



## *Lythria* (*Microlythria* subgen. nov.) *venustata* Staudinger, 1882 (Lepidoptera: Geometridae): distribution and description of the female, with a brief review of the genus

I.A. MAKHOV<sup>1</sup>, P.YU. GORBUNOV<sup>2</sup> & V.A. LUKHTANOV<sup>1,3</sup>

<sup>1</sup>Zoological Institute of the Russian Academy of Sciences, Universitetskaya embankment, 1, St. Petersburg 199034, Russia

✉ [maakhov@gmail.com](mailto:maakhov@gmail.com); ✉ [Ilya.Makhov@zin.ru](mailto:Ilya.Makhov@zin.ru); <https://orcid.org/0000-0002-3563-0139>

<sup>2</sup>Institute of plant and animal ecology, Ural Division of the Russian Academy of Sciences, 8th Marta Str. 202/3, Ekaterinburg 620144 Russia

✉ [pg18@yandex.ru](mailto:pg18@yandex.ru); <https://orcid.org/0000-0003-1913-7894>

<sup>3</sup> <https://orcid.org/0000-0002-3563-0139>

### Abstract

The article provides new localities for the little-known species *Lythria venustata* Staudinger, 1882; a map with all currently known locations is presented. A new subgenus, *Microlythria* **subgen. nov.**, within *Lythria* Hübner is proposed for *L. venustata*. A morphological description of *L. venustata* female and illustration of its genital structure are given for the first time; some corrections in the description of the male genitalia are made. Both male and female genitalia of all other species of the genus are also shown, and a comparison of *L. venustata* with its congeners is made. Colour plates depicting males and females of all species of the genus *Lythria* are provided. The systematic position of the genus in the family Geometridae, and the implication of the features of *L. venustata* female genitalia for tribal association within the Sterrhinae are discussed. Identification keys (based on external morphology and genital structure) to *Lythria* species are given.

**Key words:** new subgenus, Sterrhinae, genitalia structure, new records, Kazakhstan

### Introduction

The genus *Lythria* Hübner currently comprises 5 geometrid species (Scoble 1999; Rajaei *et al.* 2022). Although the systematic placement of the genus has been long problematic (some authors have associated the genus with the Larentiinae, while other authors have supposed that it belonged to Sterrhinae), *Lythria* was eventually placed in a monotypic tribe within the Sterrhinae subfamily (Öunap *et al.* 2008, 2009; Sihvonen *et al.* 2011; Müller *et al.* 2019). Later, as a result of more extensive molecular genetic research, *Lythria* was transferred to the tribe Rhodometrini (Sihvonen *et al.* 2020). All members of this genus exhibit a rather characteristic bright appearance (Pl. 1, 2) and diurnal activity; their larvae are predominantly confined to the Polygonaceae (Hausmann & Viidalepp 2012).

The *Lythria* representatives have Palearctic ranges; two of them, *L. purpuraria* (Linnaeus, 1758) and *L. cruentaria* (Hufnagel, 1767), are rather widely distributed from Western Europe to Central Asia: the first species inhabits the temperate zone of Europe, Turkey, the Caucasus and Transcaucasia, across Turkmenistan, Central Asia to Transbaikalia and north-western China. The second one has a European-West-asiatic distribution and is less common in the east: it occurs in Europe (penetrating into more northern areas, in contrast to *L. purpuraria*), Caucasus, Turkey and northern Kazakhstan; in Russia, the range of *L. cruentaria* extends to the Altai. The third species, *L. sanguinaria* (Duponchel, 1842), occurs only in the Iberian Peninsula and in southern France (Pyrenees). The fourth one, *L. plumularia* (Freyer, 1831), is an endemic of the European High Alps (Hausmann & Viidalepp 2012).

The fifth species, *L. venustata* Staudinger, 1882, is the least well known member of the genus, and has hitherto been known from only a few specimens. After the description of this taxon by Staudinger (1882) based on a single male, the species, according to the available literature, was collected in Western Kazakhstan in 2006 (2 males) by

R. Kadyrbekov and in north-eastern Kazakhstan in 2007 (1 male) by V. Zinchenko. Based on these materials a redescription of the *L. venustata* male and a first description of its genital structure was compiled, and a molecular phylogeny incorporating all five species of the genus was presented (Öunap *et al.* 2009; Vasilenko 2009).

Later, two more specimens (male and female) were reported by P. Gorbunov (2011) for south-western Kazakhstan, from near the winter hut in the Karynzharyk sands (42.816667N, 54.116667E) in 2009 and next to the Kendyrli cordon of Ustyurt Nature Reserve (42.950000N, 54.683333E) in 2010. For the latter specimen a photograph *in natura* was provided by the author (Gorbunov, 2011: 164), which, apparently, was the first published image of the female. In 2015, the second author of this paper published observations of several more individuals of *L. venustata* on the social network INaturalist ([https://www.inaturalist.org/taxa/1294834-Lythria-venustata/browse\\_photos](https://www.inaturalist.org/taxa/1294834-Lythria-venustata/browse_photos)), including a photograph of one female. Since then, no finds of this elusive species have been reported in the literature. Thus, at this point, only 9 published records of *L. venustata* are known (including the type specimen) of which 7 are males and 2 females. However, no description of the external morphology and genital structures of the female has yet been given.

In spring of 2023, while traveling in the western part of Kazakhstan, the first and the third authors of this article discovered another locality for *L. venustata*, where 2 females were collected. The second author recorded about 30 specimens *in natura* in the period 2013–2015. In this communication we establish a new subgenus, provide a description of the female of *L. venustata* including a comparison with its congeners, summarize all known records of *L. venustata* to date and give a brief review of all *Lythria* species with illustrations of their imagines (both sexes) and identification keys.

## Abbreviations

CPG	Private collection of Pavel Yu. Gorbunov. Yekaterinburg, Russia.
CSM	Private collection of Sergey F. Melyakh. Yekaterinburg, Russia.
HT	Holotype.
LSL	Collection of the Linnean Society. London, Natural History Museum.
MNB	Museum für Naturkunde. Berlin, Germany.
ST	Syntype.
TL	Type locality.
ZISP	Zoological Institute of Russian Academy of Sciences. Saint Petersburg, Russia.
obs.	Observation.

## Materials and methods

The moths were sampled in daytime with an entomological net. A total of 11 specimens of *L. venustata* were collected in 3 localities. The rest of the moths (about 20 individuals) were observed *in natura* and recorded with photographic equipment. The photographs *in natura* were made using Nikon D7100 camera with lens AF Micro Nikkor 105 mm 1:2.8D.

Microscopic preparations were made using a standard technique; maceration was performed with a 15% solution of potassium hydroxide. Glycerol was used for temporary preparations.

The photographs of temporary genitalia and abdomen preparations were performed using a Nikon SMZ25 stereoscopic microscope, Nikon DS-Ri2 camera and NIS-Elements BR software. Colour photographs of the total dorsal and lateral views of imago samples were taken with a Canon 5D Mark IV digital camera equipped with a lens Canon MP-E 65mm f/2.8 1–5x macro and Canon Macro Twin Lite MT–26EX–RT flash and Helicon stacking software (Helicon Focus 7.03).

The morphological terminology largely follows that of Kuznetsov & Stekolnikov (1997) (wing venation); McGuffin (1967) (wing pattern); Klots (1970); Pitkin (1993, 1996); Scoble (1994); Cook & Scoble (1995) (genitalia structures, tympanal organs).

## Results and discussion

### Taxonomy

#### *Lythria (Microlythria) subgen. nov.*

**Type species.** *Lythria venustata* Staudinger, 1882, here designated.

**Diagnosis.** The new subgenus differs from all species of the nominative subgenus, including its type species, in the following characters: [in male], the vinculum with the round saccus; the strongly reduced valva lacking a distal membranous part (valvula); the absence of a movable articulation between the valva and the genital segment; the presence of the juxta and well sclerotized anellus; the well-developed tegumen equipped with a pair of the large postero-lateral finger-like processes; [in female] the corpus bursae with a lamellar rhombic signum with a longitudinal ridge.

**Description.** See description of *Lythria (Microlythria) venustata*.

**Etymology.** The name is composed of the Greek word *micro* (μικρό), meaning small, and the genus name *Lythria*; it refers to the smallest size of *Lythria (Microlythria) venustata* among its relatives.

