



SHORT NOTE

Male or Female? New Cases of Gynandromorphism in Wool Carder Bees of the Tribe Anthidiini (Hymenoptera: Megachilidae)

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Abstract

Gynandromorphism is a condition in which both male and female morphological characteristics are present in a single specimen. This phenomenon has been well-documented in Apoidea, but with only a few cases in megachilid bees. Here, we described two new instances of gynandromorphism in wool carder bees (Hymenoptera: Megachilidae: Anthidiini), including the first record in the genus *Rhodanthidium*. The studied cases include single specimens of *Anthidium punctatum* Latreille from Bulgaria and *Rhodanthidium siculum* (Spinola) from Italy. To date, gynandromorphism in Anthidiini has been observed only in nine species of the genera *Anthidiellum* Cockerell, *Anthidium* Fabricius, *Dianthidium* Cockerell, *Rhodanthidium* Isensee, and *Trachusa* Panzer, underscoring the rarity of this phenomenon in this tribe.

Individual organisms exhibiting phenotypical male and phenotypical female characteristics are known as gynanders, whereas individuals with intermediate sexual phenotypic traits are generally indicated as intersexes (Narita et al., 2010). The reasons for gynandromorphism are varied; it typically arises due to errors in cell division early in embryonic development (Fusco & Minelli, 2023). For instance, during mitosis, if the sex chromosomes are distributed unevenly between the two daughter cells, one part of the organism may develop as male while the other develops as female (Werner, 2012). Gynandromorphism can also result from the loss of a sex chromosome in early development, leading to different sexual identities in various parts of the body, or from the fertilization of a binucleate egg (e.g., Michez et al., 2009; Fusco & Minelli, 2023). In hymenopterans, the mechanism for gynandromorphism is different, as sex determination is based

on ploidy: males have one set of chromosomes (haploid), while females have two sets (diploid) in what is known as the haplodiploid sex-determination system (e.g., Danforth et al., 2019; Kennedy, 2020).

Several underlying mechanisms have been identified for gynandromorphism in hymenopterans, which has been well-studied in the honey bee *Apis mellifera* Linnaeus, 1758. Proposed mechanisms include chromosome elimination, polyspermy, double fertilization of a binucleate egg, loss of a sex chromosome, or up-/downregulation of sex-determining genes, mutations, and genetic incompatibilities (Narita et al., 2010; Kratochwil, 2021). Epigenetic factors, i.e., environmental genetic modifiers, have also been suggested as possible causes of gynandromorphism (Sommaggio et al., 2021). To date, gynandromorphism has been reported in approximately 140 species of bees in 35 genera (Almeida et al., 2018; Zama



& Coelho, 2007; Michez et al., 2009). Herein, we report two species of the tribe Anthidiini (Megachilidae) for which gynandromorphism has not been documented yet. The morphological characteristics of the specimens of those species are compared with those of both sexes, primarily based on material from Max Kasperek's collection and species redescriptions found in Kasperek (2022).

Anthidium punctatum Latreille, 1809 (Fig 1): A gynander was collected in Sandanski, Bulgaria (41.54°N, 23.27°E), 01-08.vi.1967, by Miroslav Kocourek (coll. M. Kasperek). Of the eleven sexual character traits examined, all male traits were situated on the left side of the body, while female traits were on the right side (Table 1). The specimen is classified as a bilateral gynander according to Michez et al. (2009).

Rhodanthidium siculum (Spinola, 1838) (Fig 2): The gynander was collected within an almond grove near Paternò, Sicily, Italy (37.48°N, 14.87°E), while foraging on flowers of *Echium vulgare* L. (Boraginaceae), on 23.iii.2023 by Roberto Catania (coll. R. Catania). Of the ten sexual characters examined, seven were attributed to females, one to males, and two displayed different male and female traits on either side

of the body (Table 2). The specimen is classified as mosaic, mixed or patchy gynander, following the terminology of Harman (1917), Fusco and Minelli (2023), and others.

Along with these new records, gynandromorphism in Anthidiini has been reported from nine species of the genera *Anthidiellum* Cockerell, 1904; *Anthidium* Fabricius, 1804; *Dianthidium* Cockerell, 1900; *Rhodanthidium* Isensee, 1927; and *Trachusa* Panzer, 1804 (Table 3), which suggests that this phenomenon could be rare in the tribe. During a comprehensive survey of Old World anthidiine bees, M.K. studied and identified over 17,500 specimens. The single specimen of *Anthidium punctatum* described here was the only gynander found, representing just 0.006% of the specimens examined.

