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***Dasypoda delectabilis* sp. nov., a morphologically intriguing pantaloon bee species from south-eastern Iran (Hymenoptera: Melittidae)**

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With its diverserange of climates and landscapes, the Middle East offers a remarkable area for the study of bee taxonomy and biogeography. In this work, a new species of pantaloon bee (*Dasypoda delectabilis* Ghisbain & Michez **sp. nov.**) is described from a single male collected in south-eastern Iran. Although the new species shows affinities with the subgenus *Heterodasypoda* Michez, its morphology is highly intriguing due to the presence of characters shared by representatives of the subgenus *Dasypoda* sensu stricto Latreille. A diagnostic comparison with phenotypically close *Dasypoda* species is provided, along with comparative remarks on the morphology and biogeography of the subgenus *Heterodasypoda*. Finally, a checklist of the genus *Dasypoda* is given for the Middle East, highlighting the need for increased attention to this highly interesting yet largely overlooked fauna.

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Keywords: Anthophila; Apoidea; taxonomy; Middle East

Introduction

With approximately 150 described species, Melittidae is the most basal family among the seven accepted families of bees (Apiformes) globally (Danforth et al. 2013). Among melittids are the bees of the genus *Dasypoda* Latreille, a clade of morphologically unique pollinators referred to as the “pantaloon bees” for which around 40 valid species are described worldwide (Michez et al., 2004a; Radchenko et al., 2022). Since the beginning of the 21st century however, the genus *Dasypoda* has received sustained attention from taxonomists, with new species being continuously discovered and described from Africa (*D. riftensis* Michez & Pauly, 2012, *D. schwarzi* Radchenko & Michez, 2022), Western Asia (*D. patinyi* Michez, 2004, *D. gusenleitneri* Michez, 2004, *D. toroki* Michez, 2004, *D. syriensis* Michez, 2004, *D. warnckeii* Michez, 2004, and *D. intermedia* Michez, 2005), Eastern Asia (*D. sichuanensis* Wu, 2000) but also from the better explored and studied Europe (*D. michezi* Radchenko, 2017, *D. morawitzi* Radchenko, 2016). A subgeneric system implemented by Michez et al. (2004a) accounts for four recognized subgenera (*Dasypoda* s. str. Latreille, *Heterodasypoda* Michez, *Megadasy-*

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poda Michez and *Microdasypoda* Michez) and allows the classification of the large majority of species based on combinations of morphological features mainly involving the mouth parts (galea, labial palpi), the apical parts of the male sterna (6, 7 and 8) and male genitalia (number and organization of lobes of the gonostylus), among other criteria.

From Iran, two presumably endemic *Dasypoda* species have been recorded, namely the enigmatic *Dasypoda* (?*Megadasypoda*) *intermedia* Michez, one of the few species challenging the currently accepted subgeneric system (discussed in Michez et al., 2004a), and *Dasypoda* (*Dasypoda*) *litigator* Baker, 2002, both species being known only from their type series. In this paper, we report the discovery of *Dasypoda delectabilis* sp. nov., another Iranian species with a unique combination of morphological features that are intermediate between those of two distinct subgenera. We also provide a checklist of the *Dasypoda* species recorded in the Middle East, highlighting the need for increased attention on this highly interesting yet poorly surveyed fauna.

Methods

Pictures of the holotype were taken with a Keyence microscope VHX-970F. Reference specimens of the other *Dasypoda* species used for the diagnosis (*D. albimana*, *D. michezi*, *D. morotei* and *D. pyrotrichia*) are stored in the Laboratory of Zoology of the University of Mons (UMons, Belgium).

Abbreviations

A1, A2, etc. = first, second, ... antennomere; T1, T2, etc. = first, second, ... metasomal tergum; S1, S2, etc. = first, second, ... metasomal sternum. L = length; W = width.

Results

Taxonomy

Dasypoda (*Heterodasypoda*) *delectabilis* Ghisbain & Michez sp. nov. (Figures 1a-i)

Material examined. Holotype: Male. IRAN: Sistan and Baluchestan prov., 160 km SSE Zahedan, near Kash [28°05'09"N, 61°19'26"E], 1370 m, 26.iv.2019, O. Pak leg. The holotype is deposited in the Naturalis Biodiversity Center, Leiden, The Netherlands. The specimen is not in perfect condition: some hairs are glued together (especially on the clypeus, genae, left mid-leg, and the dorsal part of the metasoma). The description below might therefore be only partial, and more detailed structures should be visible on a fresher specimen.

