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Description of a new Middle Eastern *Lemonia* species, comments on the *Lemonia philopalus* complex and *Lemonia syriensis* (Lepidoptera: Brahmaeidae: Lemoniinae)

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Abstract

The Algerian-Tunisian *Lemonia philopalus* (Donzel, 1842) is reviewed and redescribed. The status of the Moroccan population named *Lemonia philopalus rungsi* Rougeot 1971 (type locality: Morocco, Merchouch) is revised, it is taken from the synonymy to the Iberian population and left as a subspecies of *L. philopalus* until the genetic relationship

between the Moroccan and the Algerian-Tunisian populations is studied. The Iberian population is raised to a specific level as *Lemonia vazquezi* Oberthür, 1916 **bona sp.** (type locality: Spain, Madrid, Rivas-Vaciamadrid), it has a 2.13% genetic distance from the Moroccan *L. philopalus rungsi*. A lectotype for *L. vazquezi* is designated from the Natural History Museum (London, UK). The new Middle Eastern *Lemonia levantina* sp. n. is described (type locality: Jordan, Rift Valley, 40 km N of Aqaba, sands NW Rahma). The new species is externally similar to *L. philopalus*, *L. philopalus rungsi*, and *L. vazquezi* but has a 4.86% genetic distance from the Moroccan population and 5.55% from the Iberian one. The Levantine species is compared with *Lemonia syriensis* Daniel, 1953 because the two are sympatric and show external similarities. The ecology, phenology, and distribution of the species are discussed.

Key words: barcoding, new species, North Africa, Palaearctic realm, revised status, Israel, Jordan, Egypt, Levant, Western Asia.

Introduction

This paper is reporting new findings in the genus *Lemonia* Hübner, 1820 belonging to the Brahmaeidae family (Zwick, 2008; Regier *et al.*, 2009; Zwick *et al.*, 2011; Regier *et al.*, 2013; Kitching *et al.*, 2018; Hamilton *et al.*, 2019). Earlier it was suggested (Prozorov *et al.*, 2022) that the widespread *Lemonia* species, like *Lemonia dumi* (Linnaeus, 1761) and *Lemonia taraxaci* (Denis & Schiffermüller, 1755), form isolated populations with their gene pool. These populations may be considered as species regardless of their high plasticity and lack of stable differentiating morphologic characters.

Lemonia philopalus (Donzel, 1842) was also considered to be a very local but widespread species. Most records are from Spain and Portugal (Marabuto, 2003; Marabuto, 2018), while in the Maghreb, from Morocco to Tunisia, it is becoming increasingly rarer (Donzel, 1842; Oberthür, 1916; Rougeot, 1971; de Freina & Witt, 1983; de Freina & Witt, 1987; Chavanon, 1989). For decades there has been little fresh material from North Africa, which made the species very desirable for collectors. The rarity together with external variability made various authors wonder about taxonomic relationships between the Iberian, Moroccan and Algerian-Tunisian populations, whether they are of one widespread species or a few somehow isolated subspecies. The original discovery of the fourth population in Egypt and the Levant, over 1500 km away from Tunisia, raised a question about the status of these populations again. Barcoding of three out of four populations (excluding the nominate one from Algeria, due to lack of fresh material) showed that the Iberian, Moroccan and Levantine populations have genetic distances above 2% but lack stable morphologic characters.

Sympatrically but not syntopically, the Levantine population of *L. philopalus* flies with *Lemonia syriensis* Daniel, 1953. The species originally was described from Turkey, it also occurs across the Levant and spreads southwards to South Egypt. The taxon is included in the review because very little information is known about morphology, variability, and distribution (Antoshin, Zolotuhin, 2013) and because of some external similarities with *L. philopalus*.

Material and methods

Adults were photographed with an Olympus C750UZ, a Nikon D3300 and a Nikon 40 mm f/2.8G. Morphologic preparations were photographed using Fujifilm X-T10 with Motic SMZ-161-TLED. All images were processed in Photoshop CS6 (Adobe, 2012).

Specimens from the following collections were examined:

CGM	collection of Günter Müller (Freising, Germany);
CWB	collection of Werner Bruer (Braunschweig, Germany);
MNHN	Muséum national d'Histoire naturelle (Paris, France);
MVHN	Museu Valencià d'Història Natural (Valencia, Spain);
MWM	Museum Witt Munich (Munich, Germany);
NHML	Natural History Museum (London, UK);
RCUM	Research Collection of University of Murcia (Murcia, Spain);
ZISP	Zoological Institute of Russian Academy of Science (St. Petersburg, Russia);
ZSM	Bavarian State Collection of Zoology (Munich, Germany).

Several specimens were barcoded in Guelph, Ontario, Canada within the following BOLD projects (Ratnasingham, Hebert, 2007, 2013): GWORQ, IBLAO, LBEOW, LBEOA, and SASNC. Project managers generously gave their permission to use the sequences for the present study.

Table 1. Information on barcoded specimens used in phylogenetic analysis, the sequences are publicly available within the dataset DS-LEMOPHIL on BOLD (Ratnasingham & Hebert, 2007, 2013).

Taxon	BOLD Sample ID	Sex	Collection data
<i>L. dumi</i>	LBEOW1000-11	♀	Russia, Omskaya Oblast, Krasnyj Oktjabr, 53.1114 N, 73.2947 E, 22.IX.2010
<i>L. levantina</i>	GWORQ814-10	♂	Israel, Gaza Beit, Hanun, 10–20.XII.2002
	GWORQ818-10	♂	Egypt, S Sinai, St. Catherine, 28.XI.2000
	GWORQ821-10	♂	Saudi Arabia, Rijal, 1–10.II.2002
	GWORQ847-10	♂	Iraq, Jabal Sinjar, XI.2002
<i>L. philopalus rungsi</i>	SASNC135-11	♂	Morocco, Meknes-Tafilalet Region, Central Atlas, Azrou, 33.43473 N, 5.23188 W, 1.V.1990
	GWORQ812-10	♂	Israel, near Sea of Galilee, 15.XII.2003
<i>L. vazquezi</i>	GWORQ836-10	♂	Egypt, Jabul Ghelib, 10–20.XII.2002
	GWORQ873-10	♀	Iraq, Jabal Sinjar, XII.2002
<i>L. vazquezi</i>	IBLAO731-12	♂	Spain, Murcia, Sangonera, 37.9408 N, 1.19967 W, 65 m, 4.XII.2011
	IBLAO732-12	♂	Spain, Murcia, Sangonera, 37.9408 N, 1.19967 W, 65 m, 4.XII.2011

Taxonomy

Lemonia philopalus philopalus (Donzel, 1842)

(Figs 12, 28–32, 58–60, 77–79)

Bombyx philopalus Donzel, 1842, *Annales de la Société entomologique de France*, 11, 198. Type locality: [Algeria, Constantine, 36.357° N, 6.63902° E] “prope Constantinam, Barbaria.” Type specimens unknown.

Diagnosis. Algerian-Tunisian subspecies, it differs from the sympatric yellow *Lemonia vallantini* (Oberthür, 1890) by dark brown coloration with contrasting creamy veins. Externally and morphologically variable, no reliable character was found to distinguish it from *L. philopalus rungsi* and sister species *L. vazquezi* and *L. levantina* sp. n.

Redescription. Male habitus (Figs 28, 30–32). Head and thorax speckled brown and dark brown. Forewing length: 19–30 mm; wingspan: 39–60 mm. Wing somewhat triangular, external margin rounded and smooth, apex obtuse. Background coloration ranges from brown to dark brown with creamy veins. Cilia creamy. Forewing pattern consists of paler elements: weak postmedial line, barely pronounced external field, and discal spot a creamy torus on outer margin of cell. Hindwing follows the same coloration as forewing but without discal spot. Cilia creamy. Abdomen dorsally dark brown with creamy interspace between abdominal segments, ventrally creamy; dorsal stripes may be dull depending on the state of preservation. Femur yellow and tibia creamy, tarsi black and creamy. The tibial spur formula is 0-2-2, epiphysis absent (Fig. 12). Foreleg's basitarsus bears 2 big spurs, second tarsomere bear one spur, distitarsus apically bears a pair of long chaetae. **Male genitalia** (Figs 58–60). Tegumen somewhat triangular in shape, widening basally. Socii membranous, covered with short chaetae. Uncus elongated, apically rounded or pointed, varies in width and length with pronounced isthmus near its base, covered with short chaetae, has a ridge dorsally. Gnathos

short, rounded, spatula-like with uneven surface, narrow subanal plate going from the plate towards the anal opening. Vinculum narrow, band-like. Valvae elongated, rounded, covered with chaetae, ventral lateral margin somewhat convex; sacculus weakly pronounced. Juxta boat-like, apically rounded, widened basally, surrounds aedeagus. Aedeagus elongated, narrow, c-shaped. Vesica small, bag-shaped. The eighth sternum small, somewhat triangular, apically rounded, varies in shape. The eighth tergum trapezoid. **Female habitus** similar to male (Fig. 29), but larger in size, antenna pectination shorter, discal spot less pronounced. Forewing length: 26–30 mm; wingspan: 50–68 mm. **Female genitalia** were not studied.

