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Taxonomic revision of the *Campoplex difformis* group (Ichneumonidae, Campopleginae), with particular reference to species of economic importance

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Abstract. Despite their importance as potential biological control agents, species of the campoplegine genus *Campoplex* Gravenhorst, 1829 are hard to identify. Previous works provided short descriptions or poor illustrations of crucial characters, meaning it is often impossible to distinguish closely related species. We provide illustrations to identify species of the *Campoplex difformis* group and redescriptions of and illustrations for *C. difformis* (Gmelin, 1790), *C. capitator* Aubert, 1960, *C. dubitator* Horstmann, 1985, *C. formosanae* Horstmann, 2012, and *C. unicingulatus* (Schmiedeknecht, 1909). In addition, the taxonomic status of *C. difformis* is clarified; a lectotype is designated for *C. capitator* in Aubert's collection in Lausanne and the host record for this species on *Ancylis mitterbacheriana* (Denis & Schiffermüller, 1775) is queried; *Campoplex corsicator* Aubert, 1960 stat. nov. is removed from synonymy with *Campoplex tibialis* (Szépligeti, 1916) and redescribed.

Keywords. Biological control, *Lobesia botrana*, European grapevine moth, parasitoid-host relationship, cocoons; taxonomy.

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Introduction

The campoplegine genus *Campoplex* Gravenhorst, 1829 includes more than 200 species worldwide (Yu *et al.* 2016), with most of the described species in the Western Palaearctic (about 100 valid species) (Yu *et al.* 2016; Horstmann 2012; Zwakhals & van Achterberg 2017). Species of *Campoplex* are koinobiont endoparasitoids of Lepidoptera (Shaw & Aeshlimann 1994; Athanassov *et al.* 1998; Jenner & Kuhlmann 2006) and many species are of economic importance, having been employed in biological control programs (Bartlett *et al.* 1978; Jenner *et al.* 2005; Scaramozzino *et al.* 2018).

Despite their importance, the taxonomy of *Campoplex* is tangled and identification to species is often a prohibitively difficult task without a good reference collection. In the last few decades, the European species of the group were studied by the late K. Horstmann, who added new species and clarified the status of many others (Horstmann 1980, 1985, 1993, 2008, 2012; Horstmann & Yu 1999). A few species have also been described by Aubert (1960a, 1966a, 1972, 1977, 1980), who provided, however, very short descriptions and did not produce any summary work.

During investigations on ichneumonid parasitoids of the European grapevine moth (EGVM), *Lobesia botrana* (Denis & Schiffermüller, 1775), in Italy (Scaramozzino *et al.* 2018), we came across taxonomic confusion surrounding two morphologically similar species, *Campoplex difformis* (Gmelin, 1790) and *C. capitator* Aubert, 1960, both related to the biological control of this important pest of vineyards. Recent studies showed that *C. capitator* may represent one of the best candidates for EGVM control (Ioriatti *et al.* 2011; Lucchi *et al.* 2017). Its life cycle is strongly synchronized with that of EGVM (Scaramozzino *et al.* 2018) and, beyond *L. botrana*, its host range seems limited to a few other tortricid species feeding on grapevine, such as *Eupoecilia ambiguella* (Hübner, 1796) and occasionally *Sparganothis pilleriana* (Denis & Schiffermüller, 1775) (Villemant *et al.* 2011; Yu *et al.* 2016). Aubert (1983) reports this species also from *Ancylis mitterbacheriana* (Denis & Schiffermüller, 1775) on *Quercus pubescens* Wild., but the record is doubtful, as *A. mitterbacheriana* is a leaf-rolling tortricid that lives in deciduous woodlands (Brown *et al.* 2008).

Villemant *et al.* (2011) pointed out that *Campoplex capitator* has often been confused with *C. difformis* in the past and many reports of *C. difformis* on EGVM probably refer to *C. capitator* (see for example Scaramozzino *et al.* 2018). These two species belong to the *difformis* species group, which has been revised by Horstmann (1985) and which includes species that are often better characterized on the basis of their biology than external morphology (Horstmann 2012). Unfortunately, Aubert's descriptions of *C. capitator* (Aubert 1960a, 1960b, 1962, 1966b) are poor and Horstmann (1985), although providing a key to separate species of the group, did not illustrate crucial characters for distinguishing them.

In addition, the interpretation of *Ichneumon difformis* Gmelin, 1790, the type of which has been destroyed (Horstmann 1969, 1985; Townes *et al.* 1965), has been disputed by Aubert (1971, 1974, 1981). Following the interpretation given by Gravenhorst (1829), Horstmann (1969) fixed the lectotype of *Limneria mutabilis* Holmgren, 1860, in Holmgren's collection, as the neotype of *Campoplex difformis*, thus making *mutabilis* a junior synonym of *difformis*. On the other hand, authors in the distant past like Holmgren or Thomson, considered *C. difformis* and *C. mutabilis* as distinct species and applied the name *difformis* to *C. deficiens* Gravenhorst, 1829 (Horstmann 1969, 1985). For this reason, Aubert (1971, 1974, 1981) rejected the neotype designation of Horstmann and created a neotype for *difformis* in Thomson's collection in Lund, in order to keep *mutabilis* as a distinct species, separate from *difformis* (syn. *C. deficiens*). Aubert's designation is invalid and must be rejected, as there is no provision in the ICZN Code to simply reject a primary type designation.

After studying Horstmann's collection in Munich and Aubert's collection in Lausanne, we endorse here the interpretation of *difformis* provided by Horstmann (1969, 1985, 2000) and Yu & Horstmann (1997),

since it is a valid nomenclatural (Art. 75 of ICZN). Therefore, we reinterpreted specimens in Aubert's collection in the light of Horstmann's revision of the *Campoplex difformis* group (Horstmann 1985). A lectotype is designated for *C. capitator* in Aubert's collection in Lausanne; in addition, the host record of this species from *Ancylis mitterbacheriana* on *Quercus pubescens* was queried. *Campoplex corsicator* Aubert, 1960 stat. nov. is removed from synonymy with *C. tibialis* (Szépligeti, 1916) and redescribed. Also, we provide characters and illustrations to recognize species belonging to the *Campoplex difformis* group and to tentatively separate the cluster of closely related species represented by *C. difformis*, *C. capitator*, *C. dubitator* Horstmann, 1985, *C. formosanae* Horstmann, 2012, and *C. unicingulatus* (Schmiedeknecht, 1909).

Material and methods

Photographs were taken with a Nikon D5300 digital camera attached to a Leica Z16 APO stereoscope in Pisa (Italy) and Nikon V1 digital camera attached to a Leica DMRBE stereoscope in Munich (Germany). Images were acquired using StackShot TM multiple-focus imaging system and stacked in a single in-focus image using Zerene Stacker software ver. 1.04 and Helicon Focus 3D ver. 3.9.7W.

Morphological terminology of adults follows Broad *et al.* (2018). Ovipositor ratio is defined as the ratio between the length of the ovipositor sheath (or the equivalent length of the ovipositor) and the length of the hind tibia. Height of the face is measured as the distance between the lower margin of the antennal socket and the dorsal margin of the clypeus (at the centre), while width of the face is taken as the minimum distance between internal orbits. OOD (ocular-ocellar distance) is taken as the minimum distance between the eye and a posterior ocellus. As in most species of *Campoplex* the area superomedia is not always clearly separated from the area petiolaris by a discernible carina (formally the median section of the posterior transverse carina), the length of the area superomedia is tentatively measured from the anterior transverse carina between the area basalis and area superomedia to the indicative point of the presence of the posterior transverse carina between the area superomedia and area petiolaris, which can be inferred from the bending of the lateromedian longitudinal carina.

In addition, cocoons from specimens in MZL, NMS, and ZSM have been examined. Measurements follow Sarzetti *et al.* (2019), morphological terminology follows Quicke (2015) and Sarzetti *et al.* (2019).

Institutional abbreviations

- DISAAA = Department of Agriculture, Food and Environment at Pisa University, Pisa, Italy [specimens of *C. capitator* obtained from *Lobesia botrana* (Lepidoptera, Tortricidae) collected in San Rossore (Pisa) on *Daphne gnidium* L. (Thymelaeaceae) or collected in Italian vineyards, and preserved in the collection of the DISAAA]
- MSNV = Museo di Storia Naturale di Verona, Italy [specimen identified by J-F. Aubert as *C. capitator* and obtained from *Ancylis mitterbacheriana* on *Quercus pubescens*, and preserved in the MSNV]
- MZL = J-F. Aubert's collection at the Musée cantonal de Zoologie in Lausanne, Switzerland
- NMS = National Museums of Scotland, Edinburgh, Scotland [*Campoplex* spp. determined by K. Horstmann]
- ZSM = Zoologische Staatssammlung Munich, Germany [main collection (mainly material of R. Bauer & R. Hinz) and K. Horstmann's collection]

Abbreviations for morphological terms used in the text

- CEB = central equatorial band
 OOD = ocular-ocellar distance

Results

The taxonomic confusion surrounding *Campoplex difformis*

During his taxonomic works on the genus *Campoplex*, Horstmann (1969, 1985) fixed the lectotype of *Limneria mutabilis* Holmgren, 1860 as neotype of *Ichneumon difformis* Gmelin, 1790. Gmelin (1790) named the species after the catalogue of Leskeanus Museum collections in Leipzig of Zschach (1788), who first recognized the species as new, but without naming it (Horstmann 1985). The description of the species by Gmelin (1790: 2720, species n° 392), who basically reproduced that of Zschach (1788: 70, species n° 348), is insufficient. The collections of the Leskeanus Museum were sold to the National Museum of Ireland in Dublin, but the types of Gmelin were lost (Townes *et al.* 1965; Horstmann 1985). Gravenhorst (1829) was the first author to revise the species (Horstmann 1969, 1985) and redescribed it based on his own material (Gravenhorst 1829; Horstmann 1985). According to Horstmann (1969, 1985), Gravenhorst's *difformis* is a synonym of *L. mutabilis*. Therefore, he designated the lectotype of *Limneria mutabilis* in Holmgren's collection in Stockholm as neotype for *I. difformis* (Horstmann 1969), since the material in Gravenhorst's collection was partially destroyed or in a bad state of conservation (Horstmann 1985). Beyond the choice of Horstmann, there is the need to maintain stability in nomenclature as *Campoplex difformis* sensu Gravenhorst is the type species of the genus *Campoplex* (Westwood 1840; Viereck 1914; Horstmann 1969, 1985). Moreover, the interpretation of Gravenhorst was not in contradiction with the description of Gmelin.

On the other hand, Aubert (1971, 1974, 1981) rejected the interpretation of Horstmann (1969), as it would have invalidated the use of the name *mutabilis*. Therefore, he designated a neotype for *difformis* in Thomson's collection in Lund, in order to keep *Campoplex mutabilis* and *C. difformis* as separate species and following the consideration that the name *mutabilis* has been used for more than a century by many entomologists (Aubert 1971). As pointed out by Klopstein & Baur (2011), Aubert, although one of the most important ichneumonologists in Europe, often did not follow the International Code of Zoological Nomenclature. Aubert's interpretation of *difformis* leads to synonymy with *C. deficiens* Gravenhorst, 1829, as established by Hedwig (1940), a species which belongs, however, to a different species group from *mutabilis* (= *difformis* sensu Gravenhorst and sensu Horstmann; Horstmann 1985). In addition, Horstmann (1985) pointed out that several authors in the past misidentified *difformis* as different species of the genus *Campoplex* or related genera (i.e., *Sinophorus* Förster, 1869) and thus their statements are not fully reliable. Horstmann's designation of a neotype clearly satisfied Article 75.3 of the ICZN Code, while the subsequent designation of a neotype of *C. difformis* by Aubert has to be considered invalid.