Description (male holotype). *Head* (Figure 1a-e). Clypeus, supraclypeal and paraocular areas covered by dense, long and erect yellowish pilosity; clypeus surface hidden by dense pilosity; vertex covered with erect, yellowish pilosity (Figure 1b); vertex sculpture squamous along compound eye, and shiny along lateral ocelli; gena (behind compound eye) apparently shiny but obscured by adpressed glued yellowish pilosity on specimen; malar space very short (Figure 1c); scape partly covered with yellowish hairs; pedicel brown, flagellum brown basally and dorsally, reddish elsewhere; flagellomeres brown and concave dorsally, reddish and convex ventrally, covered with very short, light yellow hairs; A3 clearly longer than A4 (Figure 1d); mandible with cuticle dark brown basally and reddish apically; mandible externally with yellowish hairs; galea fully covered with small grains, its distal third from below with fringe of setae longer in apical part (Figure 1e). – *Mesosoma*. Scutum, scutellum, metanotum and propodeum covered with yellowish erect pilosity; mesepisternum pilosity cream white; scutum



Figure 1. Key morphological features of the holotype male *Dasygaster delectabilis* Ghisbain & Michez sp. nov. **a)** general habitus, oblique view; **b)** head in frontal view, showing the particular colour and morphology of the flagellomeres; **c)** malar space in lateral view, showing its especially small size; **d)** lateral view of selected antennal segments (white arrow = A3, black arrow = A4), showing their relative sizes; **e)** mouthparts in lateral view, showing the sculpture of the galea and the relative size of this segment compared to the labial palpi; **f)** apex of S6 in ventral view, showing its apico-lateral sparse pilosity (white arrow) and apico-central gibbous area (black arrow); **g)** one of the latero-apical processes of S7 (black arrow), showing its color and shape, and one of the baso-lateral hooks (teeth) of S8 (white arrow); **h)** teeth on the postero-apical part of S8 (black arrows) and the three lobes of the gonostylus (white arrows) **i)** shape and sculpture of the external lobe of the left gonostylus.

shiny in center but sculpture obscured by dense pilosity; scutellum shiny with punctures distant by less than one puncture diameter; metanotum also shiny but with punctures distant by >1 point diameter; propodeum shiny and squamous; wing hyaline, nervulus antefurcal; femur, tibia and basitarsus with cuticle black but all tarsi brownish-reddish; leg pilosity entirely yellowish except on ventral parts of coxa, trochanter and femora in which it is cream white; meso- and metatibia spurs light yellow. Hind tibia with thin, elevated carina on its inner side. – *Metasoma* (Figure 1f-i). All terga cuticle largely obscured by glued hairs covering sculpture details, but cuticle moderately shiny, finely shagreened with distance between punctures apparently more than one point diameter where visible; terga apical slightly translucent; tergal pilosity damaged on specimen, but overall sparse and yellowish on disc with cream-white hair fringes distally on T1(-T3?) and latero-distally on T4-T6; T6 with yellowish pilosity and cream-white hair patch centrally; T7 with yellowish pilosity and brown hair patch centrally; sterna cuticle very finely sculptured with wave-like lines; S1 with cream-white, long, erect pilosity covering whole sternum; S2 also with cream-white pilosity but absent in segment center (maybe abraded in available specimen); pilosity of S3-S5 restricted to apico-lateral yellow hair tufts; S6 apically with short, sparse yellowish hairs, allowing to see cuticle behind (Figure 1f, white arrow); S6 apico-central part gibbous (Figure 1f, black arrow), and segment apical part inflated; S7 with long latero-apical processes enlarged apically and with reddish cuticle (Figure 1g, black arrow); S8 apical part truncated, with latero-basal teeth (Figure 1g, white arrow); S8 postero-dorsal part with two separated teeth (Figure 1h, black arrows); genitalia with gonostylus internal ventral lobe rounded, scaly and reddish, external lobe with squamous surface, large and blunt apically (Figure 1h, white arrows); penis inflated apically and curved.

Female: Unknown.

Subgeneric affinity. *Dasypoda delectabilis* sp. nov. shows highest affinities with the subgenus *Heterodasypoda* Michez (following the subgeneric concept of Michez et al., 2004a) due to the combination of its diagnostic features. All *Heterodasypoda*, including this new species, are characterized by a medium to large body size (in contrast to *Microdasypoda*, the smallest pantaloon bees). The subgenus *Heterodasypoda* also differs from the other subgenera by their trilobed gonostylus, which includes an inner ventral lobe with a scaly surface, whereas *Dasypoda* s. str. has two lobes joined by a membrane, *Megadasypoda* has three lobes but without a scaly surface on the inner ventral one, and *Microdasypoda* has a gonostylus that is either unilobed with a basal tooth, or bilobed but with no membranous structure connecting the lobes.