Variability. The species' coloration varies from light to dark brown (Figs 28 and 31). External line on forewing, and medial line and medial field on hindwing may be pronounced. External field of male's fore and hind wings may get paler, hindwing thus may be completely pale with faded dark medial line (Fig. 32). Male genitalia show variability in uncus and valva shape. Uncus apically more or less "swollen" (Figs 59 and 60), with well or weakly pronounced isthmus (Figs 59 and 58, shown with arrows). Valva may be smooth round or with prominences (Figs 60 and 59).

Distribution (Fig. 77). The subspecies is spread in Algeria and Tunisia. One adult from the collection of Grand Duke Nicholas Mikhailovich of Russia (ZISP; Fig. 27) labeled "Mauritania" with no additional data, it was probably collected either in Morocco or in Algeria.

Taxonomic note. 1. The taxon was mentioned recently as "the most common species of insect fauna associated with the flora at Burullus Lake, Kafr El-Sheikh Governorate" in Egypt (Refaei et al., 2021), but according to pictured life stages, and a worn adult, it was clearly misidentified. The pictured specimen is in fact *Bombycopsis bufo* (Lederer, 1861), Lasiocampidae.

2. We leave *L. philopalus philopalus* and *L. philopalus rungsi* as separate subspecies until *L. philopalus philopalus* is barcoded and their relationship clarified.

Material examined: **Algeria:** ♂, Aïn Séfra, 32.75911° N, 0.57826° W, 1081 m, XII.1895 (MNHN); ♂, Guelt es Stel, 35.16453° N, 3.02691° E, 912 m, 1914, leg. J. Domenech (CGM); 3♂, ♀, Guelt es Stel, 35.16453° N, 3.02691° E, 912 m, 10.X.1913, 15.XI.1913, 22.XI.1913 29.XI.1913, slides Lemon-1, Lemon-2 (MWM/ZSM, ZSM); ♂, Hassi Bahbah, 35.07625° N, 3.02672° E, 880 m (CGM); ♂, Hassi Bahbah, 35.07625° N, 3.02672° E, 880 m, X.1929, leg. Stättermayer (MWM/ZSM). **Tunisia:** ♂, Gabes, 33.88807° N, 10.09752° E, 7 m, 10.XII.1948, leg. Chnéour (MWM/ZSM).

Lemonia philopalus rungsi Rougeot, 1971, stat. rev. (Figs 13, 24–26, 56–57, 77–79)

Lemonia philopalus rungsi Rougeot, 1971, Les Bombycoïdes (Lepidoptera-Bombycoïdea) de l'Europe et du Bassin Méditerranéen 5, 24. Type locality: [Morocco, Merchouch, 33.56131° N, 6.69188° W, 428 m] "Merchouche." Holotype male (MNHN).

Diagnosis. Moroccan subspecies, it has a 2.13% genetic distance from the Iberian *L. vazquezi* and 4.86% from the Levantine-Egyptian *L. levantina* sp. n. (Figs 77–78). Externally and morphologically variable, no reliable character found to distinguish it from other species.

Variability. External line on forewing, and medial line and medial field on hindwing may be pronounced. Valva slightly different in shape.

Distribution (Fig. 77). In Northern and Central Morocco.

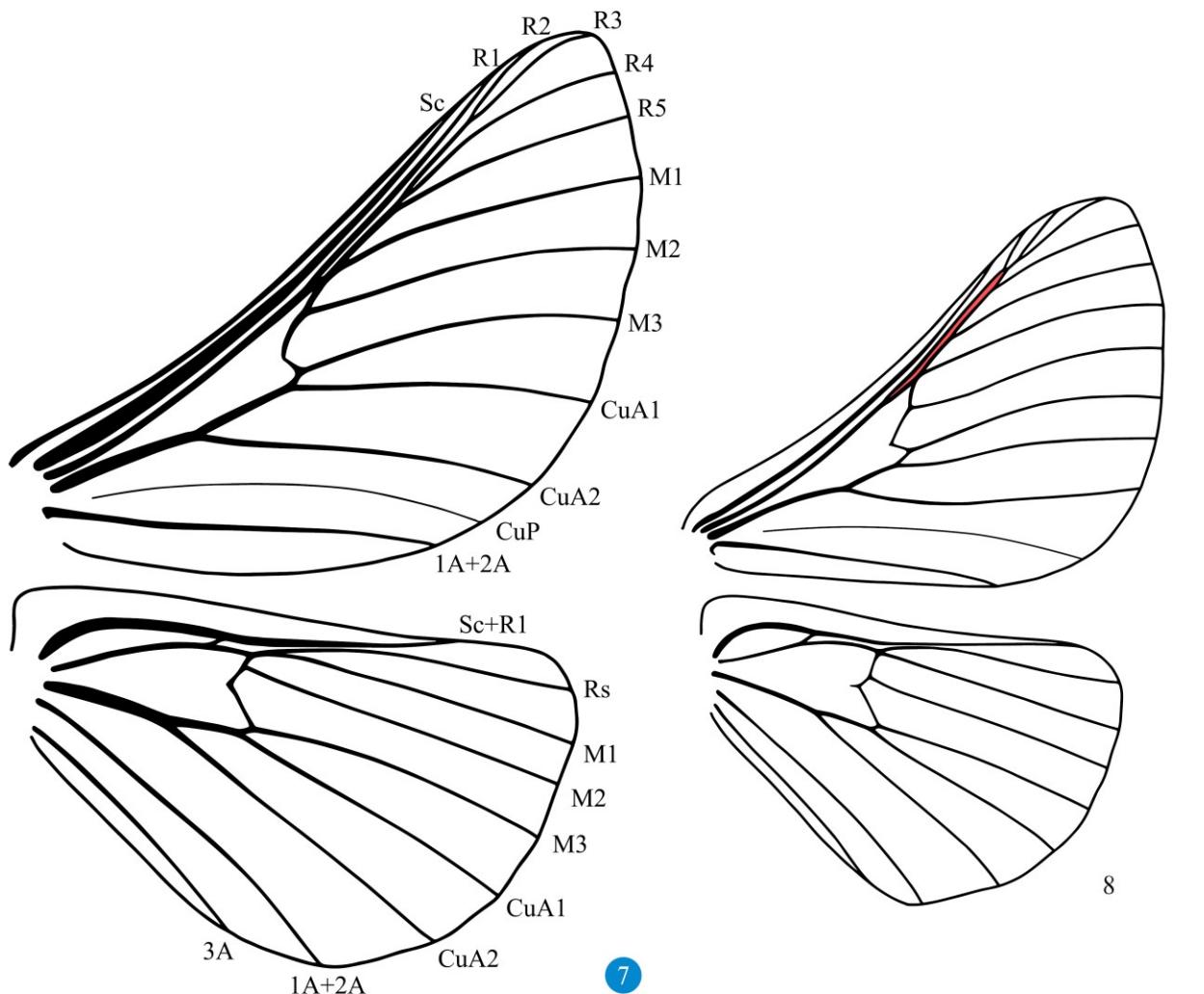
Taxonomic notes. 1. De Freina and Witt (1983) synonymized *L. philopalus rungsi* with *L. philopalus vazquezi* because of "2 males from Morocco, Tessaout, Temelelt, leg. Dr. A. Laborius from coll. Witt, Munich which correspond to the *rungsi* holotype as well as to the range of variation of the Spanish populations" ("Aus coll. Witt, München liegen zum Vergleich 2♂♂ Marokko, Tessaout, Temelelt, leg. Dr. A. Laborius vor, die sowohl dem *rungsi*-Holotypus entsprechen als auch in die Variationsbreite der

spanischen Populationen einzureihen sind," de Freina & Witt, 1983: 92). Regardless of the lack of any stable morphologic difference between the taxa, we restore the separate status of *L. philopalus rungsi* basing on a 2.13% genetic distance from the Spanish *L. vazquezi*, which is considered to be **bona species** (see below).

2. We leave *L. philopalus rungsi* and *L. philopalus philopalus* as separate subspecies until the Algerian-Tunisian population is barcoded and the two taxa relationship is clarified.