Authors' Contribution

MK: Conceptualization, methodology, investigation, analysis, visualization, writing-original draft, writing-review & editing. MB: methodology, investigation, writing-review & editing. RC: Conceptualization, methodology, investigation, analysis, visualization, writing-original draft, writing-review & editing.

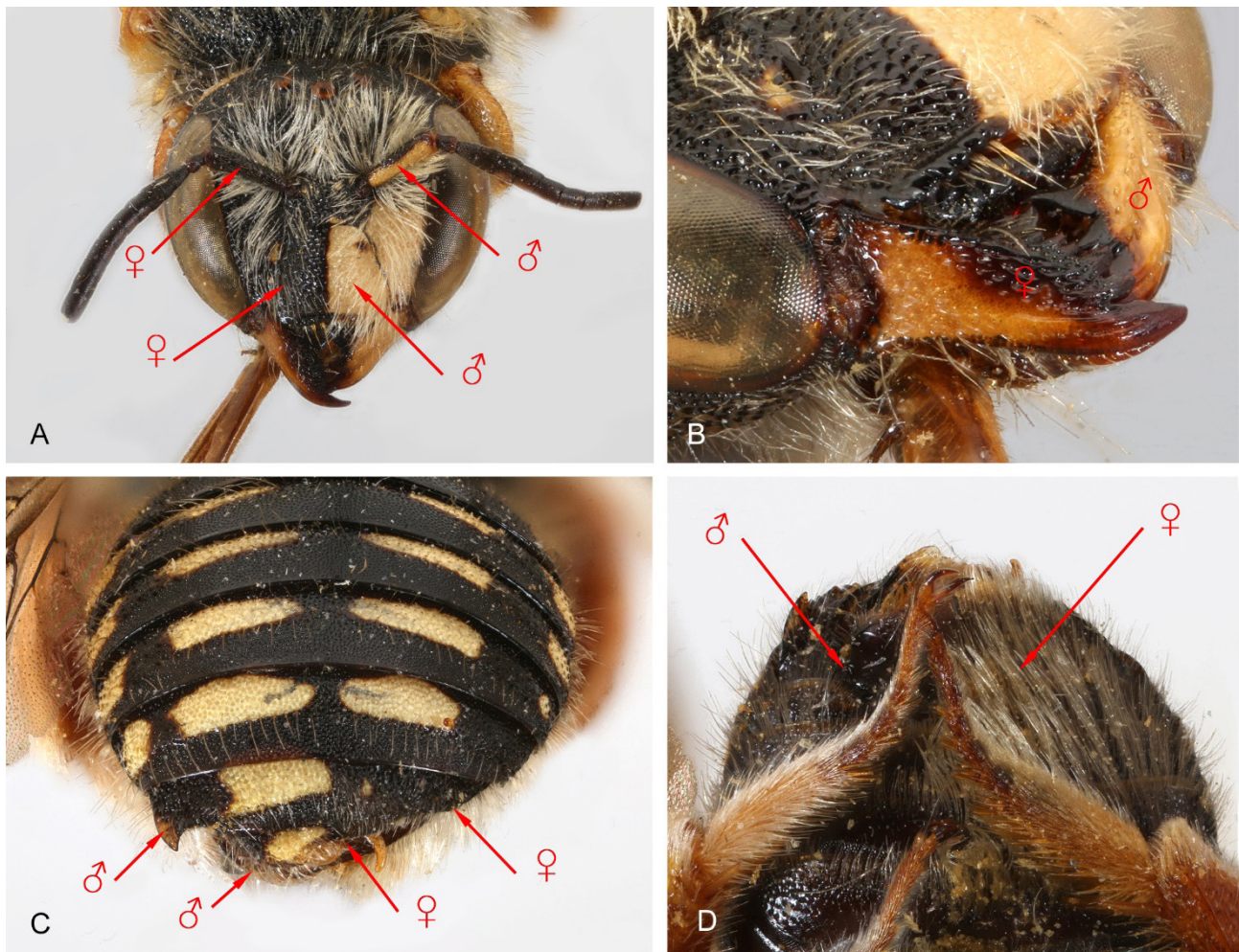


Fig 1. Gynander of *Anthidium punctatum* from Bulgaria. **A:** frontal view of the head; **B:** mandibles; **C:** dorsal view of the metasoma with details of the last terga; **D:** ventral view of the metasoma.

