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First record of gynandromorphism in the subfamily Chrysidinae (Hymenoptera: Chrysididae)

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A b s t r a c t : A gynandromorph of *Holopyga fervida* (FABRICIUS, 1781) is described. This is the first record of a gynandromorph for the subfamily Chrysidinae and the second for the family Chrysididae. *Holopyga fervida* shows a strong sexual dimorphism in colour and surface sculpture. The studied specimen from Lower Austria is a mostly female-like mosaic gynandromorph with a male-like area on the pronotum.

K e y w o r d s : *Holopyga fervida*, gynandromorph, sexual dimorphism, cuckoo wasps.

Introduction

Gynandromorphism is the phenomenon by which an organism possesses tissue that is genotypically and phenotypically male and female (NARITA et al. 2010), thus showing male and female features. A gynandromorph (or gynander) can have a bilateral or transversal symmetry, when male and females traits are clearly developed along a particular axis of the body, or a mosaic pattern having male and female patches across the body (CAMPOS et al. 2011, WCISLO et al. 2004, SKVARLA & DOWLING 2014).

Gynandromorphy is a widespread phenomenon among Hymenoptera in general and many cases have been reported in the last decades (see, e.g., Apidae listed by MICHEZ et al. 2009 for bees). The underlying genetic mechanism of gynandromorphy concerns a gen locus, the so-called "single locus of complementary sex determination" (sl-CSD) (WILGENBURG et al. 2006). Hymenopteran females are normally diploid heterozygotes (A_1A_2), and males are either haploid (A_1 or A_2) or, rarely, diploid and homozygous (A_1A_1 or A_2A_2) for the mentioned sex determination allele. In gynandromorphs showing female and male characters, female parts have to be CSD heterozygous while male tissues should be either CSD hemizygous (A_1 or A_2) or CSD homozygous (WILGENBURG et al. 2006, MICHEZ et al. 2009). For mosaic gynandromorphs, as in the treated case, two theories have been developed: in the first case it is implied that the chromosome bearing CSD is lost which might take place during the stage of zygote cell division. The second case implies mutation and/or inhibition that inactivates (A_1~~A_2~~ or ~~A_1~~A_2) or removes part of the CSD allele (A_1 or A_2) but not the entire chromosome (MICHEZ et al. 2009, and references cited therein).

Within Hymenoptera, gynandromorphy may be the result of developmental aberrations or *Wolbachia*-induced parthenogenesis; higher temperatures partially suppress the action of the bacterial symbiont and result in the formation of gynandromorphs (BOWEN & STERN 1966, CABELLO-GARCÍA &VARGAS-PIQUERAS 1985, RAFAEL et al. 2017).

More generally, gynandromorphs are known from 16 insect orders (RAFAEL et al. 2017) and at least 29 hymenopteran families (SKVARLA & DOWLING 2014, completed): Agaonidae (PEREIRA et al. 2003), Andrenidae (XU & CUI 2007, MICHEZ et al. 2009), Apidae (WCISLO et al. 2004, MICHEZ et al. 2009), Braconidae (WHITING & WHITING 1927), Chalcididae (HALTEAD 1988), Colletidae (WCISLO et al. 2004, MICHEZ et al. 2009), Crabronidae (SCHNEIDER & FEITZ 2003), Diapriidae (COMÉRIO et al. 2015), Diprionidae (MARTINI et al. 1999), Dryinidae (VIRLA 2001), Encyrtidae (ZHANG & ZHU 2007), Formicidae (YANG & ABOUHEIF 2011), Halictidae (WCISLO et al. 2004, MICHEZ et al. 2009), Ichneumonidae (TARASCO 1996), Megachilidae (GERBER & AKRE 1969, MICHEZ et al. 2009), Melittidae (WCISLO et al. 2004, MICHEZ et al. 2009), Mutillidae (TURRISI & FOUCART 2008), Mymaridae (JACKSON 1959), Pompilidae (WAHIS 1996), Pteromalidae (KAMPING et al. 2007), Scelionidae (HUGGERT 1977), Sphecidae (MENKE 1964), Scoliidae (KROMBEIN 1949), Tenthredinidae (PEACOCK 1925), Tiphiidae (KROMBEIN 1949), Torymidae (ZAVADA 2003), Trichogrammatidae (BESERRA et al. 2003), and Vespidae (TURRISI & BORSATO 2008).