Interpretation of Aubert's material of the *Campoplex difformis* species group

After comparing Aubert's material belonging to the *difformis* species group sensu Horstmann with Horstmann's material and descriptions, we drew the following conclusions:

1. *Campoplex mutabilis mutabilis* (Holmgren, 1860) (MZL). The specimens bear red labels specifying that the identification was made from comparison with Thomson's material in Lund. We studied two females in Aubert's collection and, after comparison with *C. difformis* in Horstmann's collection, we think they are likely *C. unicingulatus* as they have the epicnemial carina evenly raised ventrally and submedially, propodeum with the area superomedia and area petiolaris only slightly depressed and with fine transverse striae starting from the base of the area petiolaris, and an ovipositor ratio of 1.5–1.6 (ovipositor ratio slightly exceeding that stated for *C. unicingulatus*). In our opinion, this misidentification could be the reason that led Aubert to reject Horstmann's interpretation of *mutabilis* as a synonym of *difformis*.

2. *Campoplex mutabilis* var. *gracilis* (Ulbricht, 1910) (MZL). *Campoplex gracilis* is a synonym of *C. dubitator* Horstmann, 1985 (Horstmann 1985). Specimens of *C. gracilis* in Aubert's collection are actually *C. difformis* sensu Horstmann; two specimens in Aubert's collection, one female and one male, have been correctly identified and labelled as *difformis* by Horstmann himself.

3. *Campoplex difformis* sensu Aubert (MZL). This species does not belong to the *difformis* species group but it is *C. deficiens* Gravenhorst, 1829 sensu Horstmann. According to Horstmann's collection, *C. deficiens* forms a group of its own, being characterized by the occipital carina in the ventral half not turned outwards, meeting the hypostomal carina at an acute angle at the base of the mandible; head and mesopleuron with strong punctures on a polished surface; propodeal carinae strong, with the area superomedia about $1.5 \times$ as long as wide, open posteriorly and mostly striate; posterior margins of the female sixth and seventh metasomal tergites clearly concave (Horstmann 1979) (Figs 1, 2A–C).

4. *Campoplex mutabilis corsicator* Aubert, 1960 (MZL). This was reported by Horstmann (1985) as a synonym of *C. tibialis*. Following Horstmann (1985), specimens of *corsicator* in Aubert's collection belong to neither *tibialis* nor related species, as they have an ovipositor ratio of about 1.6 (whilst *tibialis* in Horstmann's collection has an index of about 1.3). *Campoplex corsicator* also has very short temples (temple in lateral view about 0.5–0.6 as long as the transverse diameter of the eye in *C. tibialis*) and the area basalis triangular, i.e., with lateral carinae bounding the area basalis converging posteriorly to a single point, then extended to a short longitudinal carina towards the base of the area superomedia (area basalis trapezoidal, i.e., with lateral carinae converging posteriorly, but not touching at the base of the area superomedia in *C. tibialis*) (see redescription below and Fig. 3).

5. *Campoplex capitator* ex *Ancylis mitterbacheriana* on *Quercus pubescens* (MSNV). The record of Aubert (1983) consists of a single male collected in Liguria (Passo Turchino). Although the specimen certainly belongs to the *difformis* group, males of this group are indeterminable (Horstmann 2012), especially if not obtained together with the females by rearing. On the basis of the known host records and the biology of *C. capitator* (Villemant *et al.* 2011; Lucchi *et al.* 2017; Scaramozzino *et al.* 2017, 2018), we think that this record should be treated as doubtful as males cannot be reliably assigned to any species.

Notes on the identification of species of the *Campoplex difformis* group

In his original boxes at the ZSM in Munich, Horstmann arranged the species of *Campoplex* into ten groups: *borealis*, *continuus*, *difformis*, *discrepans*, *deficiens*, *faunus*, *fusciplica*, *melanostictus*, *spurius*, and *tumidulus* groups. Of these, only five (*borealis*, *continuus*, *difformis*, *discrepans*, and *melanostictus* groups) have been defined by Horstmann in his works (1985, 2000, 2008).

Horstmann (1985) provided a key to European species belonging to the *continuus*, *difformis*, *discrepans*, *melanostictus* and *spurius* groups (the last one included in the *melanostictus* group in Horstmann (1985), but separated in Horstmann's original boxes), which can be distinguished from the other European species of the genus *Campoplex* in having the occipital carina in the ventral half turned outwards, meeting the hypostomal carina at a right angle at the base of the mandible (Fig. 2E–F). Even if the demarcation between these groups is often difficult (Horstmann 1985), species of the *difformis* group are characterized by the mesopleuron with scattered and shallow punctures on a coriaceous background (i.e., Figs 3C, 4A–B, 4D, 5, 8B, 11B, 15B); posterior margins of the female sixth and seventh metasomal tergites only very slightly concave (Fig. 2D); hind tibia yellowish to red-brown, seldom proximally and distally slightly darker, rarely proximally with a light spot (in *C. helveticus* Horstmann, 1985 and *C. hercynicus* Horstmann, 1985); hind femur red (with the exception of *C. helveticus* and *C. nigricanae* Horstmann, 1980, with the hind femur brown to black); and hind coxa black (except *C. canariensis* Horstmann, 1980 that has a red hind coxa).



Fig. 1. *Campoplex deficiens* Gravenhorst, 1829 (*difformis* sensu Aubert), ♀ (MZL). **A.** Habitus and labels. **B.** Propodeum and propodeal carinae, dorsal view. **C.** Head, frontal view. **D.** Head and mesonotum, lateral view. **E.** Shape of temples behind eyes, dorsal view.

In the *difformis* group, a few species can easily be recognized by the peculiar shape of the epicnemial carina. In *Campoplex melanostoma* (Strobl, 1904) (syn. *C. anterior* Aubert, 1960) and *C. punctulatus* (Szépligeti, 1916), the epicnemial carina is subventrally abruptly turned towards the ventral hind corner of the pronotum, forming a sharp angled keel (Fig. 4A–C), while it is subventrally more or less straight in the other species of the group (Fig. 4D–E); in *C. bilobus* (Thomson, 1887) and *C. hinziator* Aubert, 1980, the epicnemial carina is ventrally raised and divided into two distinct lobes, thus with a clear notch in the middle separating the two parts (Fig. 5A); in *C. hercynicus*, the epicnemial carina is strongly raised ventrally, gently rounded and slightly notched in the middle, its width ventrally clearly greater than its width subventrally (Fig. 5B); in *C. unicingulatus*, the epicnemial carina is evenly raised ventrally and submedially, its width in the middle approximately as high as the width of the fore basitarsus, and not divided in the middle (Fig. 5C).

Females of the remaining species can be separated on the basis of the ovipositor sheath ratio. The ovipositor ratio is less than 1.4 (usually significantly less) in *Campoplex tibialis* and related species (Fig. 6A), while it is 1.4 or more in species related to *C. difformis*. In *C. restrictor* Aubert, 1960 and *C. striatus* Horstmann, 1985, the temples are strongly narrowed behind the eyes: imaginary lines connecting the outer side of the eye and temple intersect at the level of the scutellar groove (Fig. 4F), while in species strictly related to *C. difformis* the temples are not so narrowed: imaginary lines connecting the outer side of the eye and temple intersect at the level of the scutellum or just behind it (Figs 4G, 7; with the only possible exception of *C. corsicator* stat. rev., that has imaginary lines connecting the outer side of the eye and temple intersecting at the level of the scutellar groove or just behind it).

Since the revision of the *difformis* group by Horstmann (1985), two new species have been described, *Campoplex ocellanae* Horstmann, 1993 and *C. formosanae* Horstmann, 2012, and a third one, *C. psilopterus* Gravenhorst, 1829, was recognized as belonging to this group by Horstmann (2000).

According to Horstmann (1993), the identification of *Campoplex ocellanae* in his key led to *C. parvus* Horstmann & Yu, 1999 (syn. *C. minor* Horstmann, 1985). *Campoplex ocellanae* can be inserted at couplet 26 in Horstmann's key (1985) as follows:

- 26a. Temples slightly narrowed behind eyes, imaginary lines connecting outer side of eye and temple intersect at the base of the metasoma (Horstmann 1985: fig. 5). Area superomedia finely coriaceous, not wrinkled; area petiolaris anteriorly coriaceous, posteriorly finely striate; area superomedia and area petiolaris slightly depressed (Horstmann 1985: fig. 15). Body length about 4 mm. ***C. parvus*** Horstmann & Yu, 1999
- Temples comparatively more narrowed behind eyes, imaginary lines connecting outer side of eye and temple intersect behind the middle of the mesoscutum (Horstmann 1985: fig. 6; Horstmann 1993: fig. 4)..... 26b
- 26b. Area superomedia and area petiolaris coriaceous and finely wrinkled; area petiolaris in addition with fine transverse wrinkles (Horstmann 1985: fig. 16). Body length about 6 mm. ***C. sulcatus*** Horstmann, 1985
- Area superomedia coriaceous and wrinkled only at the lateral margins; area petiolaris entirely and strongly striate, slightly depressed (Horstmann 1993: fig. 8). Body length about 5 mm. ***C. ocellanae*** Horstmann, 1993

Campoplex formosanae and *C. psilopterus* belong to the subgroup of closely related species, together with *C. difformis*, *C. capitator*, *C. dubitator*, and *C. unicingulatus*, which form a tricky complex of very similar species that are better characterized by their host association (Horstmann 2012).

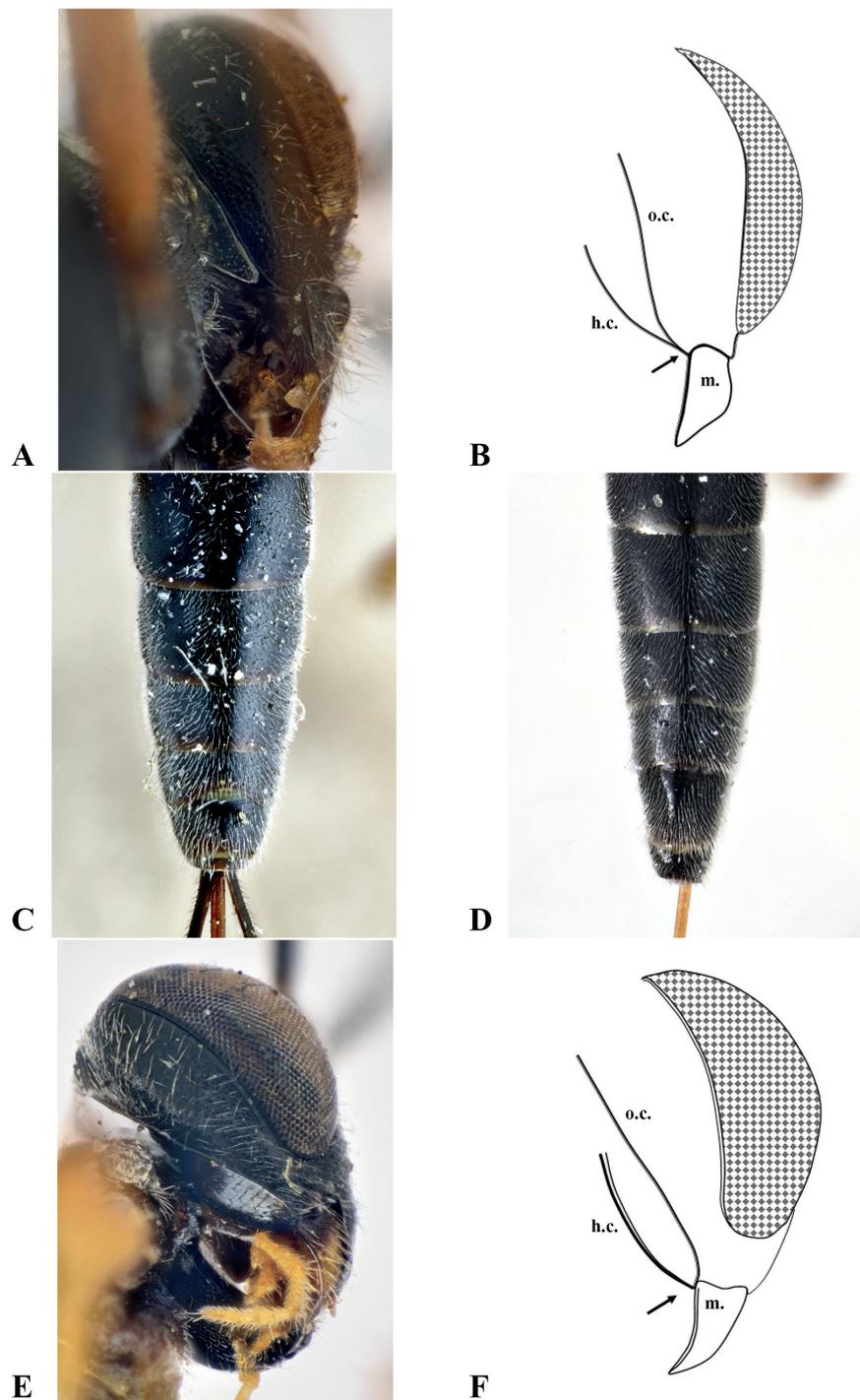


Fig. 2. Occipital carina in ventral half and last metasomal tergites. **A.** *Campoplex deficiens* Gravenhorst, 1829 (MZL), head, posteroventral view. **B.** Schematic drawing illustrating the occipital carina in ventral half not turned outwards and meeting the hypostomal carina at an acute angle little before mandibular base. **C.** *C. deficiens* Gravenhorst, 1829 (MZL), ♀, last metasomal tergites. **D.** *C. dubitator* Horstmann, 1985 (ZSM), ♀, last metasomal tergites. **E.** *C. corsicator* Aubert, 1960 (MZL), head, posteroventral view. **F.** Schematic drawing illustrating the occipital carina in ventral half turned outwards and meeting the hypostomal carina at a right angle at the base of mandible. Abbreviations: o.c. = occipital carina; h.c. = hypostomal carina; m. = mandible.