Figures 1–6. Heads of *Lemonia* spp. 1–3. *L. levantina*, male, Egypt, border to Sudan, slide Lemon-12 (CGM). 4–6. *L. italicana* Prozorov et al., 2022, male, Italy, Basilicata (ZSM). 1, 4. Head and antenna. 2, 5. Magnified details of antenna. 3, 6. Magnified palpi. Scale bar – 1 mm.



Figures 7–8. Venation of *Lemonia* spp. 7. *L. levantina*, male, Israel, N Eliat, slide Lemon-14 (CGM). 8. *L. sibirica* Wnukowsky, 1934, male, Russia, Ulyanovsk Oblast (CGM). Deviant cell in *L. sibirica* forewing venation is highlighted with red. Scale bar – 1 cm.

Type material examined: Morocco: Holotype ♂, Merchouch, 33.56131° N, 6.69188° W, 428 m, 4.I.1967, leg. Ch. Rungs (MNHN). **Additional material examined:** Morocco: 6♂, Tamallalt, 31.81319° N, 7.52201° W, 584 m, 1975, 30.XI.1977, 22.XII.1977, 5.I.1977, leg. A. Laborius, slide Lemon-11 (MWM/ZSM, CGM); ♂, Tangier, 35.75946° N, 5.83395° W, 53 m, XI.1928 (ZISP); ♂, Meknes-Tafilalet, Ifrane, Central Atlas, Azrou, 1600 m, 1.V.1990, leg. Diemer, SASNC135-11 (CWB).

***Lemonia vazquezi* Oberthür, 1916, bona sp.**
(Figs 14, 17–23, 54–55, 72–73, 77–79)

Lemonia philopalus vazquezi Oberthür, 1916, *Études de lépidoptérologie comparée*, XII, 365. Type locality: [Spain, Madrid, Rivas-Vaciamadrid, 40.3519° N, 3.53573° W, 615 m] “Rivas.” Lectotype male (NHML), here designated.

= *Lemonia philopalus phantasma* Marten, 1955, *Entomologische Zeitschrift*, 65, 196. Type locality: Spain, Seville, [37.38909° N, 5.98445° W, 17 m]. Lectotype male (MWM/ZSM).

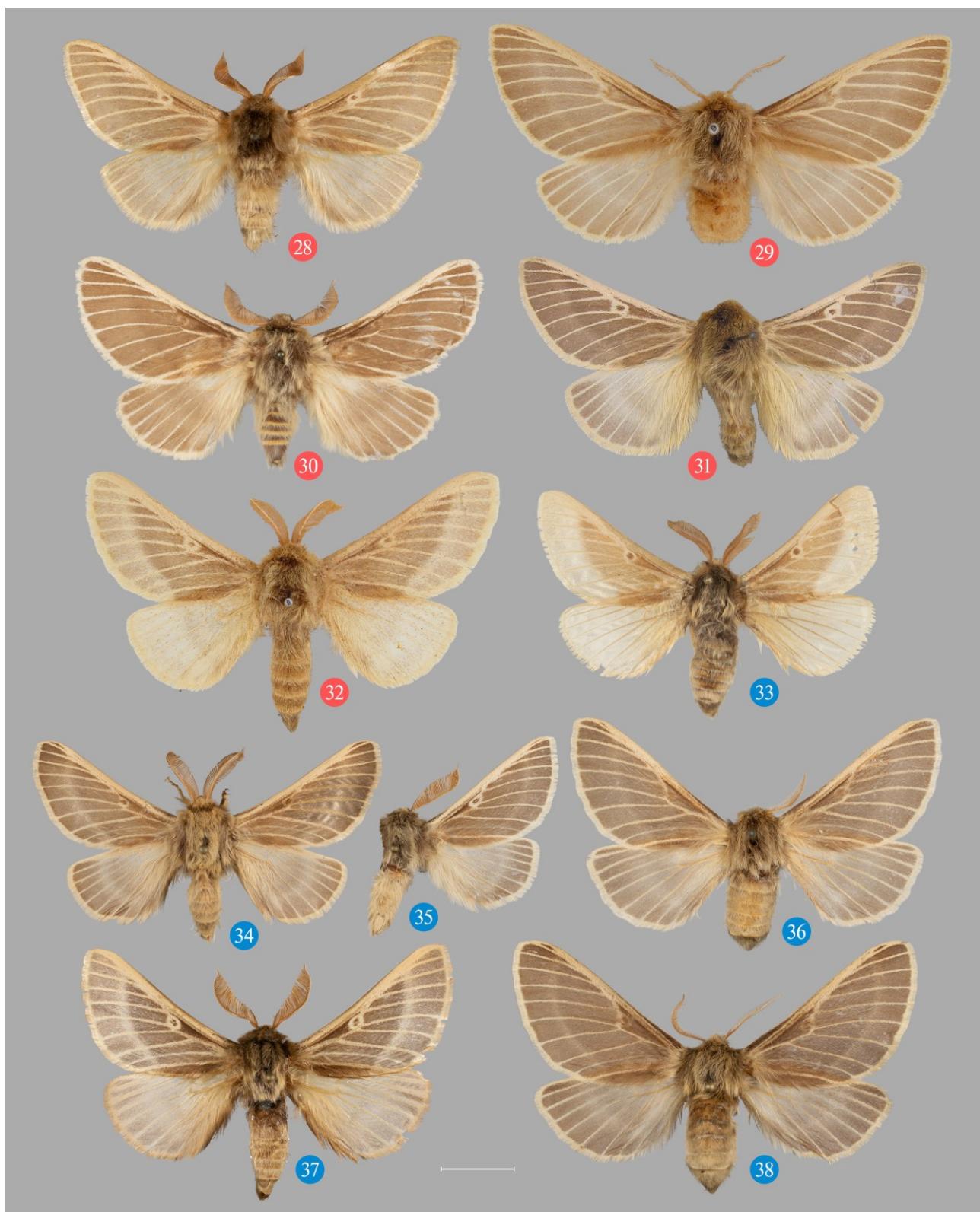
Diagnosis. Iberian species, it has a 2.13% genetic distance from the Moroccan *L. philopalus rungsi* and 5.55% from the Levantine-Egyptian *L. levantinus* sp. n. (Figs 77–78). Externally and morphologically variable, no reliable character found to distinguish it from the sister species.



Figures 9–16. Legs of *Lemonia* spp. 9–11. *L. syriensis*. 9. Male, Lebanon, Bequa Valley, slide 14.565 (MWM/ZSM). 10. Male, Israel, slide 14.557 (MWM/ZSM). 11. Male, Jordan, slide 14.567 (MWM/ZSM). 12. *L. philopalus philopaus*, male, Algeria, slide 8698 (MWM/ZSM). 13. *L. philopalus rungsi*, male, Morocco, Temelelt (CGM). 14. *L. vazquezi*, male, Spain, slide 8697 (MWM/ZSM). 15–16. *L. levantina*. 15. Male, Israel, slide 8696 (MWM/ZSM). 16. Male, Egypt, border to Sudan, slide Lemon-12 (CGM). Scale bar – 1 mm.



Figures 17–27. Adults of *Lemonia* spp. 17–23. *L. vazquezi*. 17. Lectotype male, Spain, Madrid (NHML). 18–19. Males from Oberthür, 1916. 20. Male, Spain, Cebreros, slide Lemon-3 (ZSM). 21. Female, Spain, Cebreros, slide Lemon-4 (ZSM). 22. Lectotype male of *L. philopalus phantasma*, Spain, Seville (MWM/ZSM). 23. Paralectotype female of *L. philopalus phantasma*, Spain, Seville (MWM/ZSM). 24–26. *L. philopalus rungsi*. 24. Holotype male, Morocco, Merchouch (MNHN). 25. Male, Morocco, Tamelelt (MWM/ZSM). 26. Male, Morocco, Tamelelt (CGM). 27. *L. philopalus philopalus* or *L. philopalus rungsi*, male, Mauritania (ZISP). Scale bar – 1 cm.



Figures 28–38. Adults of *Lemonia* spp. 28–32. *L. philopalus*. 28. Male, Algeria, Guelt es Stel, slide Lemon-1 (ZSM). 29. Female, Algeria, Guelt es Stel, BC JM 0101 (MWM/ZSM). 30. Male, Algeria, Hassi Bahbah (CGM). 31. Male, Tunisia, Gabes (MWM/ZSM). 32. Male, Algeria, Guelt es Stel, BC JM 0097 (MWM/ZSM). 33–38. *L. levantina*. 33. Male, Jordan, Al Maidal, BC JM 0055 (CGM). 34. Holotype male, Jordan, Rift Valley (ZSM). 35. Male, Egypt, border to Sudan (CGM). 36. Female, Saudi Arabia, Al Bid (CGM). 37. Male, Israel, Eilat (CGM). 38. Female, Israel, Samar (CGM). Scale bar – 1 cm.



