

Taxonomic notes on the morphology, ecology and distribution of the *Crocallis elinguaris* (LINNAEUS, 1758) species lineage of Asia Minor and the eastern adjacent territories with description of five new species and one new subspecies (Lep. Geometridae)

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Abstract

A complete overview of all members of the *Crocallis elinguaris* (LINNAEUS, 1758) species lineage in Asia Minor and the eastern adjacent territories is given, and all available information regarding bionomics, habitats and distribution pattern is presented. Five new species of *Crocallis* TREITSCHKE, 1825 are described: *Crocallis merzbacheri* spec. nov., *Crocallis elingomorpha* spec. nov., *Crocallis loebeli* spec. nov., *Crocallis rothei* spec. nov., *Crocallis sylvana* spec. nov., together with one new subspecies *Crocallis inexpectata cappadoica* subsp. nov. A preliminary characterisation of this lineage is also presented.

Introduction

The genus *Crocallis* was established for *Phalaena elinguaris* (LINNAEUS, 1758) by TREITSCHKE in 1825. It consists of several medium sized Geometrid moths with strong and hairy bodies. The members of the genus are found in wide range of habitat from high montane forests, high mountain and a range of lowland areas including Mediterranean Macchia. All species are univoltine, flying from late summer to early autumn. So far, 20 species have been described (SCOBLE & HAUSMANN 2007, STADIE & LEHMANN 2012). The genus has an exclusively Palaearctic distribution with the centre of occurrence in the Mediterranean basin and Asia Minor.

Apart from several descriptions of new species, only a few comprehensive articles on the genus have been published. WEHRLI summarized all available information regarding the genus and described several new taxa without reference to the genital structure (SEITZ 1940, 1954). WARNECKE presented good descriptions of *Crocallis elinguaris* (LINNAEUS, 1758), *C. albarracina* WEHRLI, 1940 and *C. inexpectata* WARNECKE, 1940, and included good drawings of the genitalia (WARNECKE 1940). DANTART et al. published a complete overview of all *Crocallis* species of the Iberian peninsula, including genitalia, distribution maps and bionomical data (DANTART et al. 1993).

However a clear morphological characterization of *Crocallis* and its separation from related genera, *Scodiomyia* STAUDINGER, 1892, *Odontopera* STEPHENS, 1831, *Gonodontis* HÜBNER, [1823] and *Aethiopodes* WARREN, 1902 on a worldwide basis has never been made, a situation that was regretted even by DANTART et al. (DANTART et al. 1993).

Therefore a complete revision of the whole genus is badly needed. This paper presents a comprehensive overview of all taxa closely related to *Crocallis elinguaris* and gives a characterization of this species group based on external morphology and genital structure, bionomics and genetic data, as a first step towards a complete revision of the genus.

Material and methods

For the present study, the material in the Museum für Naturkunde, Humboldt-Universität zu Berlin, Germany (MNHU), the Naturhistorische Museum, Vienna, Austria, the Zoologisches Forschungsinstitut und Museum Alexander Koenig, Bonn, Germany (ZFMK) and the Zoologische Staatssammlung München, Germany (ZSM) and all specimens in the private collections of Thomas DRECHSEL, Neubrandenburg, Germany, Jörg GELBRECHT, Königs Wusterhausen, Germany, Egbert FRIEDRICH, Jena, Germany, Michael LEIPNITZ, Stuttgart, Germany, Hans LÖBEL, Sondershausen, Germany, Bernd MÜLLER, Berlin, Germany, Bernd SCHACHT, Dahlewitz, Germany, Steffen ROTHE, Taucha, Germany and the private collections of the authors have been included.

The holotypes of *Crocallis albarracina*, 1940, *Crocallis mirabica* BRANDT, 1941 and the syntypes of *Crocallis inexpectata caucasi* WEHRLI, 1954 and paratypes of *Crocallis pototskii* VIDALEPP, 1988 have also been checked.

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Altogether, 100 dissections of genitalia have been made and compared.

In addition, the results of DNA-barcoding were used, totalling 55 specimens from all available taxa. During expeditions, females of *Crocallis* species were collected whenever possible for oviposition. All 5th instar larvae were studied and photographed. All experiences of colleagues regarding bionomics and habitats have been carefully evaluated.

