

**Identification of the ant-loving crickets, *Myrmecophilus* Berthold, 1827
(Orthoptera: Myrmecophilidae), in Central Europe and the northern
Mediterranean Basin**

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Abstract

The identification of *Myrmecophilus* species from Central Europe and the northern Mediterranean Basin is discussed and an identification key is presented. New criteria for their identification based on the shape and density of the hairs on the body surface, the shape of the female subgenital plate, the body colouration and the number and positions of the spines on the hind leg metatarsi are provided. The first record of *Myrmecophilus hirticaudus* Fischer von Waldheim, 1846 is reported from the treated area, Croatia: island of Cres.

Zusammenfassung

Die Bestimmung der Ameisengrillen (*Myrmecophilus* spp.) von Mitteleuropa und dem nördlichen Mittelmeergebiet wird diskutiert, es werden neue Kriterien für die Bestimmung vorgestellt und verschlüsselt. Wichtige Merkmale finden sich in der Behaarung des Körpers, der Form der weiblichen Subgenitalplatte, der Färbung des Körpers sowie in der Anzahl und Position der Metatarsaldornen der Hinterbeine. Ferner wird der erste Nachweis von *Myrmecophilus hirticaudus* Fischer von Waldheim, 1846 im Bearbeitungsgebiet publiziert: von der Insel Cres, nördliches Kroatien.

Introduction

Ant-loving crickets (*Myrmecophilus* Berthold, 1827) are small crickets that live as guests in the nests of ants. Their ecology was studied and described many years ago (SCHIMMER 1909, HÖLLDOBLER 1947); however, specimens are not easy to find because of the cryptic way of life so they have attracted little attention until now.

This study addresses the identification of *Myrmecophilus* species from Central Europe, France, northern Italy and Croatia. Only *Myrmecophilus acervorum* (Panzer, [1799]) is known from Central Europe. This species is known from Austria (JUNKER & RATSCHKER 2000), Czech Republic (BEZDĚČKA et al. 2000), France (CHOPARD 1951, DEFAULT et al. 2009), Germany (SCHIMMER 1909, HÖLLDOBLER 1947), Hungary (ZOLTAN 2006), Luxembourg (PROESS 2004), Poland (BACCETTI 1966), Russian Kaliningrad Oblast (SCHIMMER 1909) and Slovakia (FEDOR 2001). *Myrmecophilus aequispina* Chopard, 1923 and *Myrmecophilus myrmecophilus* (Savi, 1819) are known from southern France and northern Italy (BACCETTI 1966). *Myrmecophilus aequispina* was considered to be known from

Germany and Austria, but this record can be traced back to a misinterpretation by BACCETTI (1966). These records are actually attributable to the form *major* of *M. acervorum*, which was described by HÖLLDOBLER (1947).

Most criteria used for the identification of *M. acervorum*, *M. aequispina* and *M. myrmecophilus* that are cited in the literature (e.g., HARZ 1969, DEFAULT 2004) were developed by BACCETTI (1966); however, these criteria appear to be unreliable. Therefore, this study presents new criteria for the identification of these species. In addition the first record of *Myrmecophilus hirticaudus* Fischer von Waldheim, 1846 in the study area is reported, which is included in the identification key. *M. hirticaudus* was previously only known from Bulgaria (POPOV 2007), Ukraine (FISCHER VON WALDHEIM 1846, GOROCHOV 1984a) and Armenia (GOROCHOV 1984b, own. obs.).

Materials and Methods

Specimens were collected from France, Germany, northern Italy and western Croatia and differential criteria were identified to distinguish species in the genus *Myrmecophilus*. The specimens were examined under a dissecting microscope using 40-60x magnification. To examine the body surfaces in greater detail, images of some exemplary specimens were captured using a scanning electron microscope (SEM). Samples were investigated in the collections of Stefan Birrer (CSB) and Thomas Stalling (CTS), as well as material from the natural history museums in Geneva (MHNG), Lausanne (MZLS), Munich (ZSM) and Genoa (MSNG). The latter museum houses the collection of Baccio Baccetti. Table 1 shows details of the specimens examined and the comparative criteria that were determined.

Results

First records of *Myrmecophilus hirticaudus* from Croatia

Myrmecophilus hirticaudus was recorded for the first time in Croatia. Stefan Birrer discovered the species on the Island of Cres, Primorje-Gorski Kotar county, western Croatia in 2007. A total of seven specimens were collected at two sites in the northern part of the island during several expeditions from 2007 until 2010 (Filožići, 45° 04' N, 14° 20' E: 11.05.2007, 1 adult female in an ant's nest in dead wood, leg. S. Birrer; 24.04.2009, 1 nymph in nest of the host ant *Crematogaster scutellaris* (Olivier, 1791) in dead wood, leg. T. Stalling; 02.10.2010, 1 adult male in an ant's nest under a stone, leg. S. Birrer & T. Stalling; Sveti Petar, 45° 04' N, 14° 21' E: 02.10.2010, 1 adult female, 1 subadult female and two adult males in a nest of *Crematogaster scutellaris* in dead wood, leg. S. Birrer & T. Stalling).