One case of gynandromorphy has already been reported for the family Chrysididae, subfamily Cleptinae (STRUMIA 2004), even if this record remained widely ignored because it was published within a taxonomical article. STRUMIA (2004) described an outstanding mosaic gynandromorph of *Cleptes triestensis* MÓCZÁR, 2000.

Here we describe the first case of gynandromorphism in *Holopyga fervida* (FABRICIUS, 1781) and by that in the entire subfamily Chrysidinae. This subfamily is well known for sexually dimorphic characters, especially in body colour and surface sculpture (LINSENMAIER 1959).

Holopyga fervida is a common and widespread species in Central Europe and in the Mediterranean countries; northwards it reaches Denmark (PAUKKUNEN et al. 2015), eastwards the Middle East (ROSA et al. 2013). The host is unknown. The wasps usually fly on sparsely vegetated areas, on sand, loess and clay banks, visiting flowers of Apicaceae, Asteraceae, and Euphorbiaceae (HEINRICH 1964, HOOP 1971, LINSENMAIER 1997, ROSA 2004).

Materials and methods

M a t e r i a l e x a m i n e d : Gynandromorph collected at Spitz an der Donau (N 48°22', E 15°25', ca. 220 m a.s.l.) in Lower Austria and deposited in the collection of the Natural History Museum in Vienna.

M e t h o d s : The specimen was examined and described under a Carton Togal stereomicroscope. Photographs were taken with a Nikon D-3400 camera connected to the Togal SCZ stereomicroscope and stacked with the Combine ZP software.

Results and discussion

Description of the gynandromorph of *Holopyga fervida* (FABRICIUS, 1781)

Body length: 6.2 mm.

Head. General appearance female-like (Figs. 1A, 2A). Red-purple, with blue scapal

basin. Frons, vertex, gena, face between eye, and scapal basin with tiny and shallow punctures, 1-3 puncture diameters apart, separated by polished interstices; scapal basin asetose and smooth; ocellar-triangle isosceles; postocellar line distinct and deep; antennae 13-segmented; in dorsal view, angular margins of the head (temples) as acute angles.

Mesosoma. Female-like, except for a male mosaic area on pronotum. Pronotum medially divided into a left masculine and a right feminine part (Figs. 1A, 2A). The most evident difference is colour: the left side is emerald green as typical for males, in contrast with the red-purple colouration of the female body. Yet, the punctation of this area is critical for a sexual assignment: male punctation is coarser, with larger punctures closer, and micropunctate on interstices, whereas the female's pronotum has sparser punctures, without micropunctation on interstices, but with smooth intervals (comp. Figs. 1B-C). Mesoscutum, mesoscutellum, metanotum, propodeum, and mesopleuron female-like, with mesoscutum and mesoscutellum red-purple, the latter largely impunctate and apically with large punctures, with greenish-blue bottom; mesopleuron, metanotum, and propodeum dark blue, metanotum with foveate-reticulate punctures.

Metasoma. Female-like, terga red-purple, sterna brownish. Terga evenly punctate, with small punctures about one puncture diameter apart; laterally with denser punctures. Apical margin of metasomal terga impunctate or shallowly punctate, brownish; apex of third metasomal tergum with raised brownish rim.

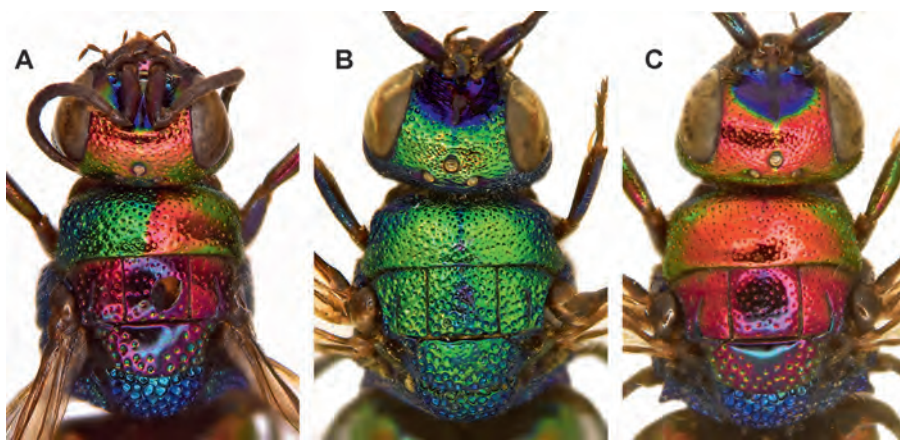

Fig. 1: *Holopyga fervida*, head and mesosoma: (**A**) gynandromorph; (**B**) male; (**C**) female.