Figures 39–53. Adults of *L. syriensis*. 39. Holotype male, Turkey, Kahramanmaraş, BC JM 0107 (ZSM). 40–41. Female and male, Turkey, Kahramanmaraş (CGM). 42. Male, Syria, Shaghir Bazar (CGM). 43–44. Female and male, Syria, Homs (CGM). 45–46. Male and female, Lebanon, Bsharri (CGM). 47. Male, Jordan, Malka (CGM). 48. Male, Jordan, Allenby bridge (CGM). 49. Female, Jordan, Hisban (CGM). 50. Male, Jordan, Wadi Araba (CGM). 51. Male, Syria, Golan Heights (CGM). 52. Male, Israel, Rosh Pinna (CGM). 53. Male, Egypt, Hurghada (CGM). Scale bar – 1 cm.

Variability. External line on forewing, and medial line and medial field on hindwing may be pronounced. Uncus with more or less pointed apex and more or less pronounced isthmus. Ductus bursae with wide distal end.

Distribution (Fig. 77). Central to South Spain, South Portugal (Marabuto, 2003).



Figures 54–57. Male genitalia of *Lemonia* spp. 54–55. *L. vazquezi*. 54. Spain, slide 8697 (MWM/ZSM). 55. Spain, Cebreros, slide Lemon-3 (ZSM). 56–57. *L. philopalus rungsi*. 56. Morocco, Temelelt, slide Lemon-11 (CGM). 57. Morocco, Temelelt (CGM). Scale bar – 1 mm.

Taxonomic note. The taxon was described as a Spanish form of *L. philopalus* after a series of specimens that “originate from Rivas and are part of the Vazquez’ collection” (“proviennent de Rivas et faisaient partie de la collection Vazquez,” Oberthür, 1916: 365). Two males and one female were figured in the original description, males showed the pattern variability – forewing’s external field and hindwing’s medial line may present (Fig. 18) or absent (Fig. 19). We know one specimen from the NHML collection that seems to belong to the type series according to its labels and even resembles one of the two figured males (compare Figs 17 and 18). It is a well-preserved male that bears four labels (“|” separates lines): 1. Handwritten “var. Vazquezi | Obthr.;” 2. Handwritten “*Lemonia* | *Philopalus* | Rivas;” 3. Typed “Ex Collection | Vazquez | De

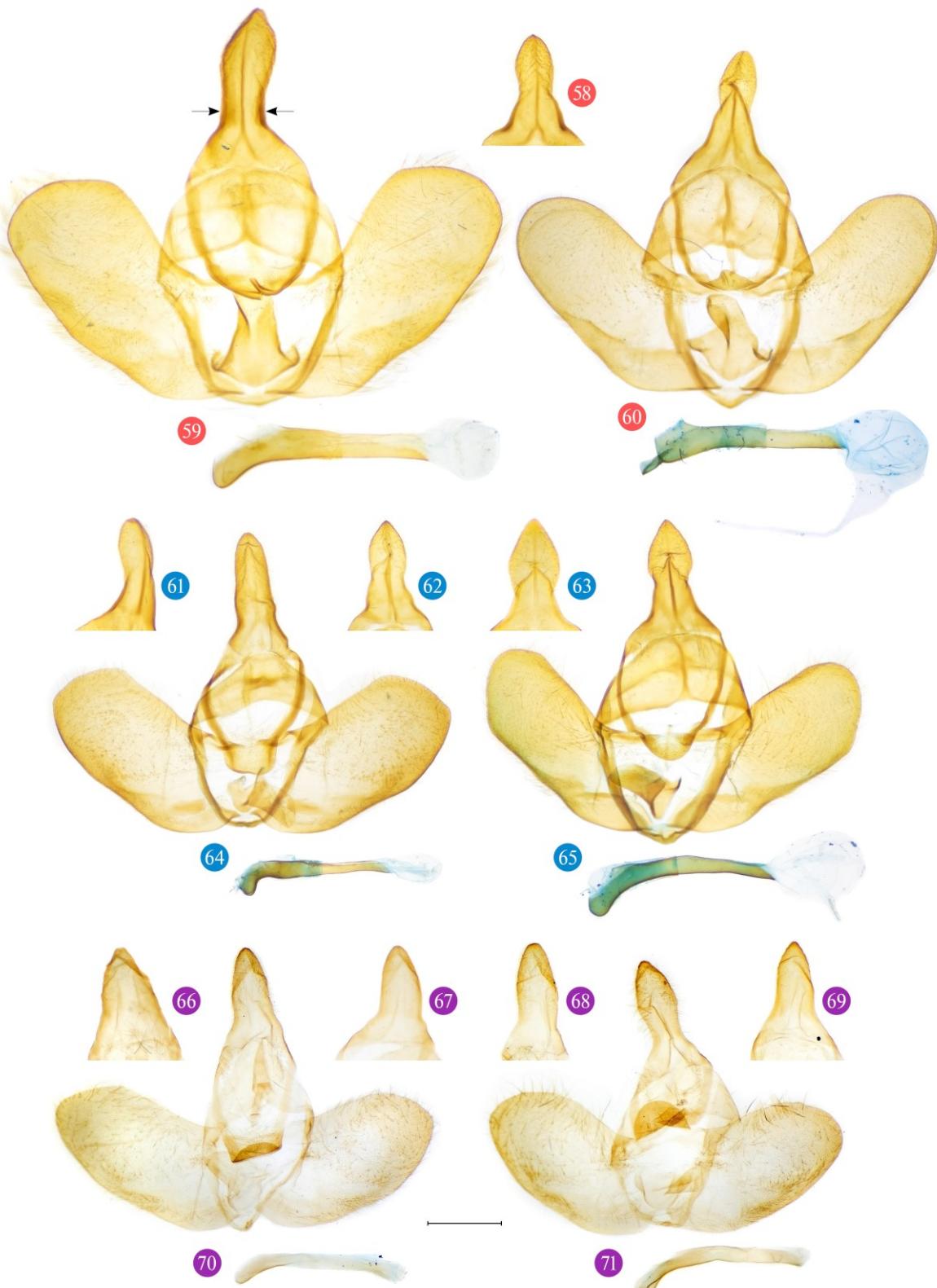
Madrid | reçue en 1912;” 4. Typed “Ex Oberthür Coll. | Brit. Mus. 1927–3.” Here we designate it as a lectotype of *Lemonia philopalus vazquezi* Oberthür, 1916.

Type material examined: **Spain:** Lectotype ♂, Madrid, Rivas-Vaciamadrid, 40.3519° N, 3.53573° W, 615 m (NHML); lectotype ♂ of *L. philopalus phantasma*, Seville, 37.38909° N, 5.98445° W, 17 m, 20.XII.1941, leg. W. Marten (MWM/ZSM); paralectotype ♀ of *L. philopalus phantasma*, Seville, 37.38909° N, 5.98445° W, 17 m, 10.XII.1941, leg. Marten (MWM/ZSM). **Additional material examined:** **Spain:** ♂, Madrid, Casa de Campo, 40.42328° N, 3.75855° W, 661 m, 17.XII.1950, leg. A. Moreno (MWM/ZSM); ♂, Madrid, San Martin de la Vega, 40.2103° N, 3.57873° W, 524 m, 9.XI.1969, leg. Meinas (MWM/ZSM); ♂, ♀, Sierra de Gredos, Cebreros, 40.46101° N, 4.46429° W, 788 m, slides Lemon-3, Lemon-4 (ZSM); 2♂, Spain, Murcia, Murcia, Sangonera, 37.9408 N, 1.19967 W, 65 m, 4.XII.2011, leg. A. S. Ortiz, IBLAO731-12, IBLAO732-12 (RCUM); 2♂, Spain, Murcia, Murcia, Rambla Salada-Las Torres de Cotillas, 37.9992 N, 1.24696 W, 90 m, 12.XII.2003, 4.I.2005, leg J. J. Guerrero, IBLAO2628-22, IBLAO2629-22 (RCUM); ♂, Spain, Murcia, Murcia, Embalse de Los Rodeos-Las Torres de Cotillas, 38.044 N, 1.3 W, 120 m, 26.XI.2003, leg. J.J. Guerrero, IBLAO2627-22 (RCUM); ♂, Spain, Andalusia, Sevilla, Cortijo La Harinosa-Cabezas de San Juan, 36.9572 N, 5.8291 W, 127 m, 31.XII.2004, leg. S. Montagud, IBLAO2665-22 (MVHN); 2♂, Spain, Andalusia, Cadiz, Centro de Conservacion-Alcala de Los Gazules, 36.4479 N, 5.7488 W, 65 m, 23.XII.2011, leg. A. Iglesias, IBLAO2646-22, IBLAO2647-22 (RCUM); ♂, Spain, Andalusia, Cadiz, San Fernando, 36.4395 N, 6.21189 W, 9 m, 23.XII.1998, leg. A. Verdugo, IBLAO2668-22 (MVHN); 2♂, Spain, Andalusia, Cadiz, Sanlucar de Barrameda, 36.811 N, 6.35921 W, 3 m, 9.XII.1982, 12.XII.1982, leg. M. Carrasco, IBLAO2666-22, IBLAO2667-22 (MVHN).