**Species included.** *Lythria (Microlythria) venustata* Staudinger, 1882.

#### *Lythria (Microlythria) venustata* Staudinger, 1882

Figs 1, 3; Pl. 1: 1a–1c

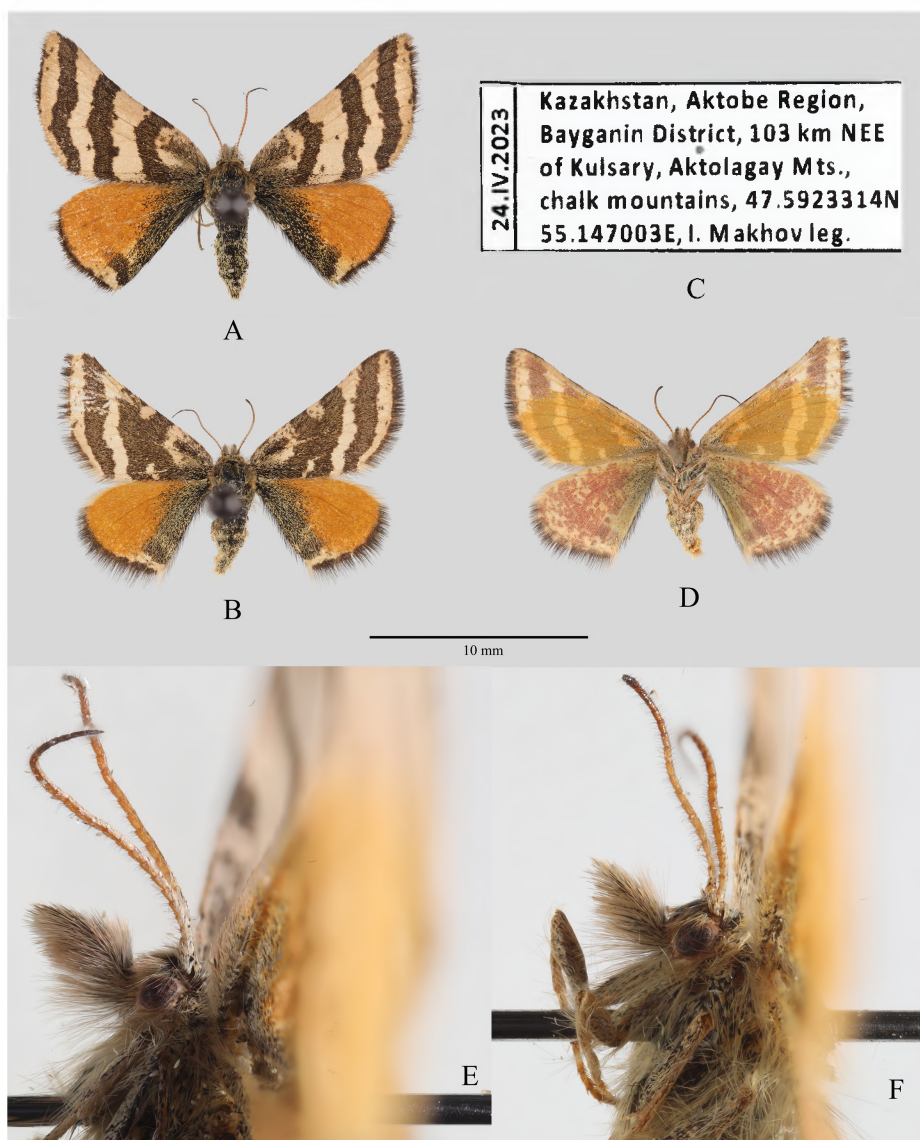
*Lythria venustata* Staudinger, 1882: 64. TL: [Kazakhstan]: “Saisan” [Saur] (HT ♂ in MNB)

**Material examined.** *Western Kazakhstan:* Aktobe Region, Bayganin District, 103 km NEE of Kulsary, Aktolagai Mts., chalk mountains, 47.5923314N, 55.147003E, 24.IV.2023, 2 ♀, (biotope: Figs 4A), I. Makhov leg. (the moths were collected among *Caragana* bushes) [ZISP]; Aktolagai Plateau, 35 km E of Miyaly, 140 m a.s.l., 47.483333N, 55.183333E, 16.IV.2013, 6 ♀, 1 ♂, P. Gorbunov leg. [CSM]; *Southern Kazakhstan:* Syrdariya Karatau Mt. Range, 12 km NW of Aksumbe, 450 m, 44.516667N, 67.416667E (biotope: Fig. 5B), 19.IV.2014, 1 ♀, P. Gorbunov leg. [CPG].

**Other material** (visual observations). *Western Kazakhstan:* Ustyurt Nature Reserve, Karynzhyryk Sands at Akkuduk, Kyzylsengir, 120 m a.s.l., 42.833333N, 54.116667E (biotope: Fig. 5A), 24.IV.2009, P. Gorbunov obs.; Ustyurt Nature Reserve, Kendyrli, 130 m a.s.l., 42.950000N, 54.683333E, 20.IV.2010, 1 ♀ (imago: Fig. 3E), V. Zurilina obs.; Bostankum Sands, 35 km N of Zhanaozen, 180 m a.s.l., 43.700000N, 53.150000E, 7.IV.2013, P. Gorbunov obs.; Aktolagai Plateau, 35 km E of Miyaly, 140 m a.s.l., 47.483333N, 55.183333E, 17–18.IV.2013, 1 ♀ (imago: Figs 3D, 3F), P. Gorbunov obs.; Altynshokysu chalk cliffs, 5 km S of Akespe r/w station, 208 m., 47.333333N, 60.850000E, 30.IV.2014, P. Gorbunov obs.; Chelkar District, 7 km E of Zhylan aul, 240 m a.s.l., 47.633333N, 60.433333E, 1.V.2014, P. Gorbunov obs.; Chelkar District, Shagan River head, 72 km W of Baikadam, 280 m a.s.l., 47.450000N, 58.283333E, 3.V.2014, P. Gorbunov obs.; *Southern Kazakhstan:* Syrdariya Karatau Mt. Range, Kurkal dry valley, 40 km N of Igilik, 540 m a.s.l., 43.783333N, 68.050000E, 18.IV.2014, P. Gorbunov obs.; Syrdariya Karatau Mt. Range, 12 km NW of Aksumbe, 450 m, 44.516667N, 67.416667E, 20.IV.2014, 17.IV.2015, 12.IV.2018, P. Gorbunov obs.; Aktau Mt. Range, Daut Mt., 65 km N of Shieli town, 140 m, 44.766667N, 66.966667E (biotope: Fig. 5A), 21.IV.2014, 1 ♀ (imago: Figs 3B, 3C), P. Gorbunov obs.; Aral Sea Region, Bestoba Mt., 14 km W of Kosaman aul, 170 m a.s.l., 46.916667N, 60.383333E, 27.IV.2014, P. Gorbunov obs.; Aral Sea old bank, 6 km NE of Akespe aul, 200 m a.s.l., 46.800000N, 60.566667E, 29.IV.2014, P. Gorbunov obs.; Zhambyl Province, 10 km NE of Khantau railway station, mt. steppe, 730 m a.s.l., 44.300000N, 73.866667E, 14.IV.2015, P. Gorbunov obs.; Syrdariya Karatau Mt. Range, Koshkarata River, 980 m a.s.l., 43.666667N, 68.800000E, 16.IV.2015, P. Gorbunov obs.; *South-East Kazakhstan:* Almaty Province, Katutau Mts. Range, 8 km S of Konyrolen, 1160 m., 44.200000N, 79.333333E (biotope: Fig. 5B), 18.IV.2015, 1 ♂ (imago: Fig. 3A), 28.V.2015, P. Gorbunov obs.

A brief description of the male external morphology (wing pattern and head) was given by Vasilenko (2009). Since sexual dimorphism in *L. (M.) venustata* is expressed mainly in the structure of antennae, the description of the remaining external features is suitable for both sexes, however, below we provide the detailed description of the female morphology with additions and clarifications to the description of the male genitalia morphology.





**FIGURE 1.** *Lythria (Microlythria) venustata*, females, external morphology of imago. A, B—dorsal view; C—label of the pictured specimens; D—ventral view; E, F—head and its parts, lateral view.

### Description of female

The *head* (Figs 1E, 1F) is broad, covered with beige-gray hairy scales; the frons is almost twice as wide as the diameter of the eye. The eyes are small and oval. The antennae are short, filiform, with numerous ciliae, ochre-coloured or fulvous, gradually darkening towards the apex, dark brown at the tip. The proximal third of the antennae is covered dorsally with black scales and sparse beige scales. The palpi are long: they extend beyond the frons by more than half of the whole palpi, palpi are covered with bushy long grayish-ocher hairs and shorter black hairy scales. The proboscis is reduced. The vertex is reddish gray.

The *thorax* and femora are densely covered with greyish brown (reddish gray in fresh samples) hairs and scales. The legs are covered with cream-coloured scales.

*Wings.* The forewing length is 8–9 mm. The costal margin of the forewing is almost straight or slightly concave in the proximal half. The apex is elongated, rounded. The termen is convex, the tornus is smoothly rounded. The costal margin of the hind wing is almost straight, the apex is rounded, the termen is smooth, convex, the inner margin is straight; the tornal angle is almost right.



Upperside (Figs 1A, 1B). The ground colour of the forewing is beige. The basal area is often darkened due to a dense dusting of black and brown scales, which form two wide longitudinal dashes in the base of the discal cell and the posterior part of the basal area (the latter dash adjacent to the inner margin of the wing). The size of two these dashes varies, and they can almost completely fuse together. The wing pattern consists of 3 wide transverse dark brown or reddish brown fasciae. The antemedial fascia is convex, its anterior part bent inwards. The medial fascia is straighter than the antemedial fascia, and slightly wavy, its position varying considerably: in some specimens it is close to the wing base, while in others it is closer to the outer margin. The subterminal fascia is parallel to the medial fascia. The shape and width of the transverse fasciae vary markedly. The transverse fasciae tend to merge; the medial fascia commonly anastomoses with the antemedial fascia in its central part, and the subterminal fascia merges with the medial one at the level of the discal vein. Light wing areas are often covered with scattered dark dots of same colour as the transverse fasciae. In fresh individuals, the dark portions of the wing pattern (basal dashes, transverse fasciae and scattered dots) are covered with numerous beige scales and hairs (closer to the wing base). The fringes are dark brown along their entire length, except for a small area at the tornus, where they are beige.