Identification and variability of *Holopyga fervida*

Holopyga fervida is a typical example of a strongly sexually dimorphic species of Chrysididae, males and females being differently coloured, shaped and sculptured. The female is mostly shiny red-purple, with legs, metanotum, mesopleuron, propodeum, and lower part of head blue; conversely, the male is entirely green to blue-green, sometimes with golden reflections on metasoma and occasionally with golden reflections also on

head and mesosoma (var. *taorminensis* TRAUTMANN, 1922; Fig. 2E). The habitus is different: the metasoma of the female is elongated, whereas that of the male has a regularly rounded posterior margin. The body punctation is also considerably different: the female has small, sparse punctures with polished interstices; the male has a coarse, double punctation, with tiny dots on interstices. Significantly different is the punctation of the mesoscutellum, almost entirely polished in female (Fig. 1C) and densely micropunctate in male (Fig. 1B).

In Northern Europe, the male can be confused with *H. metallica* DAHLBOM, 1854, but it is recognizable for the coarser and denser metasomal punctation, with interstices smaller than a puncture diameter, whereas in *H. metallica* the metasoma punctation is fine and sparse (see pictures in PAUKKUNEN et al. 2015). The female of *H. metallica* is easily recognizable because its colour and sculpture are similar to the male. In Eastern Mediterranean countries, the Near East and Middle East *H. fervida* can be confused with *H. buyssoni* MERCET, 1902 (often considered as its eastern subspecies), but both sexes of this species are recognizable by large and coarse punctures on the metasoma.

For a very long time, males and females of *Holopyga fervida* were considered different species because of the remarkable sexual dimorphism. The male had been considered a valid species named either *H. curvata* (FÖRSTER, 1853) or *H. chloroidea* (DAHLBOM, 1854). TRAUTMANN's (1922) hypothesis that *H. curvata* could be the male of *H. fervida* was not immediately accepted (e.g., INVREA, 1923). Still LINSENMAIER (1959, 1968, 1969) considered *H. chloroidea* as the separate subspecies of *H. fervida* distributed in Asia Minor, Syria, Palestine, and Cyprus. His interpretation, even though not in contrast with the original distribution of *H. chloroidea*, was a source of taxonomical instability and for this reason ROSA & XU (2015) designated the lectotype of *H. chloroidea*. This eastern Mediterranean species with an obvious coarser punctation is currently referred to as *H. buyssoni*.

The Paris Museum houses an interesting female specimen of *H. fervida* with the aberrant colour of a male. It was collected near Paris and erroneously designated as the lectotype of *H. chloroidea* by KIMSEY (1986) (see ROSA & XU 2015). A second female of such colour was collected by Fritz Blühweiss in the Danube wetlands ("Donauauen") in eastern Austria (probably in or close to Vienna). This specimen (Fig. 2D), housed at the Vienna Museum, has been labelled by Karl Hammer as the type of "*Holopyga fervida* var. *viridis*", but it was never formally described.

Males of *H. fervida* can be very variable in colour (Figs 2B, 2E, 2F). The typical colour is green, but several specimens from all over Europe are entirely deep blue (Fig. 2F, *H. fervida violacea* HOFFMANN, 1935) or green with golden metasoma. In the southernmost European localities, males can be variably golden red. An extreme colour form was described as *H. fervida taorminensis* TRAUTMANN, 1922 (Fig. 2E).

The specimen here described as a gynandromorph shows the left half of the pronotum green and with coarse and double punctation, referable to a phenotypic trait of the male, while all other features are that of a female. The aberrant character of this specimen is very obvious. The authors presently do not have an explanation why gynandromorphism is so rare in cuckoo wasps, compared to some other families of Aculeata like spider wasps or bees, where this phenomenon is more frequently observed (e.g., WAHIS 1996, MICHEZ et al. 2009).