Campoplex psilopterus was described from a male by Gravenhorst (1829: 508), probably based on a specimen not completely pigmented (“Suspisor, hoc individuum, coloribus nondum perfecte temperatis, necatum esse”). The species was then cited and redescribed by Ratzeburg (1852: 86), who also described the female and reported a record of Siebold of a male and a female obtained from a species of Psychidae. According to Horstmann (2000), *C. psilopterus* is near to *C. capitator*, but it differs in its smaller body size (about 4 mm), slightly narrower face and area petiolaris clearly depressed. With respect to Gravenhorst’s description, Ratzeburg added that the female ovipositor is $\frac{1}{4}$ – $\frac{1}{5}$ as long as the metasoma. Unfortunately, the original descriptions of Gravenhorst and Ratzeburg and the short note of Horstmann based on the male in Gravenhorst’s collection do not allow this species to be unequivocally characterized. Thus – following Taxapad (Yu *et al.* 2016) – *C. psilopterus* is treated here as species inquirenda.

Campoplex formosanae was reared from the cherry-bark tortrix, *Enarmonia formosana* (Scopoli, 1763), in Germany. The species was first treated by authors as *C. dubitator* (in Tanigoshi & Starý 2003; Jenner *et al.* 2004, 2005, 2013; Jenner & Kuhlmann 2006; Hunt & Kuhlmann 2007; Hunt *et al.* 2008; Jenner & Roitberg 2009), while molecular-based studies indicated that it might be conspecific with *C. capitator*, as molecular differences between the two species were not significant (Hunt & Kuhlmann 2007; Hunt *et al.* 2008). However, laboratory tests showed that *C. formosanae* was unable to develop in *Lobesia botrana*, the selected host species of *C. capitator*, and small but constant morphological characters can be found to support *C. formosanae* as a species distinct from *C. capitator* and related species (Hunt *et al.* 2008; Jenner *et al.* 2013).

According to Horstmann (1985, 2012), *Campoplex formosanae* has morphologically intermediate characters between *C. dubitator* and *C. unicingulatus* (Horstmann 2012). It differs from *C. unicingulatus* in having ovipositor sheath ratio 1.7–1.8 the (Fig. 8A) (ovipositor ratio 1.4–1.5 in *C. unicingulatus*) and the epicnemial carina slightly raised ventrally (at most as high as half the width of the fore basitarsus, Fig. 8B) (strongly raised ventrally, about as high as the width of the fore basitarsus in *C. unicingulatus*). He reports also that flagellar segments in the apical quarter of *C. formosanae* are “as long as or slightly shorter than wide” (Horstmann 2012), but actually flagellar segments in *C. formosanae* identified by Horstmann himself in NMS seem to be relatively longer than those of *C. unicingulatus* in Horstmann’s collection (Fig. 9D–E). It differs from *C. dubitator* in having the area petiolaris clearly depressed and almost entirely covered by transverse wrinkles, including the anterior half (Figs 8C, 10D and Horstmann 2012: fig. 7) (only granulate and with no transverse wrinkles in the anterior half and with fine transverse wrinkles in the posterior half in *C. dubitator*; see Figs 10C, 11C and Horstmann 1985: fig. 10).

Notes on cocoons of the *Campoplex difformis* group

Cocoons of the following species have been examined: *Campoplex capitator* (Fig. 12A), *C. dubitator* (Fig. 12B), *C. formosanae* (Fig. 12C–E), *C. unicingulatus* (Fig. 12F), *C. punctulatus* (Fig. 13A–B), *C. restrictor* (Fig. 13C–D), *C. sulcatus* Horstmann, 1985 (Fig. 13E), and *C. melanostoma* (Fig. 13F).

Species of *Campoplex* are solitary koinobiont endoparasitoids, mainly of small moths belonging to families Coleophoridae, Gelechiidae, Pyralidae, Tortricidae, and Yponomeutidae (Aubert 1983; Horstmann 1980, 1985; Shaw & Aeshlimann 1994; Yu *et al.* 2016). They preferentially oviposit in larvae and complete their development killing the host as prepupa. Sometimes, when unusual larger hosts are attacked, the hosts are killed before they can reach the prepupal stage; also, a few species kill the host when it has pupated (Shaw & Aeshlimann 1994; Shaw *et al.* 2016; Broad *et al.* 2018); the parasitoid spins its own cocoon inside or outside the host’s remains (Leong & Oatman 1968; Shaw & Aeshlimann 1994; Athanassov *et al.* 1998; Shaw *et al.* 2016); in our samples, at least two species – *C. formosanae* and *C. punctulatus* – spin their cocoon both externally to the host’s prepupa remains (that are made by the host’s final instar skin) or wait for the host to have pupated and spin the cocoon inside the host’s chrysalis (Figs 12C–D, 13A–B). Cocoons of *Campoplex* (Figs 12–13) are elongate, sub-cylindrical, with

rounded poles; cocoon size is related to adult size, so that male cocoons are generally smaller than those of females; in the examined cocoons, the length is about $3 \times (\pm 0.3)$ in females and about $2.6 \times (\pm 0.1)$ in males, the maximum width being measured at the equatorial zone. The colour is quite variable, even within the same species, ranging from pure silky white to very dark brown or blackish, with different shades of colour. The CEB can be present or absent, even when looking at cocoons of the same species; when present, the band can be intense white or dark, or sometimes the cocoon appears bicoloured with two thin external dark bands and a lighter internal band. Thickness and texture are variable too, from very thin and translucent (like in *C. capitator*) to very thick and opaque, and from smooth to corrugated surface. The loosely woven outer layer can be reduced or thick, giving the cocoon a woolly appearance and hiding the surface details of the dense middle layer.

In several species of Ichneumonidae and Braconidae there is seasonal dimorphism in the structure and robustness of the cocoon, with the overwintering one thicker, darker and tougher than the summer one (Shaw & Huddleston 1991; Quicke 2015). The cocoons of *Campoplex* we examined show an evident dimorphism, even if probably not related to seasonality; most of them are from spring-summer generations, which have not entered diapause. Thus, the cause of observed dimorphism has to be sought in the exploited host and host plant. For example, observing a conspicuous series of cocoons of *C. capitator* reared in the laboratory on *Lobesia botrana* collected on *Daphne gnidium* and on *Vitis vinifera* L. in Italy, we noticed a constancy in the structure and colour of the cocoons, without evident seasonal variation. However, it cannot be excluded that observed variation in other species is due to the presence of further sibling species that are difficult to separate on a morphological basis. Without a better knowledge of intraspecific variation, it remains extremely difficult to reliably assign specimens developed on different hosts and different places to the same taxon on the base of cocoon features and shapes.

Redescription of species

Class Insecta Linnaeus, 1758
Order Hymenoptera Linnaeus, 1758
Superfamily Ichneumonoidea Latreille, 1802
Family Ichneumonidae Latreille, 1802
Subfamily Campopleginae Förster, 1869

Genus *Campoplex* Gravenhorst, 1829

Campoplex Gravenhorst, 1829: 453. Type-species: *Ichneumon difformis* Gmelin, 1790. Designated by Westwood 1840.

Campoplex corsicator Aubert, 1960 stat. rev.
Figs 2E, 3, 7F, 9F, 10F, 14F

Campoplex mutabilis corsicator Aubert, 1960: 64.

Material examined

Lectotype designated here

FRANCE • 1 ♀, last 6 flagellomeres of right antenna missing; “TYPE // *Campoplex* ♀; (= *Omorgus*); *mutabilis* Holm; *corsicator* Aub. // Comparée au; lectotype (Hinz) // J. F. Aubert; 13.8.1959; Ajaccio (Corse) // *Campoplex* (*Nemeritis*); *tibialis* Szepl.; (= *corsicator* Aub.) // Syntype 1/? (6); *Campoplex*; *mutabilis corsicator*; Aubert, 1960g; labelled by S. Klopstein 2009”.

Description based on the lectotype

Female

MEASUREMENTS. Body length 7.1 mm; fore wing length 4.4 mm.

HEAD. Face about 0.80–0.90 × as high as wide. Malar space 0.5–0.6 × width of mandibular base. Gena about 0.4 × as long as eye (maximum width, seen laterally); temple 0.3 × as long as eye (see dorsally), narrowed behind eye, imaginary lines connecting outer side of eye and temple intersect not before the level of the scutellar groove or just behind it. OOD 0.65 × distance between lateral ocelli. Mandibular teeth subequal. Clypeus 0.4–0.5 × as high as wide, not produced in profile medially, matt and coriaceous, its apical margin sharp and gently rounded. Face and frons granulate and matt. Vertex and temples coriaceous and subpolished. Flagellum in the examined specimen with 33 segments, flagellomeres in apical quarter about 0.8–0.9 × as long as wide.



Fig. 3. *Campoplex corsicator* Aubert, 1960 (MZL), ♀, lectotype, designated on original syntype. A. Habitus and labels. B. Head, lateral view. C. Mesopleuron and epicnemial carina, lateral view.