Results

The *Crocallis elinguaris* species group

This group consists of following known species: *Crocallis elinguaris*, *C. albarracina*, *C. pototskii*, *C. MERZ-BACHERI* spec. nov. and all taxa in the *C. inexpectata* species complex. This group is widely distributed from Morocco in the west, throughout Europe, Asia Minor, Caucasus, Siberia and eastwards towards Russian Far East and Japan.

The members of the group share some characteristic features of genital morphology. Typical is a comparatively long and slender uncus, together with a more or less triangular valva, a narrower, less sclerotized vinculum and markedly narrower saccus. Furca when present, strongly sclerotized.

Crocallis elinguaris (LINNAEUS 1758)

Material: more than 100 ♂♂ and ♀♀ from Central Europe, coll. D. STADIE, ZFMK, ZSM; 1♂ Russland Republik Altai, Aktash Umg.(ebung) Steinbruch 6km s(üdlich), N 50°16'55" E 87°40'21", 28.07./03.08.2011 LF(Lichtfang) 1393m, leg. D. STADIE & Th. DRECHSEL, coll. D. STADIE; 2 ♂♂ Russland Republik Altai, Aktash Umg.(ebung) Steinbruch 3km s(üdlich), N 50°18'20" E 87°39'27", 27./31.07.2011 LF(Lichtfang) 1396m, leg. D. STADIE & Th. DRECHSEL, coll. D. STADIE; 2 ♂♂ Russland Republik Altai, Aktash Umg.(ebung) Steinbruch 10km s(üdlich), N 50°15'12" E 87°42'31", 29.07.2012 LF(Lichtfang) 1465m, leg. D. STADIE & Th. DRECHSEL, coll. D. STADIE (DS 88/2012); 1♂, 1♀ Altai coll. LED(ERER), MNHU.

Description. External characters (Fig.1a-f). Wingspan of male 35–40mm (forewing length 18–20.5mm), females 38–42mm (forewing length: 20–22mm) slightly larger. Antennae of males bipectinate, pectination long, five times longer than diameter of the flagellum, those of females filiform. Forewing broadly triangular, apex pointed, termen strongly rounded, margin sometimes slightly undulate. Ground colour of forewing upper side rich lemon yellow to light ochre brown. Antemedian fascia more or less straight, often arched to wing base near costa, slightly curved outwardly towards dorsum; postmedian more or less parallel to termen in costal third, then slightly curved basad to dorsum. Median field trapezoid, with darker suffusion near both lines or completely darkened. In populations from the Altai the latter always completely darkened red to chocolate brown. Terminal line reduced to isolated dark brown dots or completely absent. Cell spot dark to black brown, large, dot like or oval. Whole wing surface speckled with small patches of ochre brown scales. Fringes concolorous or slightly darkened.

Hindwing upper side comparably lighter yellow, slightly darkened towards termen. Postmedian fascia weak, with low contrast, dark ochre to brown grey. Cell spot small, dot-like, occasionally completely absent.

Underside of same ground colour. Pattern of forewing underside obsolescent towards inner margin. Antemedian fascia absent; postmedian fascia usually only visible in costal third of forewing. Veins slightly darker than ground colour. Terminal dots sometimes present. Cell spot markedly weaker than on upper surface.

Hindwing underside in general much more contrasting than on upper side. All elements of pattern distinctly more strongly developed including the cell spot.

Male genitalia (Fig. I/II). Uncus narrow, moderately long. Valva triangular, elongated and somewhat tapered; outer margin slightly curved, in specimens from Altai slightly undulate (Fig.II); costa and outer margin more strongly sclerotized; infracostal bar sparsely covered with long bristles, extending to a semi-circular subapical field densely covered by bristles. A pair of strongly sclerotized juxta projections (furca) is present, reaching less than the half length of costa. Saccus narrow, rounded. Aedeagus long and slender, cylindrical, slightly but continuously curved; coecum arched, dilated basally, spoon-like; apically, with a single, delicate, medium sized cornutus.