The hind wing is orange, with a dark brown terminal band. The wing base (approximately to the middle of the discal cell) and the wide area along the inner margin between the inner margin and the vein  $Cu_2$  (1/4–1/3 of the wing width) are almost black, densely covered with beige scales and light hairs. This dark area does not reach the wing termen; distad to this dark area (closer to the tornus), there is a more or less pronounced trace of a dark transverse band (submarginal fascia); and even more distad (at the tornus), a narrow beige space is located between the posterior margin of the wing and the vein  $Cu_2$ . The fringes from the wing base to the apex are pale orange or cream-coloured, along the termen and posterior margin they are dark brown, almost black, at the tornus they are cream-coloured. Discal spots are absent from the both wings.

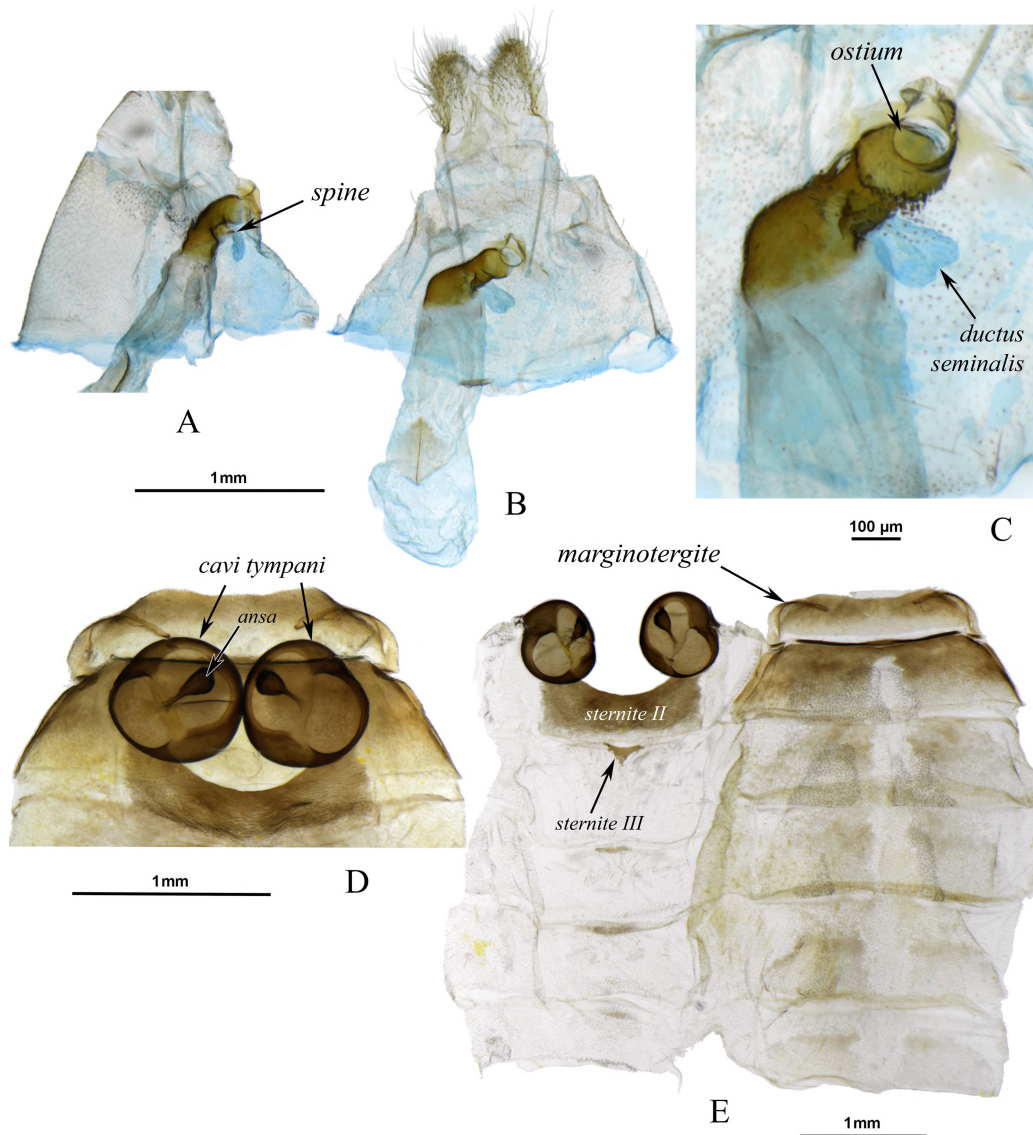
Underside (Fig. 1D). The pattern of the forewing duplicates the pattern of the upper side, but the ground colour is orange: the transverse fasciae are greyish orange, the lighter areas between them are pale orange. The costa between the costal and subcostal veins is pinkish cream. The apical part of the forewing is cream-coloured, and the dark elements of the pattern in this area are pale burgundy. The wing base with greyish and black scales. The hind wing is cream-coloured, completely dotted with dark pink scales, which form numerous irregularly shaped spots merging into the larger clusters. The subterminal area is less densely covered with pinkish scales. The area between the inner margin and the vein  $Cu_2$  is darkened, with ochreous scales along the inner margin. The wing base with greyish and black scales. Most of the wing surface (especially near the wing base and along the inner margin) is covered with cream-coloured hairs. The fringes of both wings are the same as on the upper side, but slightly paler and with light areas along the veins.

The *abdomen* (dorsally) is dark brown, almost black, shiny, covered with beige scales, the density and shape of which gradually increase from the base of the abdomen to its tip. These beige scales form dorsally a narrow continuous semi-ring at the base of the abdomen, immediately at the point of attachment to the metathorax. On the terminal abdominal segments, the scales become significantly longer. The abdomen is covered ventrally with beige scales, much more densely than on the dorsal side, so that the dark vestiture is not visible in fresh specimens. Sclerotization of the abdomen is weakly developed: only the first two basal tergites in their proximal half and marginotergites are relatively well sclerotized (Fig. 2E), sternite II is well sclerotized, sternite III is reduced to a small triangular medial plate, and subsequent sternites are even smaller and are represented by tiny longitudinally elongated plates. The cavi tympani (Fig. 2D) are globular, strongly sclerotized, with a small aperture. The ansa is stout, sharply swollen in the proximal half, narrowed in the distal half, and slightly dilated at the apex.

**Genitalia** (Figs 2A–2C). The papillae anales are elongated, rounded; the apophyses posteriores are comparatively long: about 2.5 times longer than the apophyses anteriores; the ovipositor is short; the tergum A8 is rectangular, its anterior and posterior edges are almost straight, the apophyses anteriores are slightly shorter than the lateral side of the tergum A8. The ostium is small, almost round; the ostial plate is irregular in shape, weakly sclerotized, its edges are barely visible. Behind the ostium there is a small projection of the ostial plate.

The bursa copulatrix is elongated; the ductus bursae is well sclerotized, slightly swollen posteriorly, extends from the ostium to the left at an angle 30–45 degrees to the longitudinal axis of the abdomen. The ductus seminalis is membranous, with a tiny spine at the base, arising in the close proximity to the ostium. The base of the ductus seminalis is expanded, sac-like, while its distal part is extremely narrow. The corpus bursae is membranous, slightly dilated proximally, with barely sclerotized longitudinal folds in the posterior half and with a discrete large signum in the anterior half (closer to the central part). The signum is in the form of a sclerotized rhombic plate with a central longitudinal ridge.

**Note.** The female of *L. venustata* differs significantly from females of other *Lythria* species in the genitalia structure. Unlike *L. purpuraria* and *L. plumularia*, *L. venustata* lacks a broad, well sclerotized lamella antevaginalis covering the ostium. In *L. purpuraria* and *L. plumularia*, the ostium is quite wide and slit-like (C-shaped in *L. purpuraria*). The female genitalia of *L. venustata* differ from those of *L. sanguinaria* and *L. cruentaria* by



**FIGURE 2.** *Lythria (Microlythria) venustata*, details of genitalia structure and abdomen. A—abdominal VII segment, lateral view; B—bursa copulatrix, ventral view; C—ostial area and proximal portion of bursa copulatrix, enlarged; D—base of abdomen, tympanal organs; E—abdomen, dissected.