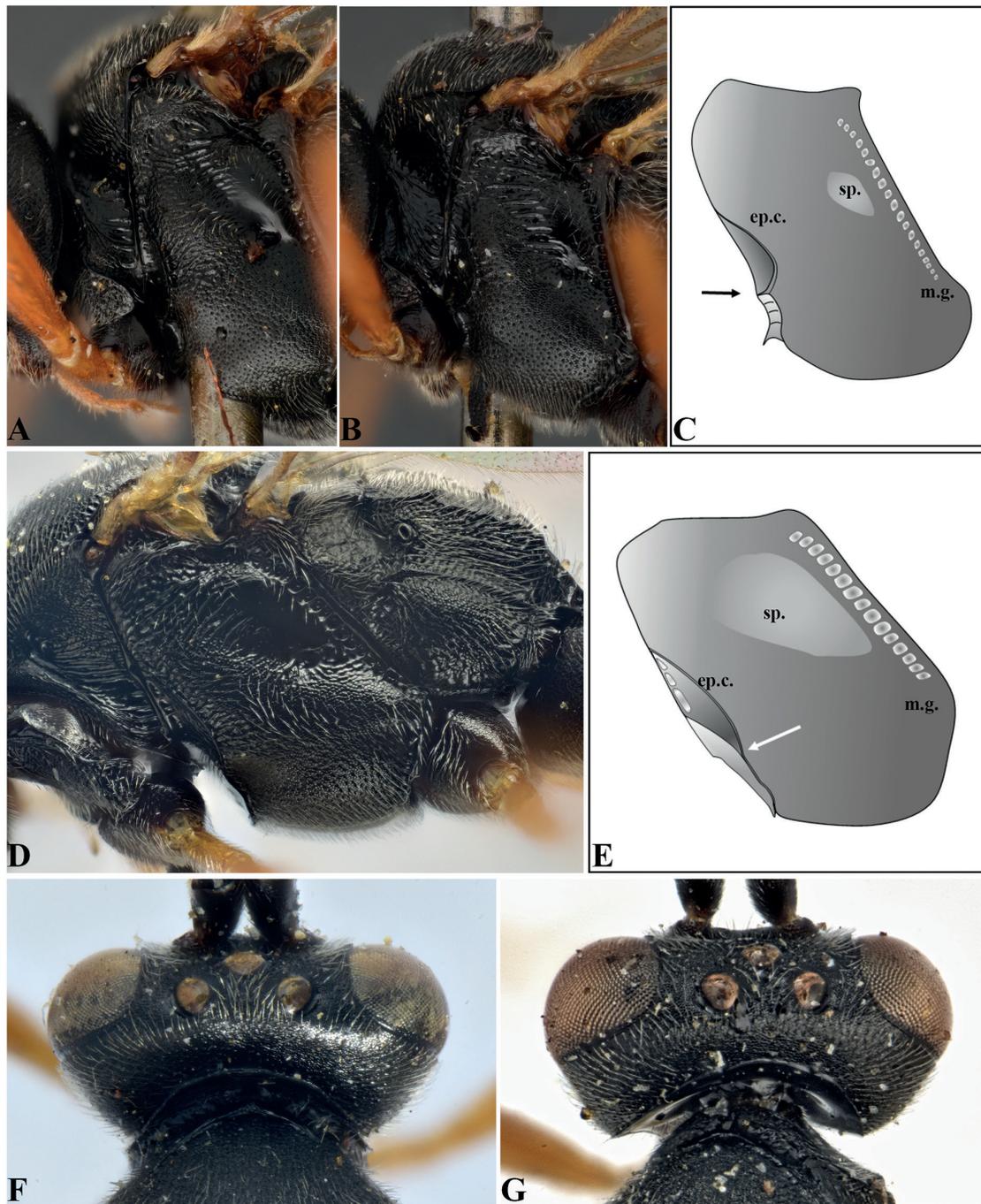


Fig. 4. Epicnemial carinae, in lateral view, and shape of temples behind eye, dorsal view. **A.** *Campoplex melanostoma* (Strobl, 1904) (ZSM). **B.** *C. punctulatus* (Szépligeti, 1916) (ZSM). **C.** Schematic drawing illustrating the epicnemial carina subventrally turned towards the ventral hind corner of pronotum. **D.** *C. difformis* (Gmelin, 1790) (ZSM). **E.** Schematic drawing illustrating the epicnemial carina subventrally more or less straight, not turned towards the ventral hind corner of pronotum. **F.** *C. restrictor* Aubert, 1960 (ZSM), temples strongly narrowed behind eyes (i.e., imaginary lines connecting outer side of eye and temple intersect at the level of the scutellar groove). **G.** *C. tibialis* (Szépligeti, 1916) (ZSM), temples not strongly narrowed behind eyes (i.e., imaginary lines connecting outer side of eye and gena intersect at the level of the scutellum or behind it). Abbreviations: ep.c. = epicnemial carina; m.g. = mesopleural groove; sp. = speculum.

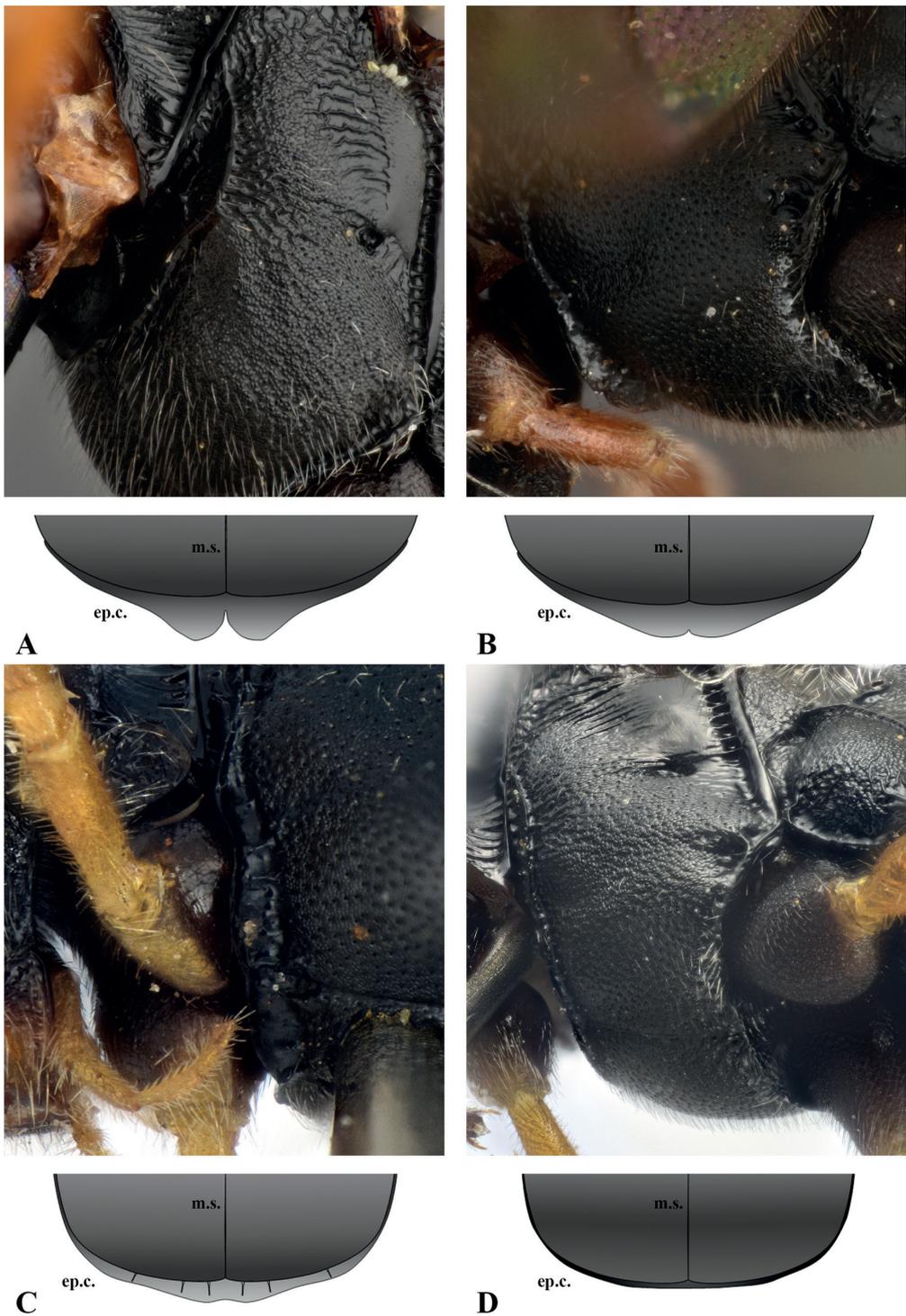


Fig. 5. Epicnemial carinae, in ventrolateral view and related schematic drawings, in frontal view. **A.** *Campoplex bilobus* (Thomson, 1887) (ZSM), epicnemial carina ventrally raised and divided into two lobes. **B.** *C. hercynicus* Horstmann, 1985 (ZSM), epicnemial carina ventrally raised and slightly notched in the middle. **C.** *C. unicingulatus* (Schmiedeknecht, 1909) (ZSM), epicnemial carina evenly raised ventrally and not divided nor notched in the middle. **D.** *C. difformis* (Gmelin, 1790) (ZSM), epicnemial carina ventrally only very slightly raised. Abbreviations: ep.c. = epicnemial carina; m.s. = medial sternal groove.

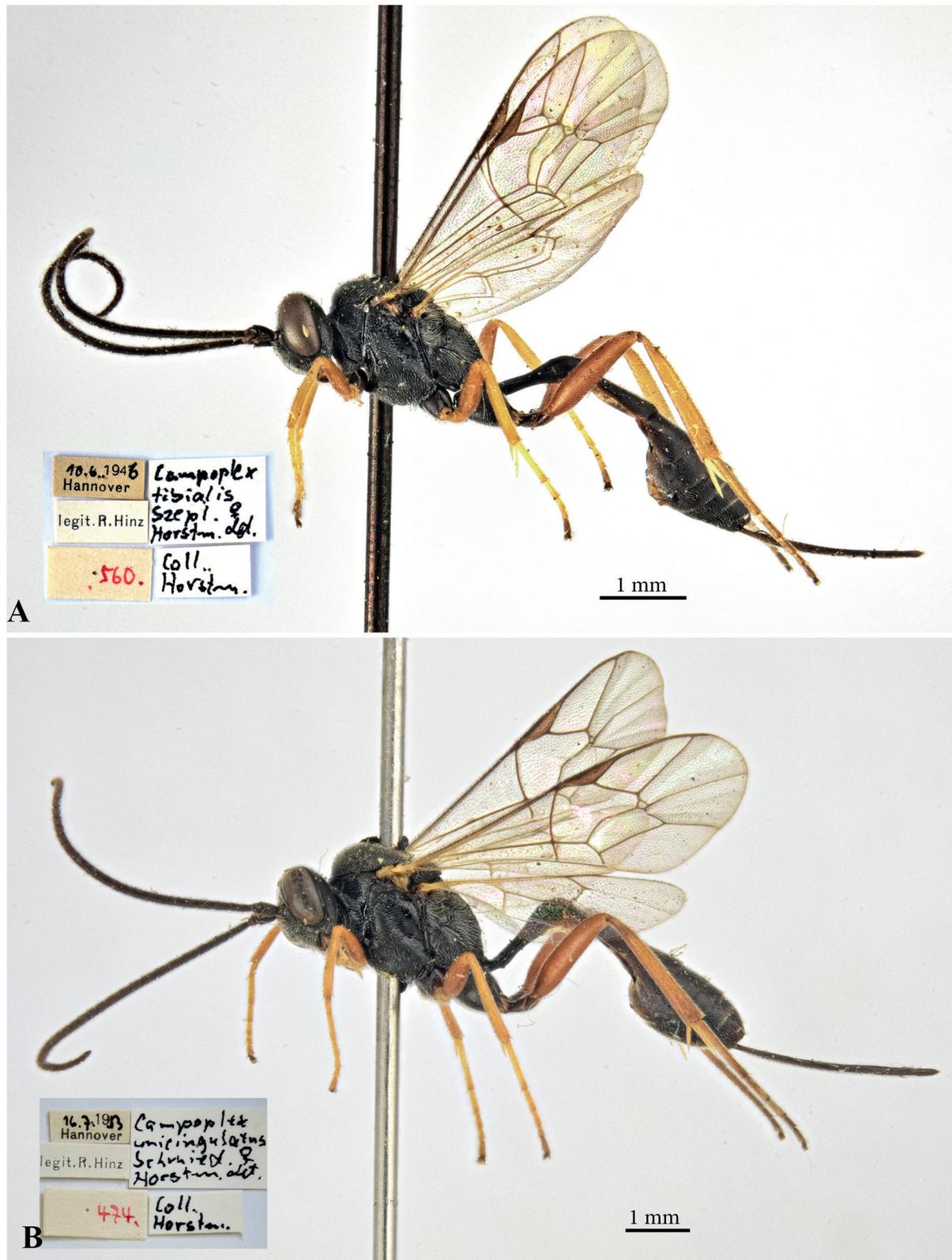


Fig. 6. A. *Campoplex tibialis* (Szépligeti, 1916), ♀ (ZSM), habitus and labels. B. *C. unicingulatus* (Schmiedeknecht, 1909), ♀ (ZSM), habitus and labels.