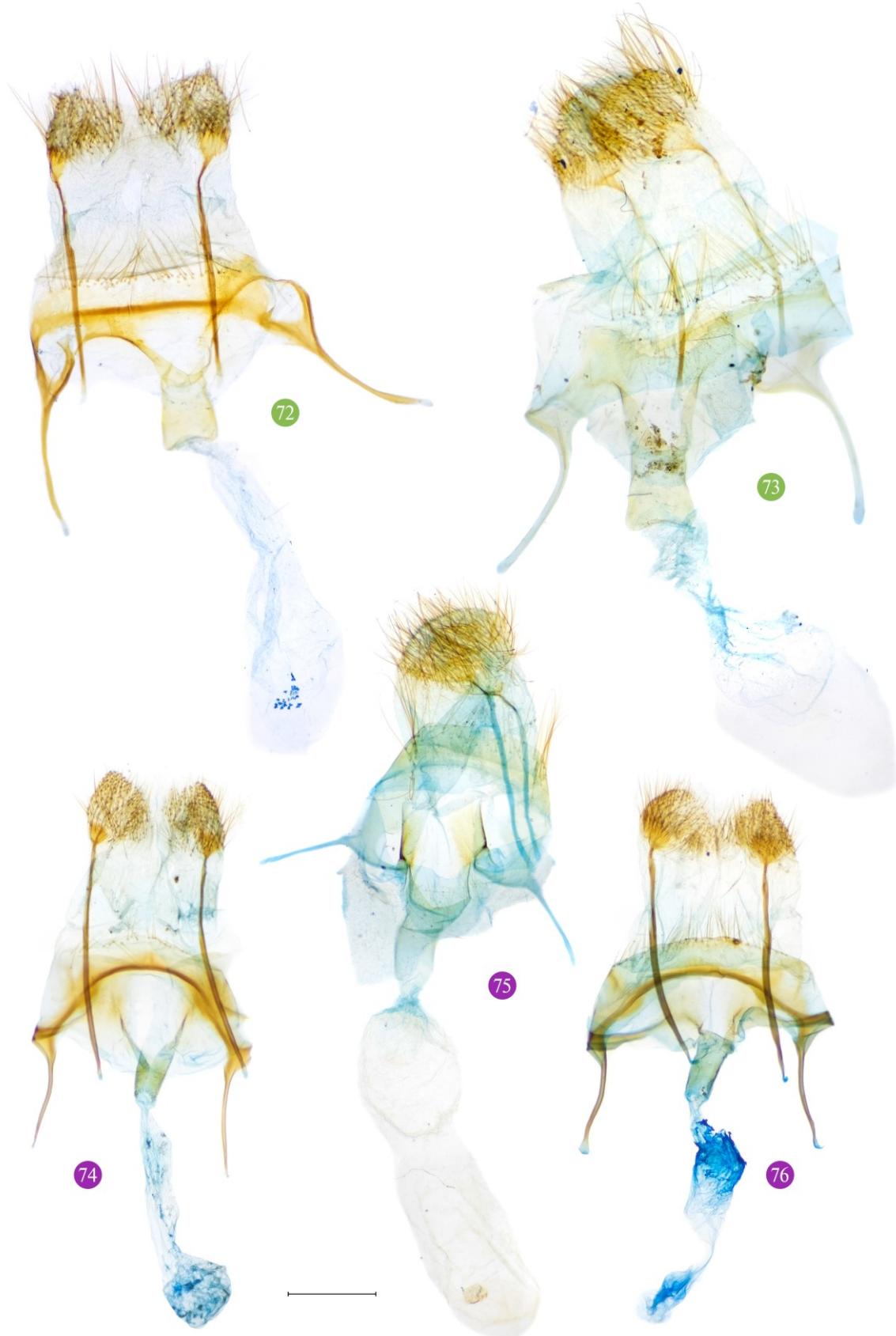
Lemonia levantina sp. n.

<http://zoobank.org/urn:lsid:zoobank.org:pub:DF78B3FB-7901-4181-9C84-F85DA02CD5E6>
(Figs 1–3, 7, 15–16, 33–38, 61–65, 77–79)

Type material: **HOLOTYPE** ♂, Jordan, Rift Valley, 40 km N of Aqaba, sands NW Rahma, ca. 100 m, leg. G. Müller & E. Revay (ZSM). **PARATYPES** (195♂, 22♀ total; all CGM): **Egypt:** 36♂, 4♀, SW Sinai, 30 km E of Abu Zenima, edge of sand dunes, contacted semi-shrub vegetation, 500 m, 25.I –5.II.1996, 28.I –12.II.1998, 5–17.II.1999, leg. G. Müller; 4♂, ♀, S Sinai, near Sharm El-Sheikh, 200 m, II.2002, I.2009, leg. V. Kravchenko & G. Müller; ♂, S Sinai, Saint Catherine, ca. 1800 m, 5–20.XI.2002, leg. G. Müller; ♂, S Sinai, Saint Catherine, ca. 500 m, I.2002, I.2003, leg. G. Müller; ♂, Sinai, Abu Darbah, I.2002, leg. G. Müller; ♂, ♀, Sinai, Dahab, ca. 200 m, I.2002, leg. G. Müller; 3♂, ♀, East Coast, Jebel Hamafah, ca. 800 m, 5–12.XII.2002, leg. V. Kravchenko & G. Müller; 2♂, Eastern Desert, Sudan border, Jebel Hamatha, ca. 800 m, II.2003, leg. V. Kravchenko & G. Müller; 2♂, Eastern Desert, Ras Garib City, 50 m, XI.2002, leg. G. Müller; ♂, Jabal al ‘Urf, 900 m, I.2003, leg. G. Müller; 4♂, Zaafarana, 500 m, I.2003, leg. G. Müller; ♂, Hurghada, Jebel Abu Harbak, 800–1200 m, XI.2002–I.2003, leg. G. Müller; ♂, Bir-Abraq, 23.35° N, 34.48° E, 1100–1400 m, 29.XII.2008, leg. Evans. **Gaza Strip:** 5♂, near Rafah, ca. 500 m, 12.I.2001, leg. G. Müller; 2♂, Beit Hanoun, 500 m, 10–20.I.2002, leg. V. Kravchenko & G. Müller; 5♂, South Gaza Strip, ca. 50 m, XII.2001, leg. G. Müller. **Israel:** 10♂, ♀, Western Negev, ca. 200 m, I.2003, leg. G. Müller; ♂, Negev, Holot ‘Agur, II.2002, leg. V. Kravchenko & G. Müller; 7♂, Arad, 500–600 m, XII.2001, I.2002, II.2002, I.2003, leg. G. Müller; 21♂, 2♀, Samar, ca. 100 m, 15.II.1985, 12–17.II.1988, II.2009, leg. G. Müller; 9♂, Southern Arava valley, near Grofit, ca. 150 m, II.2010, leg. V. Kravchenko & G. Müller; 3♂, Grofit, ca. 150 m, 8.II.1987, leg. G. Müller; 3♂, Southern Arava, Grofit, ca. 150 m, 3.II.2000, 6.II.2000, leg. G. Müller; 9♂, Southern Arava Valley, near Grofit, ca. 150 m, II.2000, leg. V. Kravchenko & G. Müller; ♂, SW Negev, Nahal Pehami, 2.II.2000, leg. G. Müller; 5♂, sands N Eilat, II.1989, leg. G. Müller; 2♂, 15 km N Eilat, I.2003, leg. G. Müller. **Jordan:** 18♂, ♀, Rift Valley, 40 km N of Aqaba, sands NW Rahma, ca. 100 m, leg. G. Müller & E. Revay; 10♂, ♀, Rift Valley, 90 km N of Aqaba, sands SW Ar-Rishah, ca. 100 m, leg. G. Müller & E. Revay; ♂, Halat Ammar, ca. 900 m, I.2002, leg. G. Müller; ♂, Al-Jafr, ca. 900 m, I.2002, leg. G. Müller; ♂, Aqaba, ca. 100 m, II.2002, leg. G. Müller; ♂, 50 km N Amman, Al Maidal, 1000 m, 25–30.I.2002, leg. G. Müller, BC JM 0055. **Iraq:** 10♂, Ad Nadhatah, ca. 600 m, I.2003, leg. G. Müller; 1♂, Wadi Muhammadi, ca. 300 m, I.2003, leg. G. Müller. **Saudi Arabia:** 7♂, 3♀, Al Bid', ca. 400 m, II.2004, leg. G. Müller; 5♂, 2♀, Rijal, ca. 1500 m, 1–10.II.2002, leg. G. Müller; ♂, Jabal Buwarah, ca. 1200 m, XII.2001, leg. G. Müller; ♂, Alflumaydah, ca. 100 m, II.2002, leg. G. Müller.