*purpuraria*). The female genitalia of *L. venustata* differ from those of *L. sanguinaria* and *L. cruentaria* by the presence of a strongly sclerotized ductus, located at a large angle to the longitudinal axis of the abdomen. The structure of the bursa copulatrix of *L. venustata* shows similarities to that both of the pair *L. sanguinaria*—*L. cruentaria* and the pair *L. purpuraria*—*L. plumularia*, in the folds in the posterior part of the corpus bursae, and the membranous anterior part. However, the main difference between *L. venustata* and all other *Lythria* members is the presence in the corpus bursae of a lamellar rhombic signum with a longitudinal ridge. A similar signum is found in the genera *Rhodometra* Meyrick (Fig. 8A) and *Casilda* Agenjo, which close to *Lythria*, as well as in some other sterrhines (*Cyclophora* Hübner, *Timandra* Duponchel, *Ochodontia* Lederer). This feature once again supports the association of *Lythria* with the Rhodometrini, and the presence of a lamellar signum in *L. venustata* can be considered as a symplesiomorphy with *Rhodometra* and the other listed sterrhine genera, which indicates the basal position of *L. venustata* in the phylogeny of the genus.





**FIGURE 3.** *Lythria (Microlythria) venustata* in natura. A—East Kazakhstan, Almaty Province, Katutau Mts. Range, 8 km S of Konyrolen; B, C—Southern Kazakhstan, Aktau Mt. Range, Daut Mt., 65 km N of Shieli town; D, F—Western Kazakhstan, Aktolagai Plateau, 35 km E of Miyaly; E—Western Kazakhstan, Ustyurt Nature Reserve, Kendyrlı. Photos by P. Gorbunov.





**FIGURE 4.** Habitats of *Lythria* (*Microlythria*) *venustata*. A—Western Kazakhstan, Aktobe Region, Aktolagai Mountains. Photos by V. Lukhtanov. B—Western Kazakhstan, Ustyurt Nature Reserve, Karynzhyryk Sands at Akkuduk, Kyzylsengir. Photo by P. Gorbunov.





**FIGURE 5.** Habitat of *Lythria* (*Microlythria*) *venustata*. A—Southern Kazakhstan, Aktau Mountain Range, Daut Mountain; B—East Kazakhstan, Almaty Province, Katutau Mountain Range, 8 km S of Konyrolen. Photos by P. Gorbunov.



These data are consistent with the conclusions reached by Öunap and co-authors (2009), which were based on the analysis of molecular genetic markers and the structure of the male genitalia.

**Remarks to the male genitalia morphology of *L. (M.) venustata*.** Vasilenko (2009) gave a description of the male genitalia of *L. venustata*, but later Öunap and co-authors (2009) made some corrections to this description and presented a male genitalia illustration, which differed significantly from the image given by Vasilenko. In the redescription they stated that «valvae of *L. venustata* are distally bipartite», and that Vasilenko's interpretation of «finger-like socii on the posterior edge of the tegumen» was erroneous, since these structures were «actually the projections of the sacculi». At the same time, Öunap and co-authors stated that *L. venustata* has «a weakly sclerotized uncus», which Vasilenko referred to as the «anellus». We examined the structure of the *L. venustata* male genitalia in two specimens: the genital preparation which was figured by Öunap and co-authors (photo of this preparation: Figs 7E, 7F), and a new genital preparation from the specimen collected by P. Gorbunov (photo of this preparation: Figs 7A–7D). We were able to establish the following: the illustration made by Vasilenko is the most accurate, but in his description the anal tube was mistakenly referred to as the «anellus», while the true anellus was referred to as «annelus». The illustration in Öunap *et al.* is incorrect, because the genital segment was torn in the area of the medial part of the tegumen. As a result, the lateral parts of the tegumen with processes were mistaken for valvae, and the anal tube was misinterpreted as a membranous uncus. We consider it necessary to make additional corrections to the description of the *L. venustata* male genital segment, as follows: the tegumen bears a pair of large postero-lateral finger-shaped processes with unclear homology (Figs 7B, 7C: *p.-l. pr. tg.*), with their tips directed ventrally; the uncus is completely reduced, and a slightly sclerotized conical anal tube is located between the postero-lateral processes of the tegumen; the valvae are reduced, and sclerotized along all edges, with a deep semicircular notch in the medial part of the outer edge and with groups of setae on the dorso-apical and ventro-basal angles; there is no movable articulation between the valva and the genital segment; the anellus is represented by a well sclerotized plate with a broad anterior part and a pair of curved postero-lateral processes (their apices meet, but are not fused together).

Thus, *L. venustata* demonstrates significant differences from other *Lythria* species in the structure of the genitalia of both sexes, which clearly indicate the isolated position of this species. The same is indicated by the molecular genetic data obtained by Öunap and co-authors (2009): according to the results of the analysis of 2 nuclear markers and the mitochondrial *COI* gene, *L. venustata* was placed phylogenetically as the sister taxon to all other species in the genus. All this taken together, in our opinion, allows us to distinguish *L. venustata* into at least the separate subgenus *Microlythria* subgen. nov.

**Biology.** Desert species, prefers bushy areas with the presence of goat's-wheat (*Atraphaxis*) and *Ephedra*. In the mountains it inhabits the mountain-desert belt, up to 1200 m a.s.l. The moths fly in April and May, and are active only in daytime (during sunny hours). The imago is characterized by a sharp, impetuous flight, reminiscent of some pyralids from the genus *Pyrausta*. Males are more timid than females, and have a sharper and more impetuous flight.

Larval stages unknown.

**Distribution:** Turanian; the species is known only from Kazakhstan (Fig. 6): the main range occupies the subzones of the northern and middle deserts of Kazakhstan. It will probably be found in Uzbekistan, perhaps in Turkmenistan, Kyrgyzstan, and Western China.

### *Lythria (Lythria) Hübner, [1823]*

**Type species.** *Phalaena purpuraria* Linnaeus, 1758.

**Diagnosis.** In male, the vinculum is deeply concave ventrally, with the pointed dorso-distal corners; the valva bears a distal membranous part (valvula), the valva-genital segment articulation is flexible; the juxta and sclerotized anellus are absent; sclerotized tegumen is not developed; in female, the corpus bursae without signum.

**Species included.** *L. (L.) cruentaria* (Hufnagel, 1767); *L. (L.) sanguinaria* (Duponchel, 1842); *L. (L.) purpuraria* (Linnaeus, 1758) and *L. (L.) phumularia* (Freyer, 1831).

### *Lythria (Lythria) cruentaria* (Hufnagel, 1767)

Pl. 1: 2a–2o

*Phalaena cruentaria* Hufnagel, 1767: 516–517. TL: Germany, Berlin distr.



**Distribution.** In Europe from France, Italy and the Balkans to the western borders of Russia; in the north from southern Norway through Sweden to Finland; Russia (from Karelia and Caucasus across the central Urals to Altai), Turkey, northern Kazakhstan.



**FIGURE 6.** Map showing all known localities of *Lythria (Microlythria) venustata*. Blue circles—localities known before this report; red circles—new localities; purple square—type locality.

***Lythria (Lythria) sanguinaria* (Duponchel, 1842)**

Pl. 1: 3a–3d

*Aspilates sanguinaria* Duponchel, 1842: 36, pl. 53, fig. 5. TL: [Spain, Andalusia] Magala district (HT ♀).

**Distribution.** Spain, Portugal, southernmost France (Pyrenees).

***Lythria (Lythria) purpuraria* (Linnaeus, 1758)**

Pl. 2: 4a–4i

*Phalaena (Geometra) purpuraria* Linnaeus, 1758: 522. TL: Europe. (ST in LSL)

**Distribution.** Europe (from Spain and France to Estonia and Ukraine), Russia (from Kaliningrad Province to Transbaikalia), Turkey, Caucasus, Transcaucasia, Iran, Kazakhstan, Turkmenistan, Uzbekistan, Tajikistan, Kyrgyzstan, Afghanistan, Northwestern China, Mongolia.

***Lythria (Lythria) plumularia* (Freyer, 1831)**

Pl. 2: 5a–5h

*Fidonia* (Orig. “Gen. XCVIII. Fidonia. Geom.[etra]”) *plumularia* Freyer, 1831: 68, Tab. 36, fig. 3. TL: [Switzerland]: Thur (ST)

**Distribution.** Alps in south-eastern France, northern Italy, southern Switzerland, through Austria to southern Germany (Bavarian Alps).

The placement of the genus *Lythria* in the Geometridae system remained controversial until the end of the first decade of the XXI century. Only molecular genetic studies, which included, in addition to the mitochondrial *COI* gene, 4 more nuclear markers, were able to link this genus convincingly with the Sterrhinae subfamily. An accurate tribal association was proposed only a few years ago (Sihvonen *et al.* 2020), and was also based on data of multigene analysis (11 molecular markers). The difficulty of using morphological characteristics of the genus *Lythria* for its tribal association was due to the fact that its widespread and well known members have “advanced” features, and some structures (e.g. the signum in the female genitalia) are secondarily lost. If the morphology of both male and female genitalia of *L. (M.) venustata* (a basal branch of the generic tree of *Lythria*) had been available to lepidopterists in the pre-molecular epoch, this species could well have been the key to understanding the place of this genus in the Sterrhinae system.

Now that the males and females of all recent *Lythria* species are known, it is possible to compile a complete identification keys to this genus. We provide two such keys below (one by external characteristics, and one based on the structure of the genitalia).