Female genitalia. (Fig. XIII). Papillae anales rounded, semicircular in shape. Apophyses posteriores twice as long as apophyses anteriores. Antrum with constriction in the middle, sclerotized; ductus bursae folded; ductus and corpus bursae membranous, the latter with a small oval signum covered with short spines.

Diagnosis. *Crocallis elinguaris* is the most widespread member of the genus. Variation is slight in this part of its range, both in external appearance and genitalic features. Typically, the ground colour is a rich, more or less bright yellow, with contrasting, darker median field and well developed cell spots on both wings with series of terminal dots on forewing upper surface. However in some Scottish populations, the ground colour is more brownish, without any contrast in the median field and terminal dots, which are more weakly developed. *C. elingomorpha* spec. nov. from the Caucasus and North East Turkey is the only species to show a great resemblance to *C. elinguaris*, but the two taxa are thought to be allopatric.

In male genitalia, *C. elinguaris* is clearly separable on the shape of the valva, which is elongated and more or less straight, and the furca is distinctly shorter, reaching less than half length of costa. In *C. elingomorpha* spec. nov. the valva is very short and broad, strongly arched at costa; the branches of furca are markedly longer and weaker, reaching 60% of costal length. Aedeagus of *C. elinguaris* with only one cornutus, whereas in *C. elingomorpha* there are two cornuti.

Distribution. Euro-Siberian. Present in parts of the Iberian Peninsula (DANTART et al. 1993, REDONDO et al. 2009), throughout North and Central Europe towards Arctic Circle and parts of South-East Europe (EBERT 2003). In the east, the species extends to the Altai, Russian Far East and Japan. Absent probably from many parts of the Balkan Peninsula, whole of Asia Minor, Transcaucasia and Central Asia. A single doubtful record from the Rif-Atlas (Morocco) in the west (DE BROS & SCHMIDT-KOEHL 1979, RUNGS 1981). Distributed from the plains up to 2000m in the Alps and Altai (pers. obs.).

The status of the populations in the Balkans is unclear and subject of recent studies within the GME-project. Therefore we decided to omit a distribution map here.

Phenology. Univoltine. Flight period from early June to mid-August depending on the altitude and local climate. Some specimens until late August (EBERT 2003, REDONDO et al. 2009, SCHÖNBORN 2011). Very late specimens recorded in September-October probably represent a partial second generation. Larval period from April to June. Usually overwintering as eggs (pers. obs.), but there are rather doubtful reports from Spain of the larva overwintering (GÓMEZ DE AZIPURA 1987).

Bionomics. Larva polyphagous on deciduous trees and shrubs of the genera *Prunus*, *Betula*, *Alnus*, *Salix*, *Quercus*, *Fagus*, *Rosa*, *Syringa* and *Lonicera*. Also reported from *Sarothamnus* and *Genista*. In higher mountains mainly found on *Vaccinium myrtillus* (BERGMANN 1953, SCHÖNBORN 2011).

Habitat. In the lowlands riverine forests, edges of deciduous forests, clearings, often southward or south-westward facing bushy slopes with large stands of *Prunus spinosa*, but in lower abundance. Much more frequent in mountain pine forests and bogs with large stands of *Vaccinium* (pers. obs. in the Harz mountains, Thuringia, Alps and Altai).

Genetic data: genetically homogeneous from Central Europe to the Altai Mountains. Most closely related species: *C. albarracina* 1.24%.

***Crocallis pototskii* VIDALEPP, 1988**

Material. 3♂♂ Tadjikistan, Gissar Mts. (mountains) 1800m, vic. Takob, Peschanbe, 16.-27.VIII. 1999 leg. Y. SHCHETKIN, coll. ZFMK (locus typicus?) (DS 131/2012; DS 132/2012; DS 137/2012)

Description. External characters (Fig.8a-b). A poorly known species. Wingspan 34-38mm, forewing length 17.5-19.5mm. Antennae of males bipectinate, branches four times longer than the diameter of the flagellum; the latter dorsally ivory white. Frons, vertex and thorax covered with hairy scales, light yellow to ochre brown. Proboscis reduced.