Table 1. Comparison of characters displayed by both sexes of *Anthidium punctatum* to those of the gynander (l = left, r = right).

Character	Female	Male	Gynander
Antenna	Black, 12 segments	Dark brown with some light brown on the underside; underside of scape yellow; 13 segments	l: ♂; r: ♀
Clypeus	Black, shallowly emarginate apical rim with low, vertically projecting, shiny tubercles	Yellow, light brown apical rim	l: ♂; r: ♀
Mandible	Basal and lower side yellow, upper side brown; 5-6 black teeth	Yellow with three strong black teeth	l: ♂; r: ♀ (six teeth and an additional minute tooth),
Paraocular area	Black	Lower paraocular area yellow, upper paraocular area black	l: ♂; r: ♀ (with small yellow spot)
Supraclypeal area	Black	Black, mostly with small yellow spot	l: ♂ (small yellow spot present); r: ♀
Mesoscutellum	Black mostly with yellow maculation (macula strongly varying in size)	Black mostly with yellow maculation (macula strongly varying in size, but usually smaller than in female)	l: ♂ (small yellow maculation); r: ♀ (large yellow macula)
Terga 1-5	With lateral yellow maculation on T1-T4, rarely also on T5, maculae decreasing in size towards apex	Large yellow lateral maculation, often merged with mediolateral maculation; maculae larger than in female	l: ♂ (lateral maculae present on T1-T5); r: ♀ (lateral maculae present on T1-T4, smaller than on left side)
Tergum 6	Outer margin widely rounded, projection absent	Flat, pointed lateral projection	l: ♂; r: ♀
Tergum 7	Absent	With deep median emargination, pointed posterior apex	l: ♂; r: ♀
Sternum 6	Flat, rounded outer margin	With strong, black lateral tooth	l: ♂; r: ♀
Scopa	Present	Absent	l: ♂; r: ♀

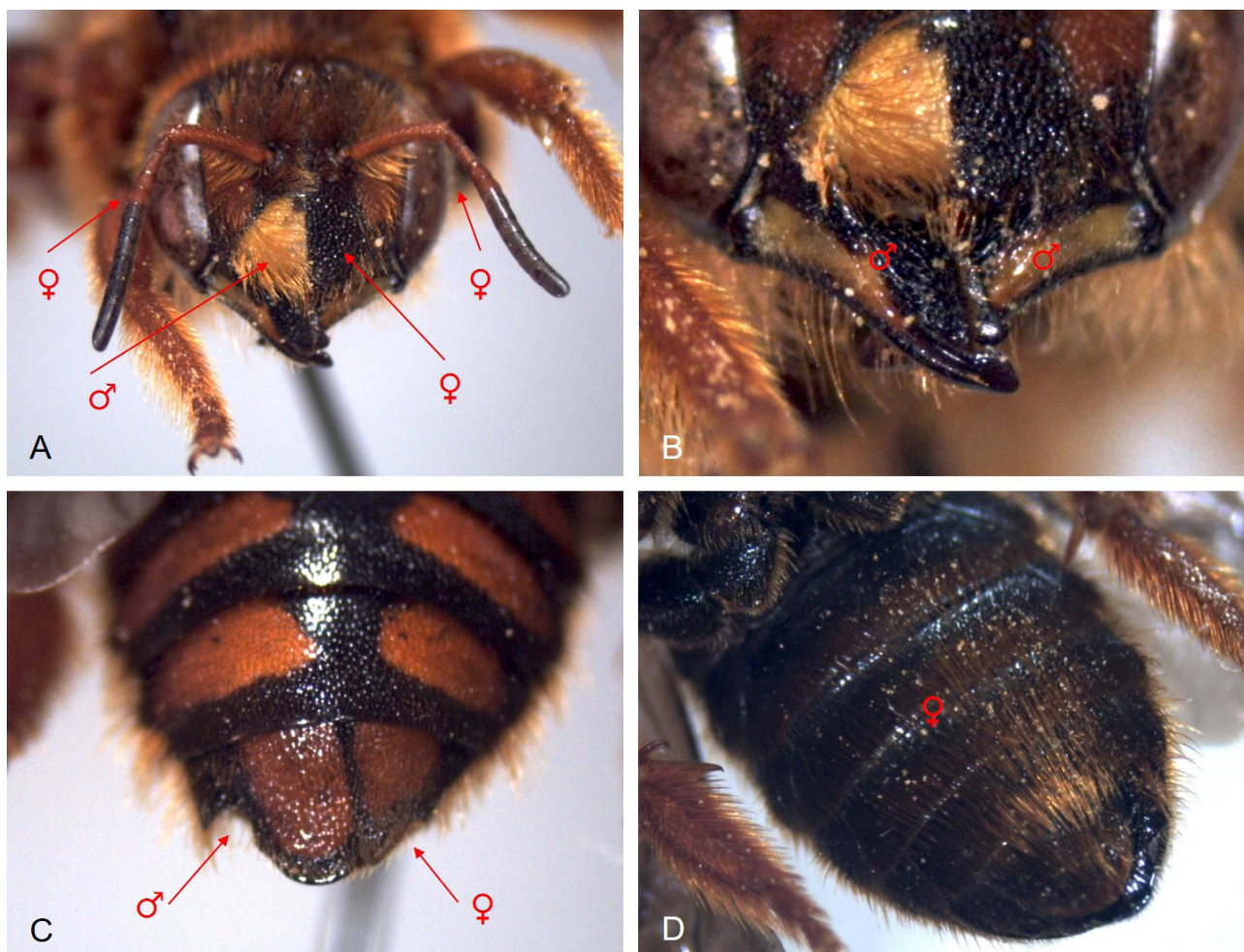
**Fig 2.** Gynander of *Rhodanthidium siculum* from Italy (Sicily). **A:** frontal view of the head; **B:** mandibles; **C:** dorsal view of the metasoma with details of the last terga; **D:** ventral view of the metasoma.