## Identification key to *Lythria* species

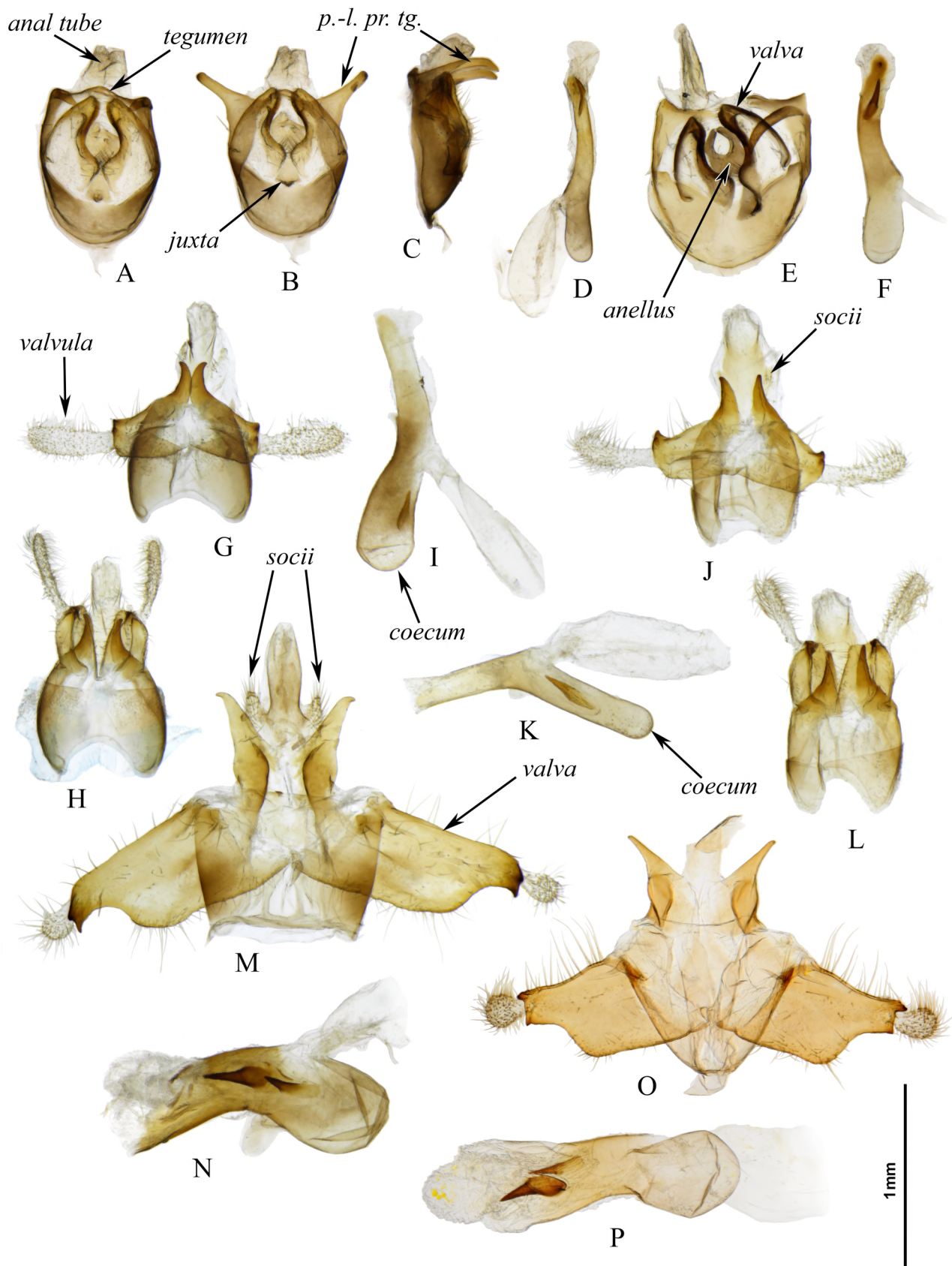
### Wing pattern:

1. Forewing pattern dark (dark brown or purple brown), contrasting with dark cream or beige ground colour, basal area markedly darkened ..... 2
- Ground colour of forewing yellowish orange to brownish yellow; pattern reddish, often with olive-grey scales, basal area barely darkened ..... 3
2. Hindwing without submarginal fascia; fringes of both wings dark brown, almost black (Pl. 1: *1a–1c*) ..... ***L. (M.) venustata***
- Hindwing with dark submarginal fascia or its distinct trace reaching costal margin; fringes of both wings dark reddish (Pl. 2: *5a–5h*) ..... ***L. (L.) plumularia***
3. Medial fascia of forewing commonly reduced to a costal spot, at equal distances from antemedial and postmedial fasciae, never fused with them (Pl. 2: *4a–4i*) ..... ***L. (L.) purpuraria***
- Medial fascia of forewing usually present, well developed, sometimes confluent with antemedial fascia ..... 4
4. Postmedial fascia of forewing continuous; medial fascia of forewing usually closer to postmedial one or confluent with that; antemedial fascia commonly broad and reaches veins  $Cu_2$  (occasionally transverse fasciae absent) (Pl. 1: *2a–2o*) ..... ***L. (L.) cruentaria***
- Postmedial fascia of forewing usually broken into a row of reddish dashes or spots on veins; medial fascia not fused with postmedial one; antemedial fascia often marked on costa only (Pl. 1: *3a–3d*) ..... ***L. (L.) sanguinaria***

### Genitalia structure:

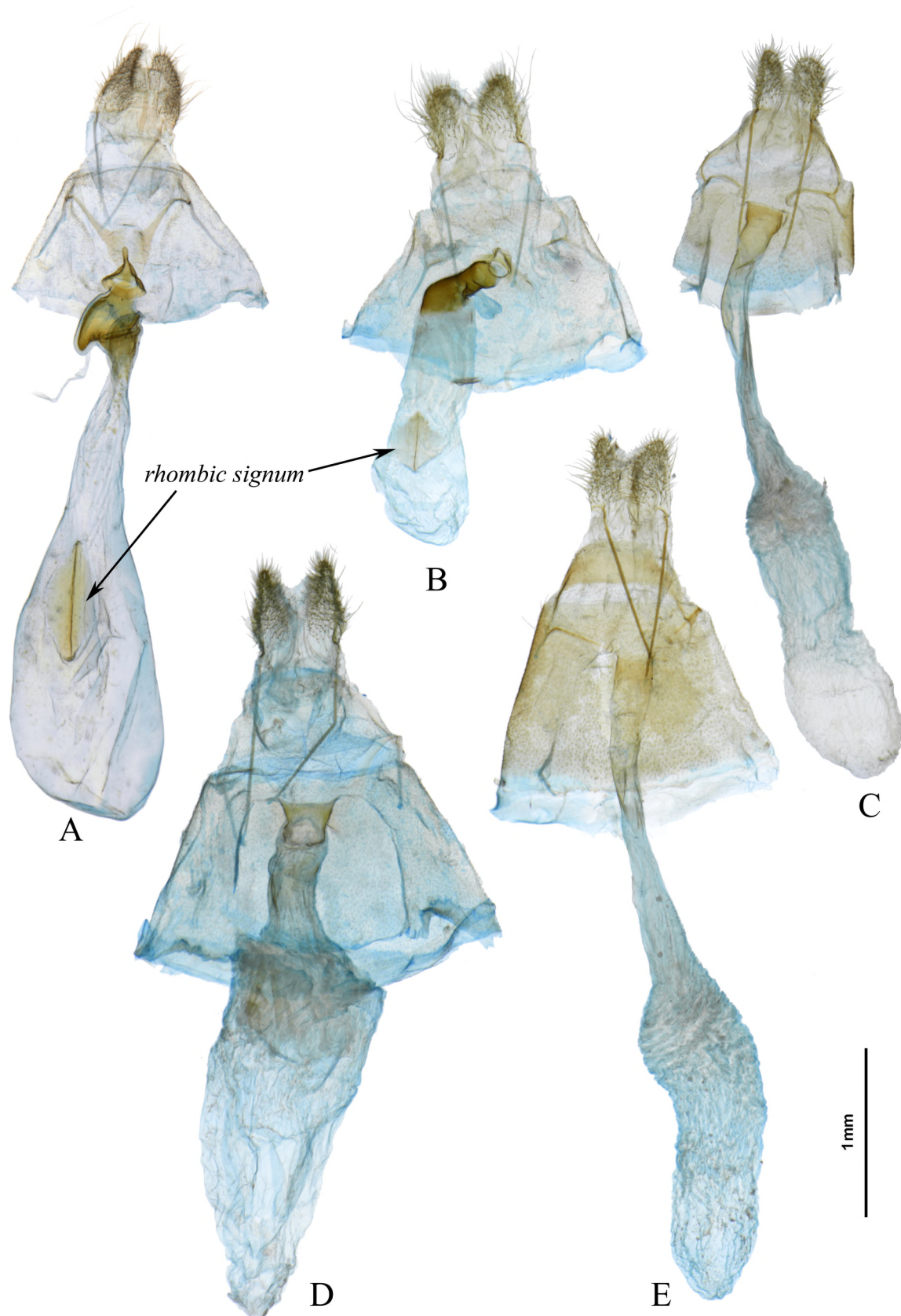
1. In male (Figs 7A–7F) valvae and genital segment articulated rigidly, distal membranous part of valva (valvula) absent, juxta well developed; in female (Fig. 8B) corpus bursae with rhombic lamellar signum. .... ***L. (M.) venustata***
- In male valvae-genital segment articulation flexible, distal membranous part of valva (valvula) developed, juxta not developed; in female signum absent. .... 2
2. In male vesica with a single cornutus, valva roughly rectangular, valvula long and narrow; in female lamella antevaginalis not developed, ductus bursae distinctly narrower than posterior part of corpus bursae. .... 3
- In male vesica with two cornuti, valva roughly triangular, valvula short, rounded sack-like; in female lamella antevaginalis well developed, sclerotized, ductus bursae equal in width with posterior part of corpus bursae or broader. .... 4
3. In male (Figs 7G–7I) coecum of aedeagus swollen, cornutus smaller than in *L. sanguinaria*; in female (Figs 8C, 8E) ductus bursae long, almost equal in length to broader posterior part of corpus bursae. .... ***L. (L.) cruentaria***
- In male (Figs 7J–7L) coecum of aedeagus not swollen, cornutus longer and stouter than in *L. cruentaria*; in female (Fig. 8D) ductus bursae short, no longer than ½ length of broader posterior part of corpus bursae ..... ***L. (L.) sanguinaria***
4. In male (Figs 7O, 7P) valva short: length of its costal margin approximately equal to its greatest width; in female (Figs 9A–9C) posterior edge of lamella antevaginalis not straight: clearly round or with distinct medial projection (often pointed apically), ostium C-shaped ..... ***L. (L.) purpuraria***
- In male (Figs 7M, 7N) valva longer: length of its costal margin clearly exceeding its greatest width; in female (Figs 9D, 9E) posterior edge of lamella antevaginalis almost straight, without any projections, ostium not C-shaped ..... ***L. (L.) plumularia***