MESOSOMA. Pronotum medio-ventrally with longitudinal striae, dorsally coriaceous. Epomia indistinct. Mesoscutum and scutellum granulate and matt, scutellum without lateral carinae. Mesopleuron coriaceous and matt, with shallow and scattered punctures, especially on antero-ventral half; speculum smooth, anteriorly with fine longitudinal striae. Epicnemial carina only slightly sinuate subventrally, ventrally slightly raised, in middle without notch and not produced into lobes. Metapleuron coriaceous and matt. Fore wing with areolet small and petiolate, 2m-cu beyond its middle; 1cu-a opposite M&RS. Hind wing with proximal abscissa of CU $4.5 \times$ as long as cu-a, distal abscissa of CU unpigmented. Hind femur $4.5 \times$ as long as its maximum width, the longer inner tibial spur about $0.5\text{--}0.6 \times$ as long as hind basitarsus. Propodeum with area basalis triangular and connected by a small longitudinal carina to anterior margin of area superomedia, at its anterior end about $0.4 \times$ as wide as area superomedia (width at level of costulae); area superomedia large, about $1.4 \times$ as wide as long, coriaceous and matt, not depressed and open posteriorly, with few transverse striae at its lateral margins. Area petiolaris very slightly depressed and with irregular transverse striae. Rim of propodeal spiracle and carina connecting propodeal spiracle to pleural carina normal.

METASOMA. Postpetiole coriaceous. Metasomal tergite II $1.6 \times$ as long as posteriorly wide. Ovipositor ratio about 1.6.

COLOUR. Black. Palps and tegulae yellowish-white. Mandibles (except black base and reddish teeth) and pedicel apically yellow. Scape and flagellum yellowish-brown, flagellum lighter distally. Pterostigma yellowish-brown. All coxae black, fore coxa yellow marked distally, all tibial spurs yellowish-white; fore and mid trochanters and trochantelli yellow, fore and mid femora, tibiae and tarsi yellowish-red. Hind trochanter and trochantellus brownish, hind femur red, hind tibia and tarsus yellowish-red, tibia with very small light spot at base, slightly brownish subbasally. Metasoma and ovipositor sheath black.

Notes

The examined specimen, which we designate as the lectotype, does not fit the description of *Campoplex tibialis*, as the ovipositor ratio is clearly greater than that of *C. tibialis*. Also, the specimen is characterized by the temple, in lateral view, at most $0.4\text{--}0.5 \times$ as long as the transverse diameter of the eye and the propodeum with the area basalis triangular (as in *Campoplex angustioranae* (Bauer, 1937); Horstmann 1985). These reasons led us to remove *C. corsicator* from synonymy with *C. tibialis* (Horstmann, 1985).

Campoplex capitator Aubert, 1960

Figs 7A, 9A, 10A, 12A, 14A, 15

Campoplex capitator Aubert, 1960: 64.

Material examined

Lectotype designated here

FRANCE • 1 ♀; “TYPE // CAMPOPLEX ♀; (=OMORGUS); CAPITATOR Aub. // J.F.AUBERT; 24.8.1958; COSPRONS (P.O.) // Comparées; toutes les; esp. de Thomson // Visage + court; +transverse; que chez *difformis*; et troch. I. clairs; Tergite II + long.; II-III et tarière; + longs que chez *fusciplica*; (...) + long que chez; *molesta*; + const; que chez *Stenogaster*; (non décrit?); ssp. de *BILOBA*?; Mais ant. + grêles; Area sup. media; non creusée; Exte des tibias; obscures et; mandib. jaunes // *Fusciplica* type; tarière tergites; II-III + courts; tibias extrémit; noire. // f. *ABBREVIATUS* Brisch.; *MAJOR* Szempl. [crossed out]; *OVATUS* Brisch. // *Algericus*; ou *fusciplica*? [all crossed out] // Syntype 1/3 (3); *Campoplex capitator*; Aubert, 1960g; labelled by S. Klopstein 2009”.

Additional material examined

ITALY • > 100 ♀♀; DISAAA.

Description

Female

MEASUREMENTS. Body length 5.0–6.5 mm; fore wing length 3.5–4.5 mm.

HEAD. Face about 0.60–0.70 × as high as wide. Malar space 0.5–0.6 × width of mandibular base. Gena 0.8 × as long as eye (maximum width, seen laterally); temple about 0.6 × as long as eye (seen dorsally),

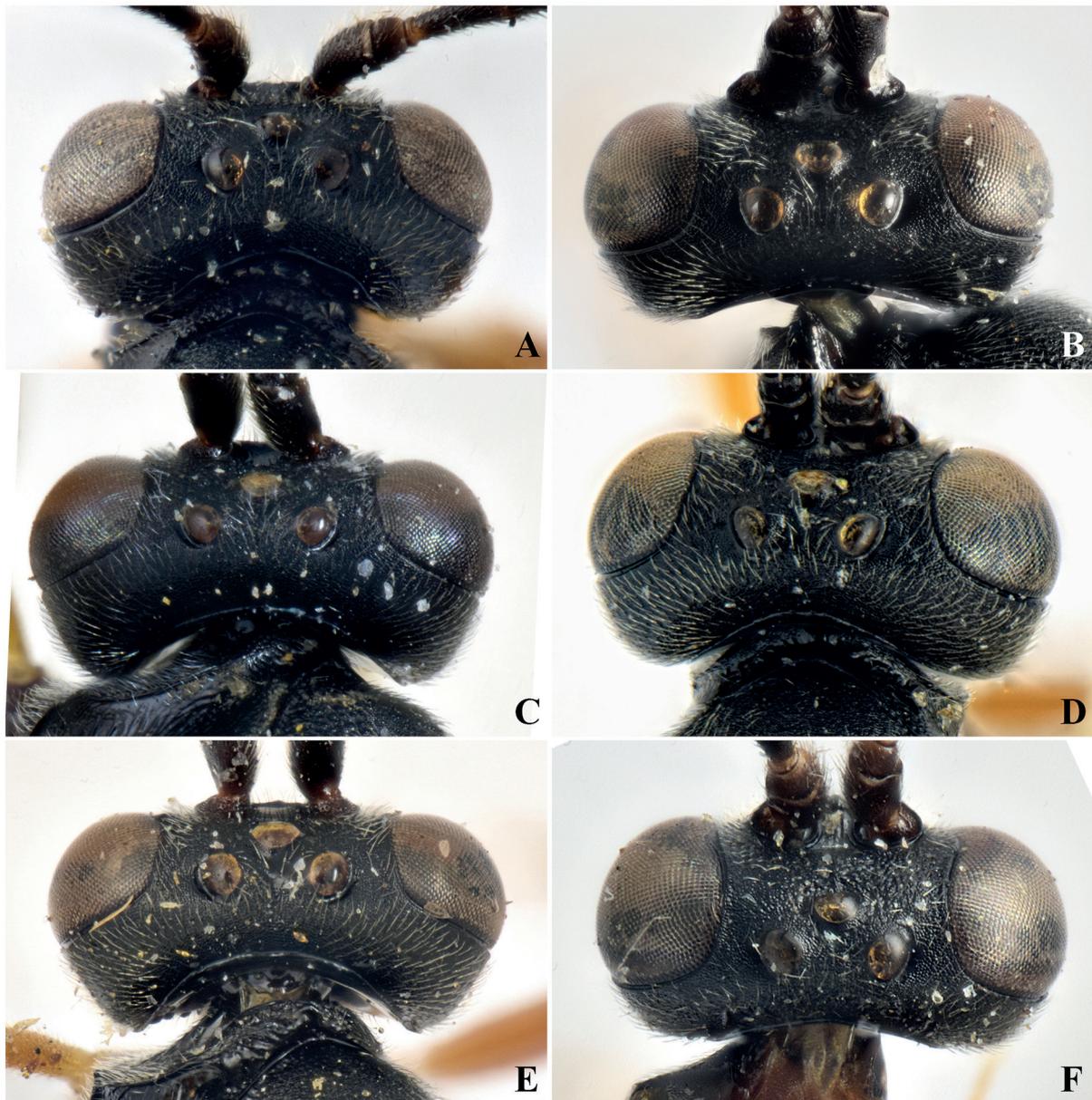


Fig. 7. Temples behind eye, dorsal view. **A.** *Campoplex capitator* Aubert, 1960, lectotype (MZL). **B.** *C. difformis* (Gmelin, 1790) (ZSM). **C.** *C. dubitator* Horstmann, 1985 (ZSM). **D.** *C. formosanae* Horstmann, 2012 (NMS). **E.** *C. unicingulatus* (Schmiedeknecht, 1909) (ZSM). **F.** *C. corsicator* Aubert, 1960, lectotype (MZL).

weakly narrowed behind eye, imaginary lines connecting outer side of eye and temple intersect at the level of scutellum. OOD $0.55 \times$ distance between lateral ocelli. Mandibular teeth subequal. Clypeus $0.5 \times$ as high as wide, not produced in profile medially, matt and coriaceous, its apical margin sharp and gently rounded. Face and frons granulate and matt. Vertex and temples coriaceous and subpolished. Flagellum in examined specimens with 27–30 (usually 28–29) segments, flagellomeres in apical quarter about $0.9\text{--}1.0 \times$ as long as wide.

MESOSOMA. Pronotum medio-ventrally with longitudinal striae, dorsally coriaceous. Epomia indistinct. Mesoscutum and scutellum granulate and matt, scutellum without lateral carinae. Mesopleuron coriaceous and matt, with shallow and scattered punctures, especially on antero-ventral half; speculum smooth, anteriorly with fine longitudinal striae. Epicnemial carina only slightly sinuate subventrally, ventrally slightly raised, in middle without notch and not produced into lobes. Metapleuron coriaceous and matt. Fore wing with areolet small and petiolate, 2m-cu beyond its middle; 1cu-a opposite M&RS. Hind wing with proximal abscissa of CU $3 \times$ as long as cu-a, distal abscissa of CU unpigmented. Hind femur $4.5 \times$ as long as its maximum width, the longer inner tibial spur about $0.5\text{--}0.6 \times$ as long as hind basitarsus. Propodeum with area basalis rectangular, about $0.4 \times$ as wide as area superomedia; area superomedia large, about $1.4 \times$ as wide as long, coriaceous and matt, not depressed, posteriorly open (just a weak hint of carina separating it from area petiolaris). Area petiolaris very slightly depressed and with irregular transverse striae. Rim of propodeal spiracle and carina connecting propodeal spiracle to pleural carina thickened.

METASOMA. Postpetiole coriaceous. Metasomal tergite II $1.3 \times$ as long as apically wide. Ovipositor ratio 1.55–1.65.

COLOUR. Black. Palps and tegulae yellowish-white. Mandibles (except black base and reddish teeth) and pedicel apically yellow. Scape and flagellum yellowish-brown, flagellum lighter distally. Pterostigma yellowish-brown. All coxae black, fore coxa yellow marked distally, all tibial spurs yellowish-white; fore and mid trochanters and trochantelli yellowish-red, fore and mid femora, tibiae and tarsi yellowish-red. Hind trochanter and trochantellus brownish, hind femur red, hind tibia and tarsus yellowish-red, tibia with very small light spot at base, very slightly brownish sub-basally and apically. Metasoma and ovipositor sheath black.

Notes

The shape of the area superomedia is rather variable. Specimens collected and/or reared from *Lobesia botrana* in Italy showed a certain degree of variation, in particular in the length of the lateral margins of the area superomedia (i.e., carina running from costula to base of area petiolaris).

Campoplex difformis (Gmelin, 1790)

Figs 4D, 5D, 7B, 9B, 10B, 14B, 16

Ichneumon difformis Gmelin, 1790: 2720.

Material examined

GERMANY • 4 ♀♀; ZSM.

Description

Female

MEASUREMENTS. Body length 6.8–7.7 mm; fore wing length 4.8–5.5 mm.

HEAD. Face about 0.75–0.85 × as high as wide. Malar space 0.5–0.6 × width of mandibular base. Gena 0.8 × as long as eye (maximum width, seen laterally); temple about 0.5 × as long as eye (seen dorsally), weakly narrowed behind eye, imaginary lines connecting outer side of eye and temple intersect at the level of the scutellum. OOD 0.55 × distance between lateral ocelli. Mandibular teeth subequal. Clypeus 0.5 × as high as wide, not produced in profile medially, matt and coriaceous, its apical margin sharp and gently rounded. Face and frons granulate and matt. Vertex and temples coriaceous and subpolished. Flagellum in examined specimens with 33 segments, flagellomeres in apical quarter about 0.7–0.8 × as long as wide.