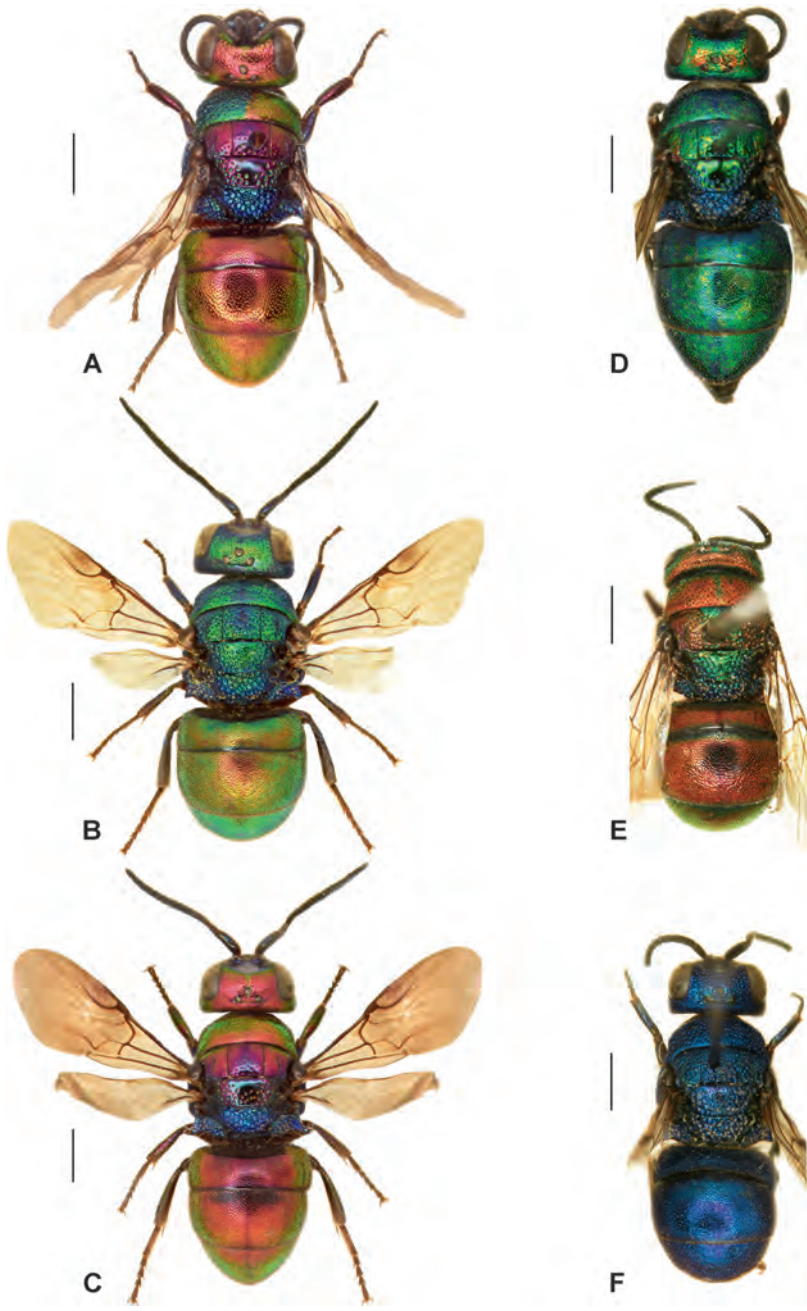

Fig. 2: *Holopyga fervida*, habitus: (**A**) gynandromorph; (**B**) male, normal colour; (**C**) female, normal colour; (**D**) female, green variation; (**E**) male, holotype of *H. fervida* var. *taorminensis*; (**F**) male, holotype of *H. fervida* var. *violacea*. Scale bars: 1.0 mm.

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Zusammenfassung

Ein Gynander der Goldwespe *Holopyga fervida* (FABRICIUS, 1781) wird beschrieben. Es handelt sich um den ersten Nachweis eines Gynander in der Unterfamilie Chrysidinae und erst den zweiten in der Familie Chrysididae. *Holopyga fervida* zeigt hinsichtlich Färbung und Oberflächenskulptur einen starken Sexualdimorphismus. Das untersuchte Exemplar aus Niederösterreich ist ein "Mosaik-Gynander" mit überwiegend weiblichen Merkmalen, aber mit einer Fläche am Pronotum, die männchenartig ist.

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