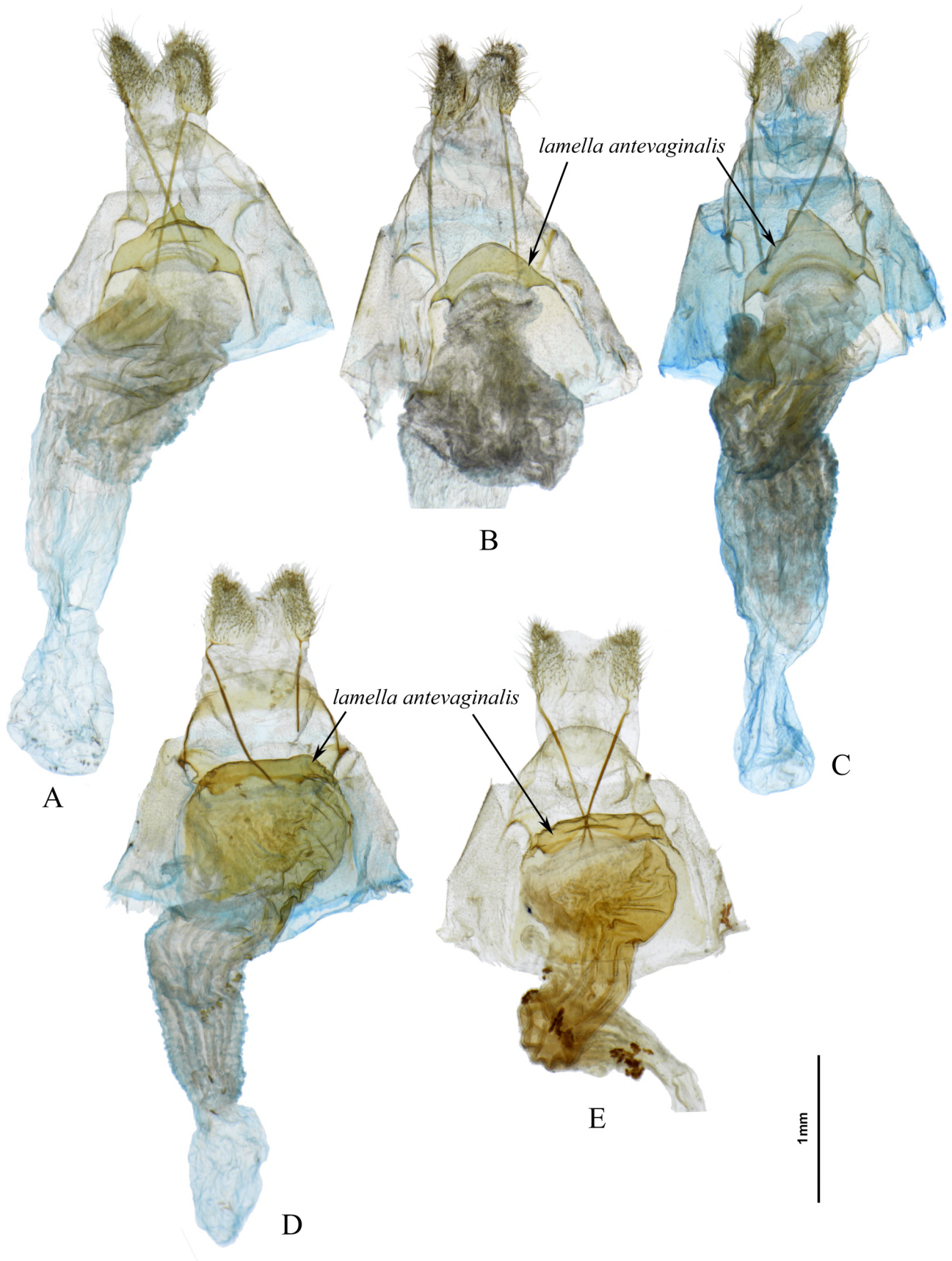


**FIGURE 7.** Male genitalia of *Lythria* species. A–F—*L. (M.) venustata*; G–I—*L. (L.) cruentaria*; J–L—*L. (L.) sanguinaria*; M, N—*L. (L.) plumularia*; O, P—*L. (L.) purpuraria*. A, E, H, L—genital segment (ventral view) in its natural position; B, G, J, M, O—ditto, unfolded position; C—ditto, lateral view; D, F, I, K, N—phallos, lateral view; P—phallos, ventral view. *p.-l. pr. tg.*—postero-lateral projections of tegumen.



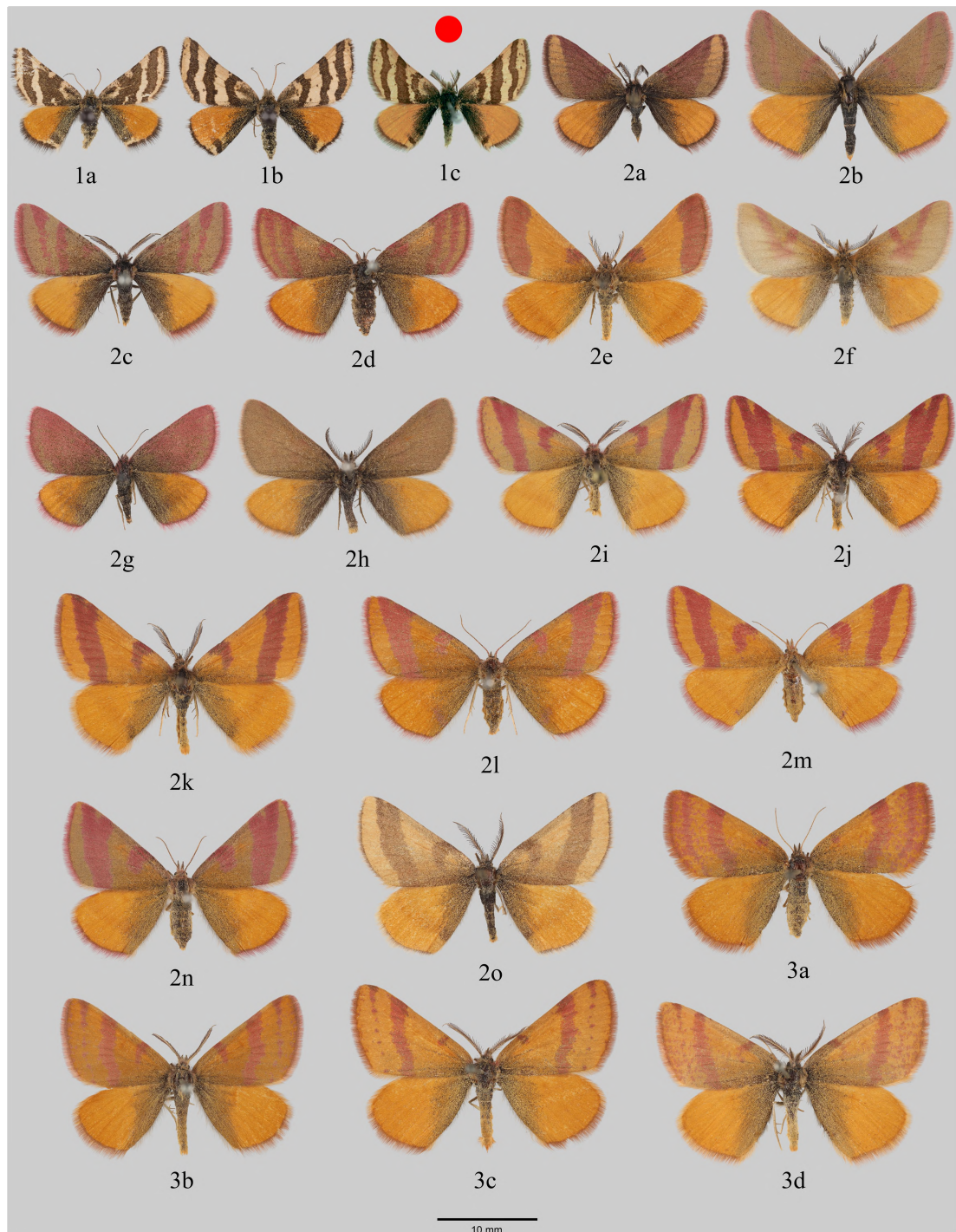


**FIGURE 8.** Female genitalia of *Rhodometra sacraria* and *Lythria* species, ventral view. A—*Rhodometra sacraria*; B—*L. (M.) venustata*; C, E—*L. (L.) cruentaria*; D—*L. (L.) sanguinaria*.