Figures 58–71. Male genitalia of *Lemonia* spp. 58–60. *L. philopalus*. 58. Algeria, slide Lemon-1 (MWM/ZSM). 59. Algeria, slide 8698 (MWM/ZSM). 60. Algeria, slide Lemon-2 (MWM/ZSM). 61–65. *L. levantina*. 61. Israel, slide 8696 (MWM/ZSM). 62. Egypt, border to Sudan, slide Lemon-12 (CGM). 63. Jordan, Ar Ruwayshid, slide 14.566 (MWM/ZSM). 64. Egypt, border so Sudan, slide Lemon-13 (CGM). 65. Israel, Eilat, slide Lemon-14 (CGM). 66–71. *L. syriensis*. 66. Egypt, Marsa Alam, slide 13.123 (MWM/ZSM). 67. Israel, W Jerusalem, slide 13.120 (MWM/ZSM). 68. Israel, slide 14.557 (MWM/ZSM). 69. Lebanon, Bequa Valley, slide 14.565 (MWM/ZSM). 70. Jordan, Ash Shobak, slide 14.563 (MWM/ZSM). 71. Jordan, slide 14.567 (MWM/ZSM). Scale bar – 1 mm.



Figures 72–76. Female genitalia of *Lemonia* spp. 72–73. *L. vazquezi*. 72. Spain, Cebreros, slide Lemon-4 (ZSM). 73. Spain, Seville, slide 10.017 (MWM/ZSM). 74–76. *L. syriensis*. 74. Israel, Sea of Galilee, slide Lemon-15 (CGM). 75. Jordan, Qa'al al Jafr, slide 10.016 (MWM/ZSM). 76. Israel, Rosh Pinna, slide Lemon-16 (CGM). Scale bar – 1 mm.

Diagnosis. Levantine-Egyptian species, it has a 4.86% genetic distance from the Moroccan *L. philopalus rungsi* and 5.55% from the Iberian *L. vazquezi* (Figs 77–78). Externally and morphologically variable, no reliable character found to distinguish it from the sister species. Worn specimens may be confused with the sympatric *Lemonia syriensis* Daniel, 1953 (Figs 39–53), but generally the coloration of *L. levantina* sp. n. is darker and more contrasting, cilia paler, forewings narrower (see Figs 34 and 45); uncus usually with well pronounced isthmus (see Figs 64 and 70); imagoes occur in sandy desert areas instead of grasslands (Figs 79–81).

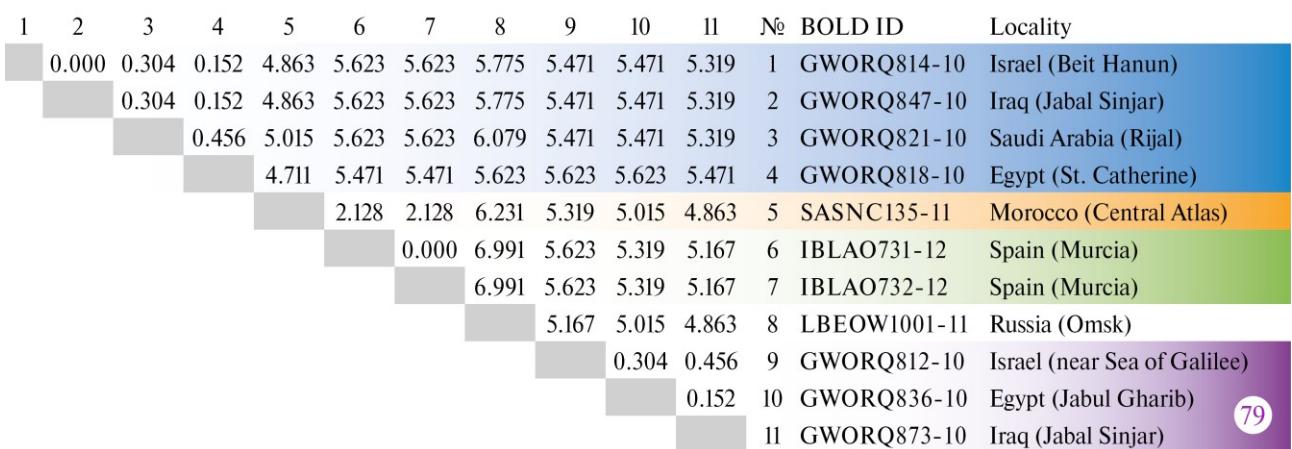
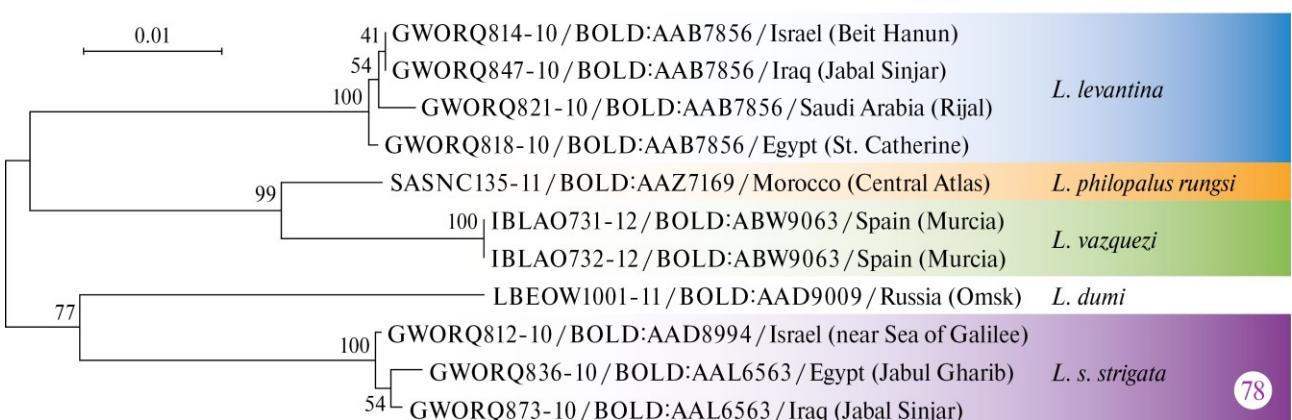
Description. Male habitus. Antenna brown, pectination elongates within the first sixth of the antenna length and stays the same length until the distal 1/6th where it quickly shortens. Flagellum tripectinate – each flagellomere bears a pair of opposite ventral lateral elongated rami and a single short medial ramus on the ventral side, all three densely covered with sensilla (Figs 1–2). Maxillary palpi very small (Fig. 1); labial palpi three-segmented (Fig. 3). Venation similar to other *Lemonia* species (Figs 7–8). Forewing length: 18–25 mm; wingspan: 40–49 mm. Background coloration brown, veins creamy. Cilia creamy. Discal spot a creamy torus on outer margin of cell. External field may be pale (Fig. 33) or of background color (Fig. 34), external line of pale color, more or less pronounced. Hindwing follows the same coloration as forewing but without discal spot, may be completely pale (Fig. 33) or with lighter medial field (Fig. 34). Cilia creamy. Abdomen dorsally dark brown with creamy interspace between abdominal segments, ventrally creamy. Femur yellow and tibia creamy, tarsi black and creamy. The tibial spur formula is 0-2-2, epiphysis absent (Figs 15–16). Foreleg's basitarsus bears 2–3 big spurs, second tarsomere may bear one big spur, distitarsus apically bears a pair of long chaetae. **Male genitalia** (Figs 61–65). Tegumen somewhat triangular, widening basally. Socii membranous, covered with short chaetae. Uncus elongated, apically may be rounded (Fig. 64) or pointed (Fig. 65), varies in width and length with more or less pronounced isthmus near its base, covered with short chaetae. Gnathos short, rounded, spatula-like with uneven surface, narrow subanal plate going from it towards anal opening. Vinculum narrow, band-like. Valvae elongated, rounded, covered with chaetae, ventral lateral margin more or less convex (Figs 64–65); sacculus weakly pronounced. Juxta boat-like, apically rounded, widened basally, surrounds aedeagus. Aedeagus elongated, narrow, c-shaped. Vesica small, bag-shaped. The eighth sternum small, somewhat triangular, apically rounded, varies in shape. The eighth tergum trapezoid not modified. **Female habitus** similar to male (Figs 36, 38), but larger in size, antenna pectination shorter, discal spot less pronounced if at all. Forewing length: 26–28 mm; wingspan: 48–55 mm. **Female genitalia** have not been studied.