Fig. 8. *Campoplex formosanae* Horstmann, 2012. A–B. ♀ (ZSM). C. ♀ (NMS). A. Habitus and labels. B. Mesopleuron and epicnemial carina, ventrolateral view. C. Propodeum, dorsolateral view.

MESOSOMA. Pronotum medio-ventrally with longitudinal striae, dorsally coriaceous. Epomia indistinct. Mesoscutum and scutellum granulate and matt, scutellum without lateral carinae. Mesopleuron coriaceous and matt, with shallow and scattered punctures, especially on antero-ventral half; speculum smooth, anteriorly with fine longitudinal striae. Epicnemial carina only slightly sinuate subventrally, ventrally slightly raised, in middle without notch and not produced into lobes. Metapleuron coriaceous and matt. Fore wing with areolet small and petiolate, 2m-cu beyond its middle; 1cu-a opposite M&RS. Hind wing with proximal abscissa of CU $5.5 \times$ as long as cu-a, distal abscissa of CU unpigmented. Hind femur $4.5 \times$ as long as its maximum width, longer inner tibial spur about $0.5\text{--}0.6 \times$ as long as hind basitarsus. Propodeum with area basalis rectangular, about $0.4 \times$ as wide as area superomedia; area

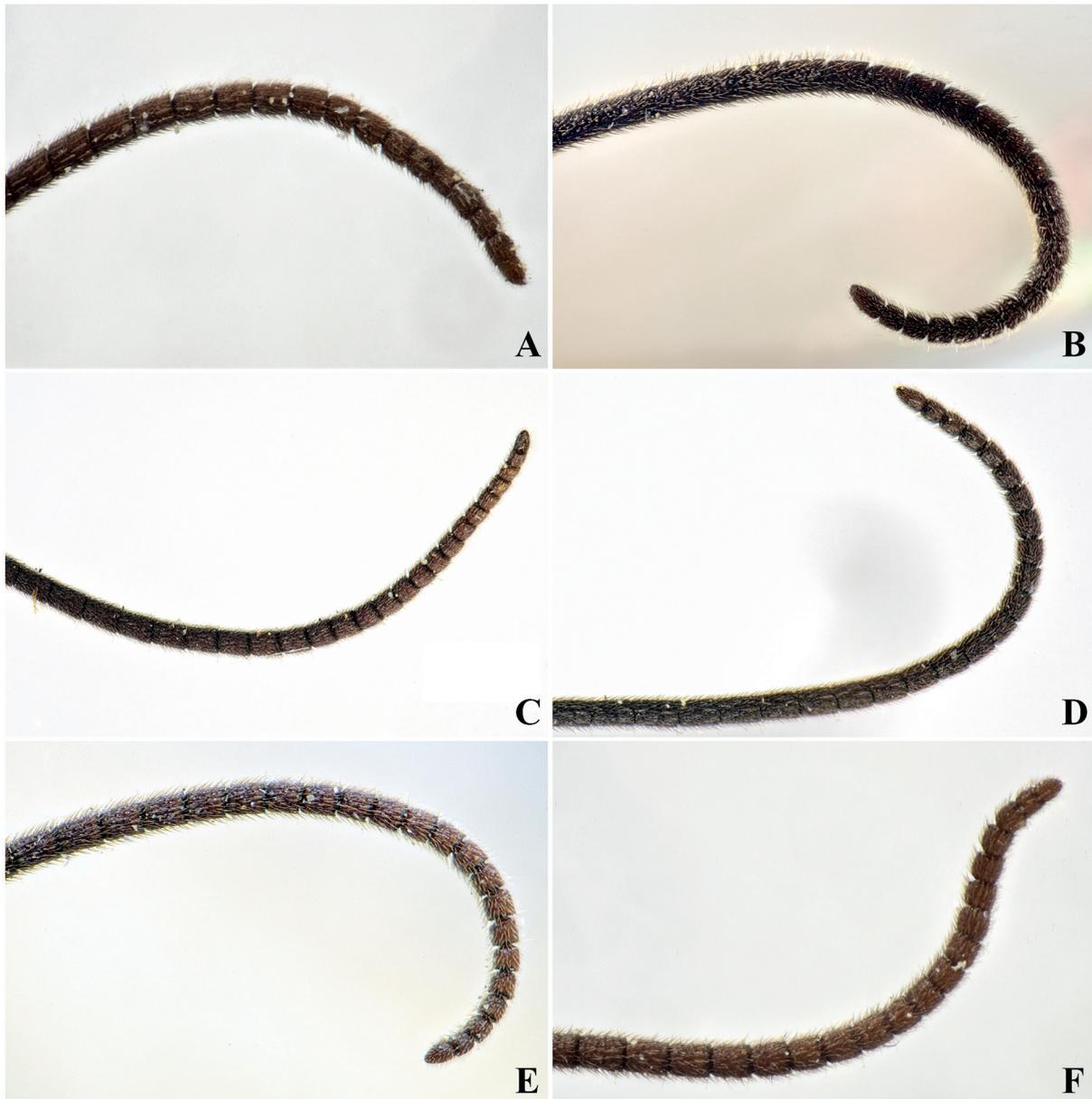


Fig. 9. Flagellum, apical quarter. **A.** *Campoplex capitator* Aubert, 1960, lectotype (MZL). **B.** *C. difformis* (Gmelin, 1790) (ZSM). **C.** *C. dubitator* Horstmann, 1985 (ZSM). **D.** *C. formosanae* Horstmann, 2012 (NMS). **E.** *C. unicingulatus* (Schmiedeknecht, 1909) (ZSM). **F.** *C. corsicator* Aubert, 1960, lectotype (MZL).



Fig. 10. Propodeum and propodeal carinae, dorsal view. **A.** *Campoplex capitator* Aubert, 1960, lectotype (MZL). **B.** *C. difformis* (Gmelin, 1790) (ZSM). **C.** *C. dubitator* Horstmann, 1985 (ZSM). **D.** *C. formosanae* Horstmann, 2012 (ZSM). **E.** *C. unicingulatus* (Schmiedeknecht, 1909) (ZSM). **F.** *C. corsicator* Aubert, 1960, lectotype (MZL).

superomedia large, about $1.8 \times$ as wide as long, coriaceous and matt, relatively strongly depressed from anterior margin and open posteriorly. Area petiolaris clearly depressed and with irregular transverse striae. Rim of propodeal spiracle and carina connecting propodeal spiracle to pleural carina normal.

METASOMA. Postpetiole coriaceous. Metasomal tergite II $1.4 \times$ as long as apically wide. Ovipositor ratio 1.6–1.7.

COLOUR. Black. Palps and tegulae yellowish-white. Mandibles (except black base and reddish teeth) and pedicel apically yellow. Scape and flagellum yellowish-brown, flagellum lighter distally. Pterostigma



Fig. 11. *Campoplex dubitator* Horstmann, 1985, ♀ (ZSM). **A.** Habitus and labels. **B.** Mesopleuron and epicnemial carina, ventrolateral view. **C.** Propodeum, dorsolateral view.

yellowish-brown. All coxae black, fore coxa yellow marked distally, all tibial spurs yellowish-white; fore and mid trochanters and trochantelli yellowish-red, fore and mid femora, tibiae and tarsi yellowish-red. Hind trochanter and trochantellus brownish, hind femur red, hind tibia and tarsus yellowish-red, tibia with very small light spot at base, very slightly brownish subbasally and apically. Metasoma and ovipositor sheath black.

Campoplex dubitator Horstmann, 1985
Figs 2D, 7C, 9C, 10C, 11AC, 12B, 14C

Campoplex dubitator Horstmann, 1985: 146–148.

Material examined

GERMANY • 4 ♀♀; ZSM.

NETHERLANDS • 1 ♀; ZSM.

Description

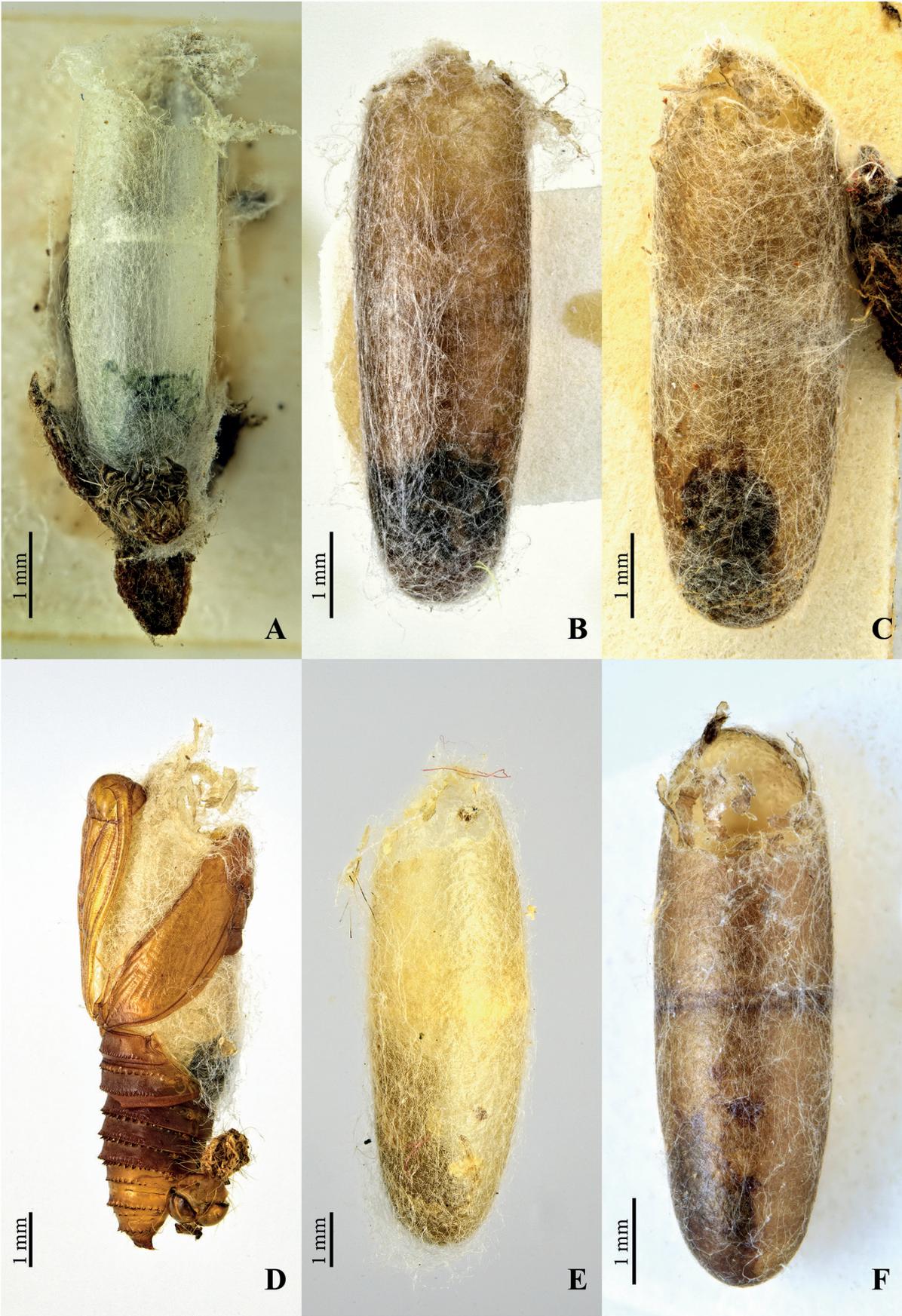
Female

MEASUREMENTS. Body length 7.7 mm; fore wing length 5.5 mm.

HEAD. Face about 0.60–0.70 × as high as wide. Malar space 0.5–0.6 × width of mandibular base. Gena 0.8 × as long as eye (maximum width, seen laterally); temple about 0.7 × as long as eye (seen dorsally), weakly narrowed behind eye, imaginary lines connecting outer side of eye and temple intersect at the level of the scutellum. OOD 0.65 × distance between lateral ocelli. Mandibular teeth subequal. Clypeus 0.5 × as high as wide, weakly produced in profile medially, matt and coriaceous, its apical margin sharp and gently rounded. Face and frons granulate and matt. Vertex and temples coriaceous and subpolished. Flagellum in examined specimens with 36 segments, flagellomeres of apical quarter about as long as wide.