**FIGURE 9.** Female genitalia of *Lythria* species, ventral view. A–C—*L. purpuraria*; D, E—*L. plumularia*.





**PLATE 1.**

1a—*Lythria (Microlythria) venustata*: Kazakhstan, Aktobe Region, Bayganin District, 103 km NEE of Kulsary, Aktolagai Mts., chalk mountains, 47.5923314N, 55.147003E, 24.IV.2023, I. Makhov leg.

1b—**ditto**: Kazakhstan, Aktobe Region, Bayganin District, 103 km NEE of Kulsary, Aktolagai Mts., chalk mountains, 47.5923314N, 55.147003E, 24.IV.2023, I. Makhov leg.

1c—**ditto**: Venustata Stgr. | Origin. | Saisan Hbhr. [HOLOTYPE, photo by Wolfram Mey]

2a—*Lythria (Lythria) cruentaria*: [Russia] Barnaul 19 V [18]98 | coll. of A.M. Djakonov | 1727.

2b—**ditto**: NE Kazakhstan, Pavlodar Reg., Berezovka. 1.VI.1984 Mironov V.G. | ex coll. Zool. Acad. Sci. St.Petersburg, Russia.

2c—**ditto**: [Spain] Castilia | coll. of A.M. Djakonov | 1733.

2d—**ditto**: Castilia | coll. of A.M. Djakonov | 1735.

2e—**ditto**: 1935 VI.[19]27 Rossia centr. Vladimir, circ. S. Tshetverikov | evening floodplain dunes.

2f—**ditto**: ♂ Austria | v. Rotaria | Collection of the Grand Duke Nikolay Mikhailovich.



- 2g—**ditto**: [Russia] Leningrad. Obl., Tolmachevo st., 29.V.1980, Mironov V.G. | ex coll. Zool. Acad. Sci. St.Petersburg, Russia.  
 2h—**ditto**: Voronezh prov., P. Slashchevsky | 21.IV.[19]16.  
 2i—**ditto**: Petrop. [Saint Petersburg, Russia], 6/7.[18]80. | Collection of the Grand Duke Nikolay Mikhailovich.  
 2j—**ditto**: Petrograd [Saint Petersburg, Russia], coll. of Meberg | 18.VII.[1]918 [illegible].  
 2k—**ditto**: Petrograd, coll. of Meberg | 18.VII.[1]918 [illegible].  
 2l—**ditto**: Petrograd, coll. of Meberg | 18.VII.[1]918 [illegible].  
 2m—**ditto**: ♂ Austr[ia] | Purpuraria | Collection of the Grand Duke Nikolay Mikhailovich.  
 2n—**ditto**: Petrograd, coll. of Meberg | 13.VII.[19]16 [illegible].  
 2o—**ditto**: 5/VII/[19]15 | ex mater. Mus. Acad. Petrop. | Coll [illegible] Jakobson Petropol.  
 3a—*Lythria (Lythria) sanguinaria*: [Spain] Andalus[ia] Staudg. | coll. Acad. Petrop.  
 3b—**ditto**: Andalusia Stgr. | 140. | Collection of the Grand Duke Nikolay Mikhailovich.  
 3c—**ditto**: ♂ Hispan[ia] | Alph. Sanguinaria | Collection of the Grand Duke Nikolay Mikhailovich.  
 3d—**ditto**: Hispania | 675. | coll. Erschov.



**PLATE 2. 4a—*Lythria (Lythria) purpuraria***: [Kazakhstan] Semirechye, Usek, Taldy loc. in West of Tyshkan, ½.VI.1915, mat. of V. Kavrigin.

- 4b—**ditto**: [Kazakhstan] Semirechye, Usek gorge, Taldy loc. in West of Tyshkan, 4.VI.1915, mat. of V. Kavargin.
- 4c—**ditto**: [Russia] Kolomna, 7 VII [1]923.
- 4d—**ditto**: 14-VI-[1]922, [Russia] Omsk, V. Shchuko | *Lythria lutearia* Viev. | coll. of Shchuko.
- 4e—**ditto**: ♂ Cauc[asus]. S. | 21 6 *Purpuraria* Alph. | Collection of the Grand Duke Nikolay Mikhailovich.
- 4f—**ditto**: Tavriisk, field, Khers[on]. obl. Ukraine, Khalin, 27 VI 1995 | forest-steppe, evening, partly cloudy.
- 4g—**ditto**: [Kazakhstan] Semirechye, Chik-Bulak in West of Usek, start VI.1915 of V. Kavargin.
- 4h—**ditto**: [Crimea] Kerch. | coll. of Kirichenko | N. Filipjev det.
- 4i—**ditto**: ♂ Austr[ia] | *Purpur[aria]* | Collection of the Grand Duke Nikolay Mikhailovich.
- 5a—***Lythria (Lythria) plumularia***: [Switzerland] Helvetia | coll. of A.M. Djakonov | 1670.
- 5b—**ditto**: ♂ Helvetia | Alph[eraky]. | Collection of the Grand Duke Nikolay Mikhailovich.
- 5c—**ditto**: ♀ Rhaetia | Alph[eraky]. | Collection of the Grand Duke Nikolay Mikhailovich.
- 5d—**ditto**: Helvetia | coll. of A.M. Djakonov | 1671.
- 5e—**ditto**: *Plumusharia* H. Sd. Fros n. Hopffer. | [illegible] | 80 a | coll Eversmann
- 5f—**ditto**: Helvetia Stgr. | Collection of the Grand Duke Nikolay Mikhailovich.
- 5g—**ditto**: *L. plumularia* Graubot | Collection of the Grand Duke Nikolay Mikhailovich.
- 5h—**ditto**: [Switzerland] Engadin | coll. Erschov.

## Label data of the moths and microscopic preparations shown in figures

### FIG. 2.

A–E. *Lythria (Microlythria) venustata*: Kazakhstan, Aktobe Region, Bayganin District, 103 km NEE of Kulsary, Aktolagai Mts., chalk mountains, 47.5923314N, 55.147003E, 24.IV.2023, I. Makhov leg.; prep. IM761 [ZISP]

### FIG. 7.

- A–D. *Lythria (Microlythria) venustata*: W. Kazakhstan, Aktolagai Plateau, 35 km E of Miyaly, 140 m, N47°29', E55°11', 16.IV.2013, P. Gorbunov leg. | prep. IM777 [CSM]
- E, F. *L. (M.) venustata*: W. Kazakhstan, Atirau reg., Karabatan env., 1.05.2006, EOP-26, Kadyrbekov R. leg. | Genit. prep. ♂ No. 627 ♂ V. Mironov | 2008 *Lythria venustata* Staudinger, 1882 V. Mironov det. | ex coll. Zool. Inst. Acad. Sci. St.Petersburg, Russia [ZISP]
- G–I. *L. (L.) cruentaria*: [Saint Petersburg] Lebyazhya village, Peterhof district, Bianki, 12 V [18]97 | prep. IM773 [ZISP]
- J–L. *L. sanguinaria*: *Sanguinaria Pyrenées orient.* | 79 b. | coll. Eversmann | prep. IM774 [ZISP]
- M, N. *L. (L.) plumularia*: [Switzerland] 568. | Engadin | coll. Erschov | prep. IM775 [ZISP]
- O, P. *L. (L.) purpuraria*: Russia, Republic of Buryatia, Kabansky Distr., Selenga river valley, 3 km NW of Selenginsk, 52°02'00"N, 106°49'15"E, , I. Makhov leg., 7.VIII.2019, | prep. IM672 [ZISP]

### FIG. 8.

- A. *Rhodometra sacraria*: [Uzbekistan] 4.VI. Buhara mer, Termez, 1912, Kiritschenko | 1642 | coll. of A.M. Djakonov | prep. IM833 [ZISP].
- B. *Lythria (Microlythria) venustata*: see Fig. 2: A–E.
- C. *L. (L.) cruentaria*: Lebedin in Sumy obl., Piskunov, 9.5[1]968 | prep. IM768 [ZISP].
- D. *L. (L.) sanguinaria*: Hisp[ania]. c. | 17/6. | 1731 | coll. of A.M. Djakonov | prep. IM758 [ZISP].
- E. *L. (L.) cruentaria*: Grabari, 1 km west of Lebedin in Sumy obl., Piskunov, 7.5[1]968 | prep. IM767 [ZISP].