These apomorphic characteristics of *Heterodasypoda* must be regarded with a particular combination of other morphological features that are individually shared with other subgenera, but not with all of them. First, the malar space of *Heterodasypoda* is always shorter than the pedicel (unlike most *Megadasypoda*). Their maxillary palpi and galea are of a sub-equal length (unlike *Dasypoda* s. str. in which the palpi/galea ratio is between 0.5-0.75 and *Megadasypoda* in which it is <0.25). The *cu-v* (nervulus) of *Heterodasypoda* is always antefurcal (unlike most *Megadasypoda*). The marginal line of the disc of T2 is relatively straight (unlike *Megadasypoda* and a fraction of *Dasypoda* s. str.).

Interestingly, *D. delectabilis* sp. nov. has a short and sparse pubescence that allows the structure of the cuticle to be clearly seen (as in *Dasypoda* s. str. and *Megadasypoda*), whereas the apical lobes of S6 of all other *Heterodasypoda* have a dense pubescence that does not allow to see the underlying cuticle. In addition, while all the other *Heterodasypoda* species lack lateral hooks at the basal half of S8, *D. delectabilis* sp. nov.



Figure 2. Arid habitat of *Dasyopoda delectabilis* sp. nov., in the Sistan and Baluchistan province, south-eastern Iran (Photograph: Oleg Pak).

presents such teeth (as in *Dasyopoda* s. str. and some *Megadasypoda*). Finally, the new species shows a thin, elevated carina on the inner side of the hind tibia, a structure that recalls those of the males of other species belonging to the subgenus *Dasyopoda* s. str. such as *D. pyriformis* Radoszkowski, *D. riftensis* Michez & Pauly and *D. tibialis* Morawitz (although the shape of this carina significantly differs here).

Based on our current understanding of subgeneric characters in the genus *Dasyopoda*, we place this enigmatic species among *Heterodasyopoda*, which is the most morphologically relevant for *Dasyopoda* (*Heterodasyopoda*) *delectabilis* sp. nov.

Diagnosis. Males of *D. delectabilis* sp. nov. can be easily differentiated from all *Heterodasyopoda* (*D. albimana*, *D. michezi*, *D. morotei*, and *D. pyrotrichia*) by (i) flagellomeres that are concave dorsally and convex ventrally (Figure 1d, other species of this subgenus have evenly cylindrical flagellomeres or vice versa, convex dorsally and concave ventrally; detailed views of flagellomeres in all other *Heterodasyopoda* are available in Radchenko, 2017), (ii) the presence of a thin carina on the inner side of the hind tibia, (iii) the very sparse and short pilosity of the apical processes of S6 (Figure 1f, white arrow), (iv) the presence of two baso-lateral hooks (teeth) on S8 (Figure 1g, white arrow) and (v) by the specific morphology of the external lobe of its gonostylus (Figure 1i, detailed views of this lobe for all other *Heterodasyopoda* are available in Radchenko, 2017). Males of the new species can be separated from all other known *Dasyopoda* based on the subgeneric characters highlighted in the section “Subgeneric affinity”.

Etymology. From the Latin *delectabilis*, meaning “delightful”, recalling the pleasure felt when discovering the highly intriguing combination of morphological features of the holotype.

Table 1. Species of *Dasypoda* Latreille recorded from the Middle East. Subgeneric classification *sensu* Michez et al. (2004b). No *Microdasypoda* species are known from the Middle East. "Sex" stands for the known gender(s).