Forewing broadly triangular, with pointed apex and rounded termen; ground colour light ochre to dark ochre brown. Antemedian and postmedian fasciae ochre brown with a whitish shadow distally, the first straight, the latter nearly parallel to termen in costal third, then slightly curved to dorsum. Median field more or less evenly darkened, ochre brown. Cell spot large, oval, dark brown. Whole wing surface covered with fine patches of ochre brownish scales. Fringes concolorous.

Hindwing upper side light ochre to light ochre brown, much paler towards wing base. Postmedian fascia hardly visible, or only present near dorsum. Cell spot weak and indistinct or completely absent. Both wings markedly glossy.

Forewing underside light ochre brown, with pattern reduced at inner margin; postmedian fascia only visible near costa; cell spot small and indistinct. Hindwing underside light ochre brown, with indistinct postmedian fascia; cell spot small, indistinct. Both wings covered with small patches of ochre brown scales.

Male genitalia. (Fig. III). Uncus moderate in length and slender. Valva triangular, rather elongated, moderately pointed; costa and basal margin more heavily sclerotized; infracostal bar covered with very sparse long bristles; subapical hairy field oval, slightly widened to base. Juxta projections (furca) very short, reaching less than a quarter length of costa; saccus narrow. Aedeagus slender, curved more or less continuously from base to tip; coecum angled and spoon-like dilated; tip remarkably conical. At base of vesica three or four long, needle-shaped cornuti.

Female genitalia. Not examined.

Diagnosis. Externally very similar to *C. inexpectata inexpectata*, *C. inexpectata caucasii*, *C. loebeli* spec. nov. and *C. elinguarina*. *C. elinguarina* has brighter yellow ground colour; it also differs in shape of antemedian fascia, which is markedly less oblique, the presence of subterminal dots on both upper and under surfaces, and a well developed cell spot on upper side of hindwing. *C. loebeli* spec. nov. differs usually in paler ground colour, the shape of the cell spot of forewing upper side, which is usually more comma-like, the different shape of antemedian fascia, which is slightly curved distally towards dorsum and the absence of patches of darker scales on both wings.

The separation of *C. pototskii* from *C. inexpectata inexpectata* and *C. inexpectata caucasii* by external characters is impossible, owing to the wide range of variation of that species.

However, the male genitalia of *C. inexpectata* and *C. loebeli* spec. nov. are quite different. Much more similar is *C. elinguarina*, in which the uncus, tegumen and shape of the valva are very similar to those of *C. pototskii*. The latter differs in the strongly reduced furca branches, the shape of the hairy field at tip of valva and in the presence of three or four, needle shaped cornuti at tip of aedeagus. A check of male genitalia is always sufficient for clear separation.

Distribution. Mountain chains of Central Asia. According to the original description, confirmed vouchers are known from Tadzhikistan (Gissar Mts.), Kirgistan (Tschatkal and Alai Chain), Uzbekistan (Tschimgan). Altitudinal distribution from 1800-3000m (VIIDALEPP 1988).



Phenology. As known at present, the flight period extends from the last two weeks of August to first week of September. One male has been reported from early August.

Bionomics and habitat. Unknown.

Genetic data. Not available.

***Crocallis merzbacheri* STADIE & FIEBIG spec. nov.**

Material.

Holotype ♂ (Kazakhstan), (Central) Tian Shan (Narynkol vic. 20.08-10.09.1902, 1800-2000m, N 42°43'24" E 80°10'40" coll. (G.) MERZB.(ACHER), coll. ZSM. (DS 161/2012)

Description. External characters (Fig. 7a-b). The holotype is fairly worn. Female unknown. Wingspan of male 33mm, forewing length 18mm. Antennae bipectinate, flagellum dorsally light ochre brown. Vertex and thorax densely covered with hairy scales of light ochre yellow colour. Both wings concolorous. Apex of forewing pointed, termen strongly rounded. Ante- and postmedian fasciae brownish with a reddish tinge. Antemedian fascia rather straight, forming a right angle at costa; postmedian fascia nearly parallel to termen in costal third of forewing, reaching costa in an acute angle, and markedly curved basad towards dorsum; median