sobczyk, T., Sohn, J.-C., Tabell, J., Tarmann, G., Tokár, Z., Trusch, R., Varga, Z., Volynkin, A.V., Wanke, D., Yakovlev, R.V., Zahiri, R., Zehzad, P., Zeller, H.C., Zolotuhin, V.V. & Karsholt, O. (2023) Catalogue of the Lepidoptera of Iran. *In: Rajaei, H. & Karsholt, O. (Eds.), Lepidoptera Iranica. Integrative Systematics*, 6 (Special Issue), 121–459.
<https://doi.org/10.18476/2023.997558.7>
- Rajaei, H., Hausmann, A., Scoble, M., Wanke, D., Plotkin, D., Brehm, G., Murillo-Ramos, L. & P. Sihvonen (2022) An online taxonomic facility of Geometridae (Lepidoptera), with an overview of global species richness and systematics. *Integrative Systematics: Stuttgart Contributions to Natural History*, 5 (2), 145–192. (23 December 2022)
<https://doi.org/10.18476/2022.577933>
- Rajaei, H., Stadie, D. & Hausmann, A. (2017) Taxonomic revision of the genus *Protorhoe* Herbulot, 1951 (Lepidoptera, Geometridae, Larentiinae), new taxonomic changes and description of two new species. *Zootaxa*, 4282 (2), 269–291.
<https://doi.org/10.11646/zootaxa.4282.2.3>
- Ratnasingham, S. & Hebert, P.D.N. (2007) BOLD: The Barcode of Life Data System (<http://www.barcodinglife.org>). *Molecular Ecology Notes*, 7 (3), 355–364.

<https://doi.org/10.1111/j.1471-8286.2007.01678.x>

- Ratnasingham, S. & Hebert, P.D.N. (2013) A DNA-based registry for all animal species: The Barcode Index Number (BIN) System. *PLOS ONE*, 8 (8), e66213.
<https://doi.org/10.1371/journal.pone.0066213>
- Ratnasingham, S. (2017) BOLD Barcode of Life Data System. –<http://www.boldsystems.org/views/login.php>. Accessed 2017 Jun 02
- Robinson, G.S. (1976) The preparation of slides of Lepidoptera genitalia with special reference to the Microlepidoptera. *Entomologist's Gazette*, 27, 127–132.
- Staudinger, O. (1892) Neue Arten und Varietäten von Paläarktischen Geometriden. *Iris*, 5, 141–260.
- Stshetkin, Y.L. (1956) Two new geometrid moths from Central Asia [in Russian]. *Nauk Tadjik Soviet Socialist Republic*, 14, 161–169.
- Tamura, K., Stecher, G., Peterson, D., Filipski, A. & Kumar, S. (2013) MEGA6: Molecular Evolutionary Genetics Analysis Version 6.0. *Molecular Biology and Evolution*, 30, 2725–2729.
<https://doi.org/10.1093/molbev/mst197>
- Ucak, H. & Kemal, M. (2023) Studies on the Ennominae Fauna and Taxonomy of the Dađlýca (Geometridae, Lepidoptera). *Bitlis Eren University Journal of Science*, 12 (3), 894–910.
<https://doi.org/10.17798/bitlisfen.1334583>
- Wiltshire, E.P. (1952) Middle East Lepidoptera X: More new species and forms from Persia (Iran) and Syria. *Bulletin de la Société Fouad Ier d'Entomologie*, 36, 187–210.
- Wiltshire, E.P. (1957) *The Lepidoptera of Iraq*. Nicholas Kaye Ltd, London & Baghdad, 162 pp.