Table 2. Comparison of characters displayed by both sexes of *Rhodanthidium siculum* to those of the gynander.

Character	Female	Male	Gynander
Antenna	12 segments	13 segments	l.: ♀; r.: ♀
Clypeus	Black	Yellow	l.: ♀; r.: ♂
Mandible	Black	Yellow with black margins and black teeth	l.: ♂; r.: ♂
Paraocular area	Red	Yellow	l.: ♀; r.: ♀
Pubescence of head	Long red-orange hair	Hairs ochreous to orange	♀
Pubescence of mesoscutum	Black with ginger hair	Dark with rich ochreous pubescence	♀
Ventral scopa	Present	Absent	♀
Exposed terga	Six	Seven	♀
Tergum 6	With apical lamella which has a small median incision, and with lateral projection on each side	With a large median projection, often slightly bilobed, at each side a broad black, blunt tooth	l.: ♂; r.: ♀
Body length	13.5-16 mm	17-25 mm	♀ (14 mm)

Table 3. Cases of gynandromorphy reported in Anthidiini.

Species	Gynander category	Country	References
<i>Anthidiellum strigatum</i> (Panzer, 1805)	mosaic	Germany	Wolf (1998)
<i>Anthidiellum strigatum</i> (Panzer, 1805)	bilateral*	Greece (mainland)	Wolf (2003)
<i>Anthidium loti</i> Perris, 1852	bilateral*	Greece (Kos)	Wolf (2006)
<i>Anthidium oblongatum</i> (Illiger, 1806)	transversal	Germany	Stöckert (1924)
<i>Anthidium oblongatum</i> (Illiger, 1806)	transversal	USA	Flickr (2014)
<i>Anthidium punctatum</i> Latreille, 1809	bilateral	Bulgaria	This study
<i>Dianthidium curvatum sayi</i> Cockerell, 1907	transversal	USA	Hicks (1926)
<i>Dianthidium pudicum pudicum</i> (Cresson, 1879)	bilateral*	USA	Mullins et al. (2024)
<i>Dianthidium ulkei</i> (Cresson, 1878)	transversal	USA	Schwarz (1926)
<i>Rhodanthidium siculum</i> (Spinola, 1838)	mosaic	Italy (Sicily)	This study
<i>Trachusa byssina</i> (Panzer, 1798)	mosaic	Czechia	Dalla Torre & Friese (1898)

*reported as imperfect bilateral gynander.

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