MESOSOMA. Pronotum medio-ventrally with longitudinal striae, dorsally coriaceous. Epomia indistinct. Mesoscutum and scutellum granulate and matt, scutellum without lateral carinae. Mesopleuron coriaceous and matt, with shallow and scattered punctures, especially on antero-ventral half; speculum smooth, anteriorly with fine longitudinal striae. Epicnemial carina only slightly sinuate subventrally, ventrally slightly raised, in middle without notch and not produced into lobes. Metapleuron coriaceous and matt. Fore wing with areolet small and petiolate, 2m-cu beyond its middle; 1cu-a opposite M&RS. Hind wing with proximal abscissa of CU 5.5 × as long as cu-a, distal abscissa of CU unpigmented. Hind femur 4.5 × as long as its maximum width, the longer inner tibial spur about 0.5–0.6 × as long as

Fig. 12 (opposite page). Cocoons of species belonging to *Campoplex difformis* species group. **A.** *Campoplex capitator* Aubert, 1960, ♀ (DISAAA) from Italy, Tuscany, Pisa, San Rossore, ex *Lobesia botrana* (Denis & Schiffermüller, 1775) on *Daphne gnidium* L. **B.** *C. dubitator* Horstmann, 1985, ♀ (ZSM) from Netherlands, West Frisian, Venhuizen, ex *Archips podana* (Scopoli, 1763) on apple, de Jong leg., K. Horstmann det. **C.** *C. formosanae* Horstmann, 2012, ♂, paratypus (ZSM), from Germany, Sipplingen-Suessenmuehle, North Lake of Constanz, ex *Enarmonia formosana* (Scopoli, 1763), K. Horstmann det. **D.** *C. formosanae* Horstmann, 2012, ♂ (NMS), from UK, Cumbria, Beelham, ex *Acleris rhombana* (Denis & Schiffermüller, 1775) on *Prunus* L. / *Crataegus* Tourn ex. L., M.R. Shaw leg., K. Horstmann det. **E.** *C. ? formosanae*, ♀ (NMS) from Hungary, Veszprém Devecseri Széki, ex undet. Microlepidoptera larva under *Ulmus* L. bark, M.R. Shaw leg., K. Horstmann det. **F.** *C. unicingulatus* (Schmiedeknecht, 1909), ♀ (NMS), from UK, Pamber Forest, Hampshire, ex *?Epinotia immundana* (Fischer von Röslerstamm, 1839) on *Alnus glutinosa* (L.) Gaertn., M.R. Shaw leg., K. Horstmann det.



hind basitarsus. Propodeum with area basalis rectangular, about $0.5 \times$ as wide as area superomedia; area superomedia large, about $1.5 \times$ as wide as long, coriaceous and matt, not depressed and open posteriorly. Area petiolaris very slightly depressed and with irregular transverse striae. Rim of propodeal spiracle and carina connecting propodeal spiracle to pleural carina normal.

METASOMA. Postpetiole coriaceous. Metasomal tergite II $1.4 \times$ as long as apically wide. Ovipositor ratio about 1.5.

COLOUR. Black. Palps and tegulae yellowish-white. Mandibles (except black base and reddish teeth) and pedicel apically yellow. Scape and flagellum yellowish-brown, flagellum lighter distally. Pterostigma yellowish-brown. All coxae black, fore coxa yellow marked distally, all tibial spurs yellowish-white; fore and mid trochanters and trochantelli yellowish-red, fore and mid femora, tibiae and tarsi yellowish-red. Hind trochanter and trochantellus brownish, hind femur red, hind tibia and tarsus yellowish-red, tibia with very small light spot at the base, very slightly brownish subbasally and apically. Metasoma and ovipositor sheath black.

Campoplex formosanae Horstmann, 2012

Figs 7D, 8, 9D, 10D, 12C–E, 14D

Campoplex formosanae Horstmann, 2012: 108–109.

Material examined

GERMANY • 1 ♀; ZSM.

HUNGARY • 1 ♀; ZSM.

UNITED KINGDOM • 18 ♀♀; NMS.

Description

Female

MEASUREMENTS. Body length 6.5–7.0 mm; fore wing length 4.6 mm.

HEAD. Face about $0.65\text{--}0.75 \times$ as high as wide. Malar space $0.5\text{--}0.6 \times$ width of mandibular base. Gena $0.5 \times$ as long as eye (maximum width, seen laterally); temple about $0.6 \times$ as long as eye (seen dorsally), weakly narrowed behind eye, imaginary lines connecting outer side of eye and temple intersect at the level of the scutellum. OOD $0.7 \times$ distance between lateral ocelli. Mandibular teeth subequal. Clypeus $0.4 \times$ as high as wide, not produced in profile medially, matt and coriaceous, its apical margin sharp and gently rounded. Face and frons granulate and matt. Vertex and temples coriaceous and subpolished.

Fig. 13 (opposite page). Cocoons of species belonging to *Campoplex difformis* species group. **A.** *Campoplex punctulatus* (Szépligeti, 1916), ♀ (NMS), from UK, Waulkmill, Glen Glasgow, ex tortricid on *Centaurea* L., R. Knill-Jones leg., K. Horstmann det. **B.** *C. punctulatus* (Szépligeti, 1916), ♂ (NMS), from UK, Hutton Roof, Cumbria, ex *Aphelia paleana* (Hübner, 1793), J.R. Langmaid leg., K. Horstmann det. **C.** *C. restrictor* Aubert, 1960, ♀ (NMS), from UK, Bentley Wood, Wilts., ex *Pandemis cerasana* (Hübner, 1786) on *Lonicera periclymenum* L., B. Fox leg., K. Horstmann det. **D.** *C. restrictor* Aubert, 1960, ♂ (NMS), from UK, Trench Wood, Worcs., ex *Epinotia sordidana* (Hübner, [1824]), A.N.B. Simpson leg., K. Horstmann det. **E.** *C. sulcatus* Horstmann, 1985, ♀ (NMS), from UK, Isle of Man, Douglas Shoprite, ex *Lozotaenia forsterana* (Fabricius, 1781) on ivy, F.D. Bennett leg., K. Horstmann det. **F.** *C. melanostoma* (Strobl, 1904), ♀ (NMS) from Portugal, Alagarve, Carrapateira SW of Bordiera, ex *Agonopterix* Hübner, 1825 sp. on *Centaurea spaerocephala* L., M.F.V. Cavley leg., K. Horstmann det.

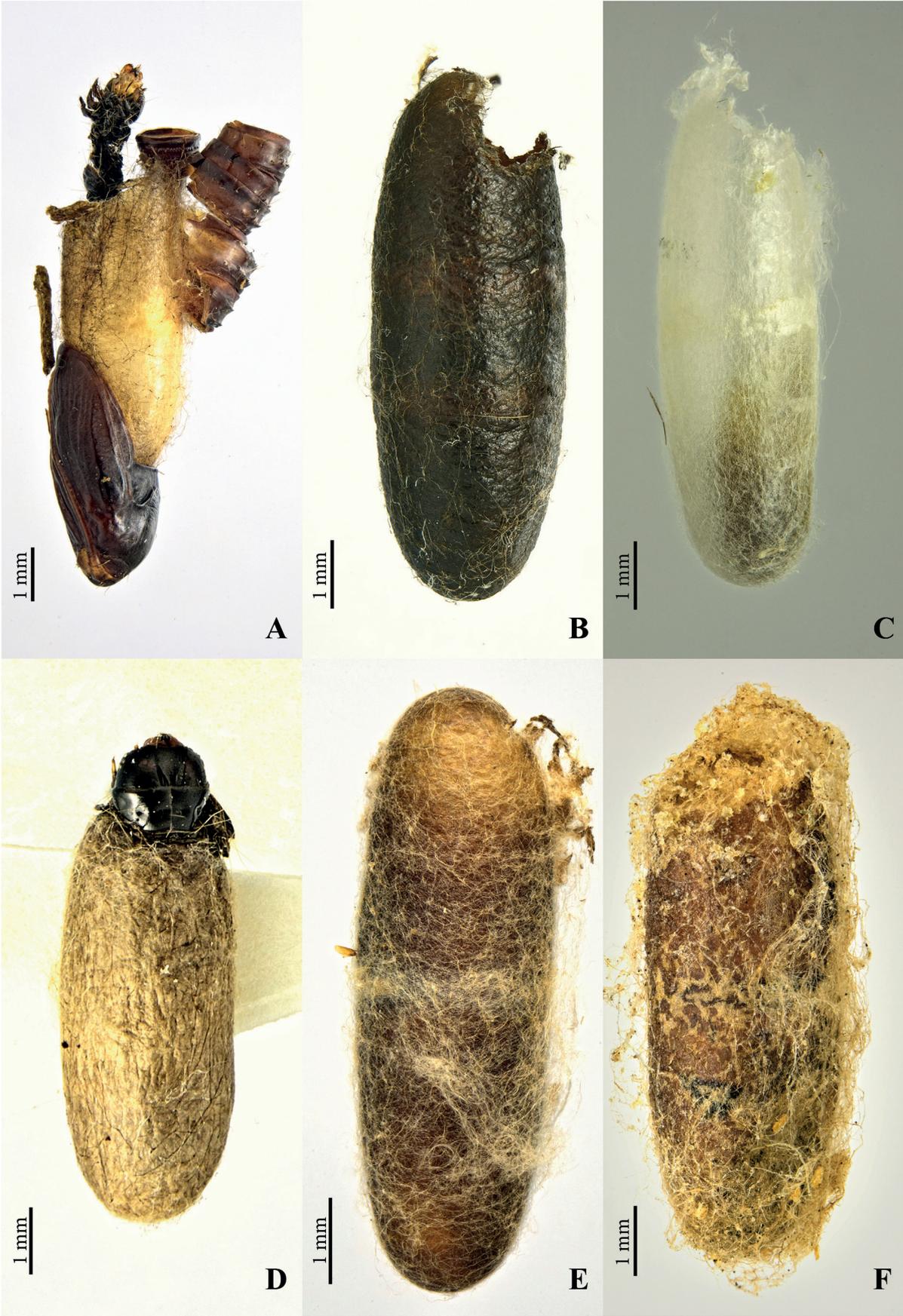




Fig. 14. Face, frontal view. **A.** *Campoplex capitator* Aubert, 1960, lectotype (MZL). **B.** *C. difformis* (Gmelin, 1790) (ZSM). **C.** *C. dubitator* Horstmann, 1985 (ZSM). **D.** *C. formosanae* Horstmann, 2012 (ZSM). **E.** *C. unicingulatus* (Schmiedeknecht, 1909) (ZSM). **F.** *C. corsicator* Aubert, 1960, lectotype (MZL).

Flagellum in examined specimens with 32 segments, flagellomeres in apical quarter about $0.95\text{--}1.00 \times$ as long as wide.

MESOSOMA. Pronotum medio-ventrally with longitudinal striae, dorsally coriaceous. Epomia indistinct. Mesoscutum and scutellum granulate and matt, scutellum without lateral carinae. Mesopleuron coriaceous and matt, with shallow and scattered punctures, especially on antero-ventral half; speculum smooth, anteriorly with fine longitudinal striae. Epicnemial carina only slightly sinuate subventrally, ventrally slightly raised, in middle without notch and not produced into lobes. Metapleuron coriaceous and matt.



Fig. 15. *Campoplex capitator* Aubert, 1960, ♀, lectotype (MZL). **A.** Habitus and labels. **B.** Mesopleuron and epicnemial carina, ventrolateral view. **C.** Propodeum, dorsolateral view showing area superomedia and area petiolaris only slightly depressed and carina connecting propodeal spiracle to pleural carina thickened (DISAAA, specimen obtained from *Lobesia botrana* (Denis & Schiffermüller, 1775)).

Fore wing with areolet small and petiolate, 2m-cu slightly beyond its middle; 1cu-a opposite M&RS. Hind wing with proximal abscissa of CU 2.8–3.0 × as long as cu-a, distal abscissa of CU unpigmented. Hind femur 4.6 × as long as its maximum width, the longer inner tibial spur about 0.6 × as long as hind basitarsus. Propodeum with area basalis rectangular, about 0.4 × as wide as area superomedia; area superomedia about 1.9 × as wide as long, granulate and matt, slightly depressed and open posteriorly. Area petiolaris slightly depressed and with irregular transverse striae. Rim of propodeal spiracle and carina connecting propodeal spiracle to pleural carina normal.