### FIG. 9.

- A. *L. (L.) purpuraria*: [Kazakhstan] Akm. Kokch.[etavskaya]. obl., Shchuchye-Barmashi, Filipjev, 5VII[19]28 | prep. IM769 [ZISP].
- B. *L. (L.) purpuraria*: 22/4 7 | Transcaspien, Sumbar, Herz, 1894. | Collection of the Grand Duke Nikolay Mikhailovich. | N. Filipjev det. | prep. IM771 [ZISP].
- C. *L. (L.) purpuraria*: Balka Shuty near Mertvovod, 23.VIII.[1]922 | prep. IM770 [ZISP].
- D. *L. (L.) plumularia*: Helvetia | coll. Erschov | prep. IM766 [ZISP].
- E. *L. (L.) plumularia*: ♀ Helvetia | Collection of the Grand Duke Nikolay Mikhailovich. | prep. IM759 [ZISP].

## Acknowledgments

The work was performed using the equipment of the Core Facilities Center ‘Taxon’ of the Zoological Institute of the Russian Academy of Sciences (sample preparation, photographing microscopic preparations).

The authors express gratitude to Evgeny Beljaev (Vladivostok, Russia) for useful consultations and to Sergey Melyakh (Yekaterinburg, Russia) for providing materials from his private collection.

The authors are grateful to the reviewers Evgeny Beljaev and Anthony Galsworthy, as well as one anonymous reviewer for their valuable remarks and comments, as well as for correcting the language.

## Funding

The work of Ilya Makhov was performed within the framework of state project no. 122031100272-3 “Systematics, morphology, ecophysiology and evolution of insects” (analysis of the material). The study of Pavel Gorbunov was partly financed by the project FUWU-2022-0007 “Interaction of natural and anthropogenic factors in the formation of biological diversity of the Ural flora and fauna” of the Institute of Plant and Animal Ecology of the Ural branch of the RAS. The travel of the first and the third authors to NW Kazakhstan was funded by the Russian Science Foundation, project number 19-14-00202 (field studies, collecting the material).

## References

- Cook, M.A. & Scoble, M.J. (1992) Tympanal organs of geometrid moths: A review of their morphology, function, and systematic importance. *Systematic Entomology*, 17, 219–232.  
<https://doi.org/10.1111/j.1365-3113.1992.tb00334.x>
- Duponchel, P.-A.-J. (1842–[1845]) n.k. In: *Histoire naturelle des lépidoptères ou papillons de France. Supplément aux tomes quatrième et suivants*. Méquignon-Marvis, Paris, pp. 1–554 + (555). [in French]
- Freyer, C.F. (1831–1833) *Neuere Beiträge zur Schmetterlingskunde mit Abbildungen nach der Natur. 1 (1–16)*. C. Kollmann’schen Buchhandlung, Augsburg, iv + 182 pp., 96 pls.  
<https://doi.org/10.5962/p.314524>
- Gorbunov, P. Yu. (2011) Geometridae. In: Matov, A. Yu. & Nupponen, K.T. (Eds.), *Higher Lepidoptera (Macrolepidoptera) of the deserts and southern steppes of Western Kazakhstan. Review of the fauna*. I.P. Lisitsyna, Yekaterinburg, pp. 23–44. [in Russian]
- Hausmann, A. & Viidalepp, J. (2012) Subfamily Larentiinae 1. In: Hausmann, A. (Ed.), *The Geometrid Moths of Europe. Vol. 3*. Apollo Books, Stenstrup, pp. 1–743.
- Hübner, J. (1816–1826) n.k. In: *Verzeichniß bekannter Schmettlinge [sic]*. bey dem Verfasser zu finden, Augsburg, pp. 1–431 (Verzeichniß) & 1–72 (Anzeiger). [imprint “1816”]
- Hufnagel, J.S. (1767) Fortsetzung der Tabelle von den Nachtvoegeln, welche die 3te Art derselben, nemlich die Spannenmesser (Phalaenas Geometras Linnaei) enthält. *Berlinisches Magazin*, 4 (5), 504–527. [in German]
- Klots, A.B. (1970) Lepidoptera. In: Tuxen, S.L. (Ed.), *Taxonomist’s Glossary of genitalia in insects. 2nd Edition*. Munksgaard, Copenhagen, pp. 115–130.  
<https://doi.org/10.2307/2411797>
- Kuznetsov, V.I. & Stekolnikov, A.A. (1997) 29. Order Lepidoptera – Cheshuyekrylye. In: *Key to the insects of Russian Far East. Vol. V. Trichoptera and Lepidoptera. Pt 1*. Dal’nauka, Vladivostok, pp. 207–238 [in Russian]
- Linnaeus, C. (1758) *Systema Naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis. Tomus I. Editio decima, reformata*. Laurentius Salvius, Holmiae [Stockholm], 824 pp.  
<https://doi.org/10.5962/bhl.title.542>
- McGuffin, W.C. (1967) Guide to the Geometridae of Canada (Lepidoptera), I, Subfamily Sterrhinae. *Memoirs of the Entomological Society of Canada*, 50, 1–67.  
<https://doi.org/10.4039/entm9950fv>
- Müller, B., Erlacher, S., Hausmann, A., Rajaei, H., Sihvonen, P. & Skou, P. (2019) Ennominae II. In: Hausmann, A., Sihvonen, P., Rajaei, H. & Skou, P. (Eds.), *Geometrid Moths of Europe. Vol. 6. Part 2*. Brill, Leiden, pp. 846.  
<https://doi.org/10.1163/9789004387485>
- Öunap, E., Mironov, V. & Viidalepp, J. (2009) Molecular phylogeny of the genus *Lythria* and description of the male genitalia of *L. venustata* (Lepidoptera: Geometridae: Sterrhinae). *European Journal of Entomology*, 106, 643–650.  
<https://doi.org/10.14411/eje.2009.080>
- Öunap, E., Viidalepp, J. & Saarma, U. (2008) Systematic position of Lythriini revised: transferred from Larentiinae to Sterrhinae (Lepidoptera, Geometridae). *Zoologica Scripta*, 37 (4), 405–413.  
<https://doi.org/10.1111/j.1463-6409.2008.00327.x>



- Pitkin, L.M. (1993) Neotropical emerald moths of the genera *Nemoria*, *Lissochlora* and *Chavarriella*, with particular reference to the species of Costa Rica (Lepidoptera: Geometridae, Geometrinae). *Bulletin of the Natural History Museum, Entomology Series*, 62 (2), 39–159.
- Pitkin, L.M. (1996) Neotropical emerald moths: a review of the genera (Lepidoptera: Geometridae, Geometrinae). *Zoological Journal of the Linnean Society*, 118, 309–440.  
<https://doi.org/10.1111/j.1096-3642.1996.tb01268.x>
- Rajaei, H., Hausmann, A., Scoble, M., Wanke, D., Plotkin, D., Brehm, G., Murillo-Ramos, L. & Sihvonen, P. (2022) An online taxonomic facility of Geometridae (Lepidoptera), with an overview of global species richness and systematics. *Integrative Systematics*, 5 (2), 145–192.  
<https://doi.org/10.18476/2022.577933>
- Scoble, M.J. (1994) A taxonomic revision of the genera *Phrygionis* Hübner and *Pityjea* Walker (Geometridae: Ennominae, Palyadini). *Zoological Journal of the Linnean Society*, 111 (2), 99–160.  
<https://doi.org/10.1111/j.1096-3642.1994.tb01480.x>
- Scoble, M.J. (Ed.) (1999) *Geometrid moths of the world: a catalogue (Lepidoptera, Geometridae)*. Vol. 2. CSIRO Publishing and Apollo Books, Collingwood, Victoria, 563 pp.  
<https://doi.org/10.1071/9780643101050>
- Sihvonen, P., Murillo-Ramos, L., Brehm, G., Staude, H. & Wahlberg, N. (2020) Molecular phylogeny of Sterrhinae moths (Lepidoptera: Geometridae): towards a global classification. *Systematic Entomology*, 45, 606–634.  
<https://doi.org/10.1111/syen.12418>
- Sihvonen, P., Mutanen, M., Kaila, L., Brehm, G., Hausmann, A. & Staude, H.S. (2011) Comprehensive molecular sampling yields a robust phylogeny for geometrid moths (Lepidoptera: Geometridae). *PLoS ONE*, 6 (6), e20356.  
<https://doi.org/10.1371/journal.pone.0020356>
- Staudinger, O. (1882) Beitrag zur Lepidopteren-Fauna Central-Asiens. *Entomologische Zeitung*, 43, 35–78. [in German]  
<https://doi.org/10.1002/mmnd.48018820203>
- Vasilenko, S.V. (2009) *Lythria venustata* (Lepidoptera, Geometridae)—a rare species from Kazakhstan. *Zoological Journal*, 88, 508–510 [in Russian]