Species	Sex	Middle East countries	Source
Subgenus <i>Dasypoda</i> s. str. Latreille, 1802			
<i>D. albipila</i> Spinola, 1838	♂, ♀	Arabian Peninsula, Israel, Jordan, Egypt	Michez et al., 2004a; Patiny & Michez, 2007; Spinola, 1838
<i>D. gusenleitneri</i> Michez, 2004	♂	Jordan	Michez et al., 2004a; Patiny & Michez, 2007
<i>D. hirtipes</i> (Fabricius, 1793)	♂, ♀	Turkey, Iran, Iraq, Syria	Warncke, 1973; Michez et al., 2004a; Özbek, 2014
<i>D. litigator</i> Baker, 2002	♂, ♀	Iran	Baker, 2002
<i>D. morawitzi</i> Radchenko, 2016	♂, ♀	Turkey	Radchenko, 2016
<i>D. pyriformis</i> Radoszkowski, 1887	♂, ♀	Turkey	Warncke, 1973; Michez et al., 2004a
<i>D. sinuata</i> Pérez, 1895	♂, ♀	Egypt	Patiny & Michez, 2007
<i>D. syriensis</i> Michez, 2004	♂	Syria	Michez et al., 2004a
<i>D. tubera</i> Warncke, 1973	♂, ♀	Turkey, Syria	Warncke, 1973; Michez et al., 2004a; Özbek, 2014
<i>D. warncke</i> Michez, 2004	♂, ♀	Turkey	Michez et al., 2004a; Özbek, 2014
Subgenus <i>Heterodasypoda</i> Michez, 2004			
<i>D. delectabilis</i> Ghisbain & Michez sp. nov.	♂	Iran	Present study
<i>D. pyrotrichia</i> Förster, 1855	♂, ♀	Turkey, Syria, Israel	Michez et al., 2004a; Özbek, 2014
Subgenus <i>Megadasypoda</i> Michez, 2004			
<i>D. argentata</i> Panzer, 1809	♂, ♀	Turkey, Iran, Iraq, Syria, Egypt	Warncke, 1973; Michez et al., 2004a; Özbek, 2014
<i>D. braccata</i> Eversmann, 1852	♂, ♀	Turkey	Warncke, 1973; Michez et al., 2004a; Özbek, 2014
<i>D. frieseana</i> Schletterer, 1890	♂, ♀	Turkey	Warncke, 1973; Michez et al., 2004a; Özbek, 2014
<i>D. intermedia</i> Michez, 2005	♂	Iran	Michez, 2005
<i>D. longigena</i> Schletterer, 1890	♂, ♀	Turkey	Warncke, 1973; Michez & Patiny, 2002; Michez et al., 2004a; Özbek, 2014
<i>D. patinyi</i> Michez, 2002	♂, ♀	Turkey, Syria	Michez, 2002; Michez et al., 2004a
<i>D. spinigera</i> Kohl, 1905	♂, ♀	Lebanon, Turkey	Warncke, 1973; Michez et al., 2004a; Özbek, 2014
<i>D. suripes</i> (Christ, 1791)	♂, ♀	Cyprus, Turkey	Warncke, 1973; Michez et al., 2004a; Özbek, 2014
<i>D. toroki</i> Michez, 2004	♂, ♀	Israel, Turkey, Syria	Michez et al., 2004a; Özbek, 2014
<i>D. visnaga</i> (Rossi, 1790)	♂, ♀	Turkey	Michez, 2012; El Abdouni et al., 2021

Flight period. April.

Ecology. The specimen was caught in an arid habitat, typical of south-eastern Iran (Figure 2).

Discussion

Here we report the finding of a new species of pantaloon bee from south-eastern Iran, *Dasygoda* (*Heterodasygoda*) *delectabilis* Ghisbain & Michez sp. nov. The combination of morphological characters found in this species, unique among all known pantaloon bees by being intermediate between two subgenera, challenges our current understanding of both the current subgeneric system used for this genus and the biogeographic history of *Dasygoda*. While all *Heterodasygoda* species known so far are mostly found around the Mediterranean basin with a putative center of diversity in the Iberian Peninsula (Michez et al., 2004a), this new species was found in the westernmost part of the Eastern Palearctic. The closest reports of any *Heterodasygoda* to the new species are eastern Turkey and western Syria, where *D. pyrotrichia* has been recorded (Michez et al., 2004b; Özbek, 2014; Michez, 2012). It cannot be excluded, however, that this gap is due to a low level of sampling efforts in the Middle East, particularly in Syria, Iraq, and large parts of the vast landmass of Iran from which a new species of *Dasygoda* has been described (Michez, 2005).

Among all known *Dasygoda*, some species challenge the subgeneric system implemented by Michez et al. (2004b). Examples include the circum-Mediterranean *D. visnaga* (Rossi) (discussed in Michez et al., 2004b), the Asian *D. vulpecula* Lebedev (discussed in Radchenko et al., 2019), and *D. intermedia* Michez (discussed in Michez, 2005), a species only known from Iran. Whether the morphological features used for classifying subgenera do not adequately represent the evolutionary history of the genus or the cited species belong to new subgenera remains unknown. Similarly, if the species truly belongs to *Heterodasygoda*, whether tibial carina, the sparse pilosity on S6, and hooks on S8 represent basal or derived characters still need to be discussed in the light of a globally resolved phylogeny of the genus.

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Disclosure Statement

No potential conflict of interest was reported by the authors.

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