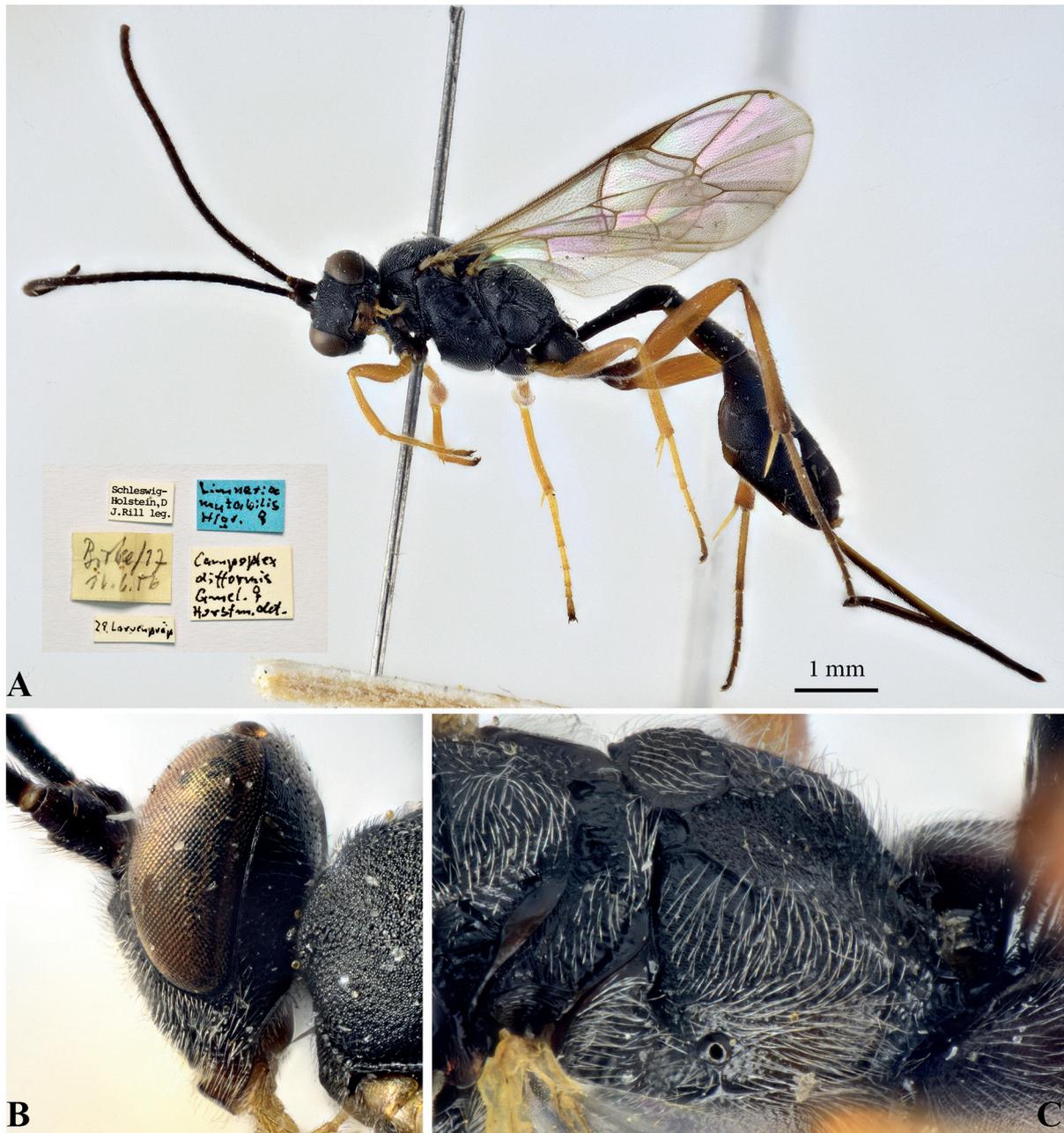


Fig. 16. *Campoplex difformis* (Gmelin, 1790), ♀ (ZSM). **A.** Habitus and labels. **B.** Head, lateral view. **C.** Propodeum, dorsolateral view showing area superomedia and area petiolaris clearly depressed and carina connecting propodeal spiracle to pleural carina normal.

METASOMA. Postpetiole coriaceous. Metasomal tergite II $1.5 \times$ as long as apically wide. Ovipositor ratio 1.4–1.5.

COLOUR. Black. Palps and tegulae yellowish-white. Mandibles (except black base and reddish teeth) and pedicel apically yellow. Scape and flagellum yellowish-brown, flagellum lighter distally. Pterostigma yellowish-brown. All coxae black, fore coxa yellow marked distally, all tibial spurs yellowish-white; fore and mid trochanters and trochantelli yellowish-red, fore and mid femora, tibiae and tarsi yellowish-red. Hind trochanter and trochantellus brownish, hind femur red, hind tibia and tarsus yellowish-red, tibia with very small light spot at base, very slightly brownish subbasally and apically. Metasoma and ovipositor sheath black.

Campoplex unicingulatus (Schmiedeknecht, 1909)

Figs 5C, 6B, 7E, 9E, 10E, 12F, 14E

Omorgus unicingulatus Schmiedeknecht, 1909: 1723.

Material examined

GERMANY • 1 ♀; ZSM.

HUNGARY • 1 ♀; ZSM.

UNITED KINGDOM • 5 ♀♀; NMS.

Description

Female

MEASUREMENTS. Body length 6.3–7.6 mm; fore wing length 4.5–5.2 mm.

HEAD. Face about $0.65\text{--}0.75 \times$ as high as wide. Malar space $0.6\text{--}0.7 \times$ width of mandibular base. Gena $0.7 \times$ as long as eye (maximum width, seen laterally); temple about $0.7 \times$ as long as eye (seen dorsally), weakly narrowed behind eye, imaginary lines connecting outer side of eye and temple intersect at the level of the scutellum. OOD $0.65 \times$ distance between lateral ocelli. Mandibular teeth subequal. Clypeus $0.5 \times$ as high as wide, not produced in profile medially, matt and coriaceous, its apical margin sharp and gently rounded. Face and frons granulate and matt. Vertex and temples coriaceous and subpolished. Flagellum in examined specimens with 32 segments, flagellomeres in apical quarter about $0.75\text{--}0.8 \times$ as long as wide.

MESOSOMA. Pronotum medio-ventrally with longitudinal striae, dorsally coriaceous. Epomia indistinct. Mesoscutum and scutellum granulate and matt, scutellum without lateral carinae. Mesopleuron coriaceous and matt, with shallow and scattered punctures, especially on antero-ventral half; speculum smooth, anteriorly with fine longitudinal striae. Epicnemial carina only slightly sinuate subventrally, from subventrally to ventrally clearly and evenly raised, in middle with a shallow notch but not produced into lobes. Metapleuron coriaceous and matt. Fore wing with areolet small and petiolate, 2m-cu beyond its middle; 1cu-a opposite M&RS. Hind wing with proximal abscissa of CU $4.5\text{--}5 \times$ as long as cu-a, distal abscissa of CU unpigmented. Hind femur $4.5 \times$ as long as its maximum width, the longer inner tibial spur about $0.5\text{--}0.6 \times$ as long as hind basitarsus. Propodeum with area basalis rectangular, about $0.4 \times$ as wide as area superomedia; area superomedia large, about $1.7 \times$ as wide as long, granulate and matt, with few small striae on lateral margins, slightly depressed and open posteriorly. Area petiolaris slightly depressed and with irregular transverse striae. Rim of propodeal spiracle and carina connecting propodeal spiracle to pleural carina normal.

METASOMA. Postpetiole coriaceous. Metasomal tergite II $1.4 \times$ as long as apically wide. Ovipositor ratio 1.4–1.5.

COLOUR. Black. Palps and tegulae yellowish-white. Mandibles (except black base and reddish teeth) and pedicel apically yellow. Scape and flagellum yellowish-brown, flagellum lighter distally. Pterostigma yellowish-brown. All coxae black, fore coxa yellow marked distally, all tibial spurs yellowish-white; fore and mid trochanters and trochantelli yellowish-red, fore and mid femora, tibiae and tarsi yellowish-red. Hind trochanter and trochantellus brownish, hind femur red, hind tibia and tarsus yellowish-red, tibia with very small light spot at the base, very slightly brownish subbasally and apically. Metasoma and ovipositor sheath black.

Discussion

Morphological characters useful in the identification of *Campoplex difformis* and related species

We propose here a tentative matrix-key summarising the morphological characters useful for the discrimination of *Campoplex difformis* and related species. Unfortunately, even considering several morphological characters at the same time, the identification of several species belonging to the *Campoplex difformis* group is still difficult without a reference collection or host records. Some morphological characters, such as wing venation (i.e., shape of the areolet in the fore wing, position of distal abscissa of CU in the hind wing) or propodeal carinae (i.e., shape of the area superomedia), can vary amongst specimens or between male and female (see notes under *C. capitator*). As stated by Horstmann (2012), females are often barely determinable, while trapped males are indeterminate and can be correctly associated with females only if obtained from rearing or through DNA barcoding analysis. Moreover, it cannot be excluded that further cryptic species will be recognized in this subgroup, as soon as morphological, faunistic, biological and molecular information will be gained.

Excluding *Campoplex hercynicus*, which can easily be recognized by the shape of the epicnemial carina (see above, Fig. 5B), and including *C. corsicator*, species belonging to the complex of *C. difformis*, *C. capitator*, *C. dubitator*, *C. formosanae* and *C. unicingulatus* can be tentatively separated on the base of the combination of characters in Table 1.

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Table 1. Table summarizing the combination of morphological characters useful for the identification of females of *Campoplex difformis* (Gmelin, 1790), *C. capitator* Aubert, 1960, *C. dubitator* Horstmann, 1985, *C. formosanae* Horstmann, 2012, *C. unicingulatus* (Schmiedeknecht, 1909) and *C. corsicator* Aubert, 1960.

species/characters	face (height/width)	temples (width with respect to transverse diameter of eye) from above	flagellomeres in the apical quarter (length/ width)	shape of epinomial carina	area superomedia	area petiolaris	ovipositor index
<i>C. capitator</i> Aubert, 1960	0.60–0.70	0.6	0.9–1.0	only slightly raised ventrally	1.4 × as wide as long, coriaceous and matt, not depressed, posteriorly open and with very fine transverse striae	very slightly depressed and with irregular transverse striae	1.6
<i>C. difformis</i> (Gmelin, 1790)	0.75–0.85	0.5	0.7–0.8	only slightly raised ventrally	about 1.8 × as wide as long, coriaceous and matt, relatively strongly depressed from the anterior margin and open posteriorly	clearly depressed and with irregular transverse striae	1.6–1.7
<i>C. dubitator</i> Horstmann, 1985	0.60–0.70	0.7	1.0	only slightly raised ventrally	about 1.5 × as wide as long, coriaceous and matt, not depressed and open posteriorly	very slightly depressed and with irregular transverse striae	1.5
<i>C. formosanae</i> Horstmann, 2012	0.65–0.75	0.6	0.95–1.0	only slightly raised ventrally	about 1.9 × as wide as long, granulate and matt, slightly depressed and open posteriorly	slightly depressed and with irregular transverse striae	1.4–1.5
<i>C. unicingulatus</i> (Schmiedeknecht, 1909)	0.65–0.75	0.7	0.75–0.8	ventrally widened, almost as wide as fore basitarsus	about 1.7 × as wide as long, granulate and matt, with few small striae on lateral margins, slightly depressed and open posteriorly	slightly depressed and with irregular transverse striae	1.4–1.5
<i>C. corsicator</i> Aubert, 1960 stat. nov.	0.80–0.90	0.3	0.8–0.9	only slightly raised ventrally	about 1.4 × as wide as long, coriaceous and matt, not depressed and open posteriorly	very slightly depressed and with irregular transverse striae	1.6

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