Etymology. We dedicate the subspecies to the region of the Levant where the species was predominantly collected.

Distribution (Fig. 77). Mainly arid, sandy areas in North East and South East Egypt, Southern Israel, Jordan, Northern Iraq and Northwestern Saudi Arabia.

Biology (Fig. 79). The new species is found in semidesert and desert habitats with annual precipitation below 300 mm. The psammophilous taxon inhabits areas with sparse and scattered vegetation. It occurs mainly on lowland with a few records in SE Egypt above 1000 m, here it is restricted to water catchments in hyper-arid environment. Adults were collected from late November to mid-February with a clear peak from late December to February. The higher the altitude, the earlier adults can be found. It is worthwhile mentioning that the flight period of single populations does not exceed two weeks. The new taxon can be regarded as a late winter – early spring species. In contrast the Western taxa appear to fly mainly in autumn and are found in open and forested Mediterranean grassland habitats, to our best knowledge there are no records from desert habitats.

The early stages of the new taxon are unknown, but the caterpillars are probably night active and feed on low herbaceous plants. The new species is very local, rare and almost the complete material was collected with long-term operated light traps within two decades. Adults appear mainly after midnight until sunrise to light sources, typically at very low temperatures.



Figures 77–79. Principal differences between *L. vazquezi* (green), *L. philopalus rungsi* (orange), *L. philopalus philopalus* (red), *L. levantina* (light blue) and *L. syriensis* (purple): 77. Distribution map (for details visit <https://bit.ly/3DunGVv>). 78. Phylogenetic tree (Neighbor-joining, Kimura-2 parameters, uniform rates, bootstrap 1000 replicates from MEGA11, Tamura *et al.*, 2021). 79. Pairwise distances (%).

***Lemonia syriensis* Daniel, 1953**

(Figs 9–11, 39–53, 66–71, 74–79)

Lemonia syriensis Daniel, 1953, *Mitteilungen der Münchener Entomologischen Gesellschaft*, 43, 255. Type locality: [Turkey, Kahramanmaraş, 37.57527° N, 36.92282° E] “Syria sept., Taurus, Marasch.” Holotype male (ZSM).

Diagnosis. The species differs most of the other *Lemonia* by brown coloration with contrasting light brown veins. It may be confused only with the sympatric *Lemonia levantina* sp. n. (Figs 33–38), but the coloration of *L. syriensis* is less contrasting and paler, cilia is darker, forewings are wider (Figs 34 and 45); the uncus usually has less pronounced isthmus (Figs 64 and 70); ductus bursae distally narrow (Figs 72 and 74); the species is mainly found in rich grassland (Figs 80–81) with few records from Egypt where it is restricted to grassland relicts within larger water catchments.

Variability. Background color varies from light to dark brown (Figs 42 and 45, 40 and 46), pale vines may be more or less pronounced (Figs 48 and 42). Uncus apically more or less pointed (Figs 69 and 67), may be narrow or wide (Figs 70 and 66), isthmus may be very well pronounced or practically absent (Figs 71 and 66).

Distribution (Fig. 77). From Southwest Turkey eastwards to North Iraq and from the Gaziantep Province southwards along the northern Rift Valley, very local in the Eastern Desert of Egypt.

Biology. Grassland species, inhabits Irano-Turanian rich grassland with and without scattered bushes and trees where annual precipitation is above 500 mm. The separate population in Southern Egypt is restricted to water catchments in mountainous areas providing the environment for grassland patches. These habitats are very small, localized, and endangered by overgrazing. Inhabits heights from minus 200 m in the Northern Rift Valley up to ca. 1200 m above sea level in Southern Egypt. Flies from October to January with a peak in mid-October to mid-December – the higher the altitude, the earlier adults occur. Flying period does not exceed two weeks within a population.

Caterpillars suggested to be night active, probably feeding on low herbaceous plants.

Type material examined: Turkey: Holotype ♂, [Turkey, Kahramanmaraş, 37.57527° N, 36.92282° E] Syria sept., Taurus, Marasch, 600–900 m, XII.1930 (ZSM); paratypes 4♂, like holotype but 800–1100, XI–XII.1929 and 1930, slide 17.710 (MWM/ZSM, ZSM); paratype ♂, Aman-Dagh, Akbez (ZSM).

Additional material examined: Turkey: ♂, Akbez, 1901, leg. R. Oberthür, slide 17.711 (MWM/ZSM); ♂, Akşehir, 1000 m, 1–31.X.1964, leg. H. Noack (CGM); ♂, ♀, Kahramanmaraş, XII.1930 (CGM). Iraq: ♂, Zawita Dohuk, 1–3.XII.1977, leg. G. Topál, slide 17.712 (MWM/ZSM); ♂, Jabal Sinjar, ca. 1200 m, IX.2003, leg. G. Müller, slide 17.713 (MWM/ZSM); ♂, Jabal Sinjar, ca. 600 m, XII.2002, leg. G. Müller, BC JM 0113 (MWM/ZSM); ♂, E Kirkuk, ca. 1800 m, XI–XII.2003, leg. G. Müller (CGM). Syria: ♂, Zawita Dohuk, 1–3.XII.1977, leg. G. Topál, slide 17.712 (MWM/ZSM); ♂, Shaghir Bazar, ca. 1800 m, 25.XI.1986 (CGM); ♂, ♀, 10 km NW Homs, grassland with scattered bushes, 8–17.XII.1993, leg. A. Awwad (CGM); ♂, Northern Golan Heights, Quneitra, ca. 800 m, XI.2001, leg. V. Kravchenko & G. Müller (CGM). Lebanon: ♂, ♀, Bsharri – Hasroun, karst sparse grassland, XII.1995, leg. J. Awwad (CGM). Jordan: ♂, Rajib, ca. 500 m, XII.2002, leg. G. Müller (CGM); ♂, Malka, ca. 500 m, I.1985 (CGM); ♂, Allenby bridge, ca. 500 m, XII.2002, leg. G. Müller (CGM); ♂, Jarash, ca. 700 m, 10.XI.2002, leg. J. de Freina (CGM); ♂, upper Wadi al Arab, grassland, ca. 300 m, 5–15.XII.1990, leg. G. Müller & Awwad (CGM); ♀, Hisba, ca. 900 m, I.2003, leg. G. Müller (CGM). Israel: ♂, 10 km S Sea of Galilee, ca. 200 m, XII.2002, leg. G. Müller (CGM); ♂, Sea of Galilee, Tiberias, –200 m, XII.2010, leg. G. Müller (CGM); ♂, Sea of Galilee, Safed, 500 m, 10–20.XII.2010, leg. V. Kravchenko & G. Müller (CGM); ♂, Sea of Galilee, 500 m, 15.XII.2003, leg. V. Kravchenko & G. Müller (CGM); ♂, Rosh Pinna, ca. 300 m, XII.2010, leg. V. Kravchenko & G. Müller (CGM). Egypt: ♂, Eastern Desert, Hurghada, Jabal Umm ‘Inab, 1800–2000 m, XI–XII.2002, leg. G. Müller (CGM); ♂, Eastern Desert, Marsa Alam, Jabal Abū Dhi’āb, 800–1000 m, XI.2002, leg. G. Müller (CGM); ♀, Eastern Desert, border to Sudan, Jabal Abū Ḥamāmīd, ca. 1500, XII.2002, leg. G. Müller (CGM).



80



81



82

Figures 80–82. Habitat of *L. levantina* (Sands near Dimona; Fig. 80) and *L. syriensis* (Golan Heights, photos by D. Benyamin; Figs 81–82) in Israel.

Conclusion

Antoshin and Zolotuhin (2011, 2013) demonstrated that the taxonomic uncertainties within *Lemonia* can only to a certain degree be clarified with morphologic characters. Recent genetic studies showed that *L. dumii* has a sister species in the Netherlands (Šumpich & Jagelka, 2021), *L. taraxaci* was split into three genetically distinct species (Prozorov *et al.*, 2022) and the clarification of the *L. philopalus* complex was the next step. The Iberian, Moroccan and Levantine-Egyptian populations were sequenced, as a result we saw that the farther the populations are from each other, the higher the genetic distance (Fig. 79). Considering that, the Moroccan *L. philopalus rungsi* may be synonymized with the Algerian-Tunisian *L. philopalus philopalus* when the latter is barcoded.

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References

- Antoshin, D.A. & Zolotuhin, V.V. (2011) *Lemonia strigata* Rougeot et Viette, 1978, stat. n., and *L. ballioni* (Christoph, 1888) (Lepidoptera: Lemoniidae) in a fauna of Europe with taxonomic notes on related species and description of a new subspecies. *Eversmannia*, 25–26, 9–24.
- Antoshin, D.A. & Zolotuhin, V.V. (2013) Taxonomic remarks on the Lemoniidae (Lepidoptera) with description of a new species from Iran. *Tinea*, 22(3), 168–174.
- Chavanon, G. (1989) Note sur deux Lépidoptères récoltés dans le nord-est du Maroc: *Charaxes jasius* L. et *Lemonia philopalus rungsi* Rougeot (Lep. Nymphalidae et Lemoniidae). *Alexanor*, 15(8), 486.
- Daniel, F. (1953) Neue Heteroceren-Arten und -Formen. *Mitteilungen der Münchener Entomologischen Gesellschaft*, 43, 252–261.
- Denis, M. & Schiffermüller, I. (1755) *Ankündigung eines systematischen Werkes von den Schmetterlingen der Wiener Gegend herausgegeben von einigen Lehrern am k. k. Theresianum*. Augustin Bernardi, Wien, 323 pp.
- Donzel, M.H. (1842) Description de deux lépidoptères nouveaux recueillis en Barbarie par le capitaine Charlon. *Annales de la Société entomologique de France*, 11, 197–199.
- de Freina, J. & Witt, Th. (1983) Taxonomische Veränderungen bei den Bombyces und Sphinges Europas und Nordwestafrikas (Lepidoptera: Lemoniidae, Lasiocampidae I). *Nota lepidopterologica*, 6(2–3), 88–98.
- de Freina, J. & Witt, Th. (1987) Die Bombyces und Sphinges der Westpalaearctis, I. Edition Forschung & Wissenschaft Verlag GmbH, München. 708 pp.
- Hamilton, C.A., St Laurent, R.A., Dexter, K., Kitching, I.J., Breinholt, J.W., Zwick A., Timmermans, M.J.T.N., Barber, J.R. & Kawahara, A.Y. (2019) Phylogenomics resolves major relationships and

- reveals significant diversification rate shifts in the evolution of silk moths and relatives. *BMC Evolutionary Biology*, 19, 182. <https://doi.org/10.1186/s12862-019-1505-1>
- Kitching, I.J., Rougerie, R., Zwick, A., Hamilton, C.A., St Laurent, R.A., Naumann, S., Ballesteros Mejia, L. & Kawahara, A.Y. (2018) A global checklist of the Bombycoidea (Insecta: Lepidoptera). *Biodiversity Data Journal*, 6: e22236. <https://doi.org/10.3897/BDJ.6.e22236>
- Lederer, J. (1861) Ueber Alb. Kindermanns letzte lepidopterologische Ausbeute. *Wiener entomologische Monatschrift*, 5(5), 144–155.
- Linnaeus, C. (1761) *Fauna svecica. Sistens animalia sveciae regni: mammalia, aves, amphibia, pisces, insecta, vermes, distributa per classes et ordines, genera et species, cum differentiis specierum, synonymis auctorum, nominibus incolarum, locis natalium, descriptionibus insectorum*. Sumtu & Literis Direct, Stockholm, 578 pp.
- Marabuto, E. (2003) *Lemonia philopalus* (Donzel, 1842), Nova espécie para a fauna de Portugal (Lepidoptera, Lemoniidae). *Boletín de la Sociedad Entomológica Aragonesa*, 33, 101–103.
- Marabuto, E. (2018) Butterfly and moth diversity in Serpa (Baixo Alentejo, Portugal): an advance in a yet poorly surveyed region (Insecta: Lepidoptera). *SHILAP Revista de lepidopterología*, 46 (183), 371–410.
- Marten, W. (1955) Über *Lemonia philopalus* Donz. *Entomologische Zeitschrift*, 65, 193–199.
- Oberthür, Ch. (1890) *Études d'Entomologie*, Volume 13. Imprimerie Oberthür, Rennes, 50 pp.
- Oberthür, Ch. (1916) Faune des Lépidoptères de Barbarie (Partie II). *Études de lépidoptérologie comparée*, XII (2): 179–371. <https://doi.org/10.5962/bhl.title.8792>
- Prozorov, A.M., Prozorova, T.A., Volkova, Ju.S., Yakovlev, R.V., Nedoshivina, S.V., Pinzari, M., Pinzari, M., Scalercio, S., Bianco, G., Saldaitis, A., Hausmann, A., Revay, E.E. & Müller, G.C. (2022) Revision of the *Lemonia taraxaci* complex, with a description of a new species from Italy and clarification of the status of *Lemonia strigata* (Lepidoptera: Brahmaeidae: Lemoniinae). *Zootaxa*. [Accepted for publication]
- 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.1471-8286.2006.01678.x>
- Ratnasingham, S. & Hebert, P.D. (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>
- Refaei, E.A., Boraei, H.A., Sharshir, F.A. & El-Sebaey, E.A. (2021) *Lemonia philopalus* (Donzel, 1842) and *Phragmites australis* weed studies at Burullus Lake, Kafr EL-Sheikh Governorate, Egypt. *Journal of Entomology and Zoology Studies*, 9(6), 273–277.
- Regier, J.C., Mitter, C., Zwick, A., Bazinet, A.L., Cummings, M.P., Kawahara, A.Y., Sohn, J.-C., Zwick, D.J., Cho, S., Davis, D.R., Baixeras, J., Brown, J., Parr, C., Weller, S., Lees, D.C. & Mitter, K.T. (2013) A Large-Scale, Higher-Level, Molecular Phylogenetic Study of the Insect Order Lepidoptera (Moths and Butterflies). *PLoS ONE*, 8(3), e58568. <https://doi.org/10.1371/journal.pone.0058568>
- Regier, J.C., Zwick, A., Cummings, M.P., Kawahara, A.Y., Cho, S., Weller, S., Roe, A., Baixeras, J., Brown, J.W., Parr, C., Davis, D.R., Epstein, M., Hallwachs, W., Hausmann, A., Janzen, D.H., Kitching, I.J., Solis, M.A., Yen, S.-H., Bazinet, A.L. & Mitter, C. (2009) Toward reconstructing the evolution of advanced moths and butterflies (Lepidoptera: Ditrysia): an initial molecular study. *BMC Evolutionary Biology*, 9, 280. <https://doi.org/10.1186/1471-2148-9-280>
- Rougeot, P.-C. (1971) Les Bombycoïdes (Lepidoptera-Bombycoïdea) de l'Europe et du Bassin Méditerranéen 5. Tome I: Lemoniidae, Bombycidae, Brahmaeidae, Attacidae, Endromididae. Masson et Cie Editeurs, Paris, 159 pp.
- Šumpich, J. & Jagelka, M. (2021) *Lemonia batavorum* sp. nov. from the Netherlands, an overlooked sibling of *L. dumi* (Lepidoptera: Brahmaeidae). *Acta Entomologica Musei Nationalis Pragae*, 61(2), 483–494. <https://doi.org/10.37520/aemnp.2021.026>
- Tamura, K., Stecher, G., & Kumar, S. (2021) MEGA11: Molecular Evolutionary Genetics Analysis Version 11. *Molecular Biology and Evolution*, 38(7), 3022–3027. <https://doi.org/10.1093/molbev/msab120>
- Zwick, A. (2008) Molecular phylogeny of Anthelidae and other bombycoid taxa (Lepidoptera: Bombycoidea). *Systematic Entomology*, 33, 190–209. <https://doi.org/10.1111/j.1365-3113.2007.00410.x>

Zwick, A., Regier, J.C., Mitter, C. & Cummings, M.P. (2011) Increased gene sampling yields robust support for higher-level clades within Bombycoidea (Lepidoptera). *Systematic Entomology*, 36, 31–43.
<https://doi.org/10.1111/j.1365-3113.2010.00543.x>