Table 1: Details of the sources of the specimens examined and the criteria evaluated. Hairs body surface = number of specimens examined to assess the structure of the body surface and the shape of hairs; subgen. plates female = number of female subgenital plates examined; colouration = number of specimens examined to assess the colour of the body; metatarsi = number of legs examined to assess the number and positions of the spines on the hind leg metatarsi (one or two legs per specimen).

Species	Country	Region	City	Longitude	Latitude	Leg.	Coll.	hairs body surface	subgen. plates female	colouration	meta tarsi
<i>acervorum</i>	Austria	Burgenland	Ruster Höhen	47° 48' N	16° 37' E	J. Winkler	ZSM	2	2	2	4
<i>acervorum</i>	Austria	Lienz	Patriasdorf	46° 50' N	12° 45' E	Dr. Kofler	MSNG	1	1	1	1
<i>acervorum</i>	Germany	Baden-Württemberg	Graben	49° 09' N	08° 30' E	S. Birrer, T. Stalling	CSB, CTS	9	9	9	15
<i>acervorum</i>	Germany	Baden-Württemberg	Holheim	48° 49' N	10° 27' E	M. Breitsameter, T. Kothe, T. Stalling	ZSM, CTS	3	2	3	4
<i>acervorum</i>	Germany	Baden-Württemberg	Karlsruhe	49° 01' N	08° 26' E	T. Stalling	CTS	2	2	2	3
<i>acervorum</i>	Germany	Baden-Württemberg	Lierheim	48° 48' N	10° 37' E	T. Stalling	CTS	6	5	6	11
<i>acervorum</i>	Germany	Baden-Württemberg	Zipplingen b. Markoffingen	48° 55' N	10° 24' E	E. Junker	ZSM	1	0	1	1
<i>acervorum</i>	Germany	Saxony	-	-	-	V. Siebold	ZSM	1	0	1	0
<i>acervorum</i>	Germany	Saxony-Anhalt	Eisleben	51° 31' N	11° 33' E	F. Kühlnhorn	ZSM	3	0	3	3
<i>acervorum</i>	Germany	Thuringia	Gotha	50° 55' N	10° 47' E	R. Ballstadt	ZSM	1	1	1	2
<i>acervorum</i>	Poland	Grodzisk Mazowiecki	Podkowa Lesna	52° 07' N	20° 44' E	Bielawski	MSNG	2	0	2	4
<i>aequispina</i>	France	Alpes Maritimes	La Penne	43° 55' N	06° 57' E	A. de Perrin	MSNG	0	0	0	1
<i>aequispina</i>	France	Alpes Maritimes	Albissola	44° 20' N	08° 30' E	F. Capra	MSNG	1	0	1	2
<i>aequispina</i>	France	Bouches-du-Rhône	Cassis	43° 13' N	05° 32' E	T. Stalling	CTS	2	0	2	3
<i>aequispina</i>	France	Var	Clavières	34° 36' N	06° 33' E	Gaudin	MSNG	0	0	0	1
<i>aequispina</i>	France	Var	Figanières	43° 33' N	06° 29' E	S. Zoia	MSNG	1	0	1	2
<i>aequispina</i>	France	Vaucluse	Mornas	44° 12' N	04° 44' E	C. Roesti, T. Stalling	CTS	17	8	17	28
<i>aequispina</i>	Italy	Genoa	Genoa	44° 25' N	08° 56' E	C. Mancini	MSNG	2	0	2	2

Species	Country	Region	City	Longitude	Latitude	Leg.	Coll.	hairs body surface	subgen. plates female	coloura- tion	meta tarsi
<i>hirticaudus</i>	Armenia	Lori	Dzoraget	40° 57' N	44° 37' E	T. Stalling	CTS	4	2	4	5
<i>hirticaudus</i>	Croatia	Primorje-Gorski Kotar County	Porozina	45° 04' N	14° 20' E	S. Birrer, T. Stalling	CSB, CTS	2	1	2	4
<i>hirticaudus</i>	Croatia	Primorje-Gorski Kotar County	Sveti Petar	45° 04' N	14° 21' E	S. Birrer, T. Stalling	CSB, CTS	3	1	3	6
<i>hirticaudus</i>	Ukraine	Crimea	Sewastopol	44° 37' N	33° 31' E	W. Pliginski	MSNG	1	0	1	1
<i>myrmeco- philus</i>	France	Bouches-du-Rhone	Aureille	43° 43' N	04° 57' E	C. Roesti	CTS	1	1	1	0
<i>myrmeco- philus</i>	France	Bouches-du-Rhone	Saint-Rémy- de-Provence	43° 45' N	04° 51' E	S. Birrer	CSB	1	1	1	2
<i>myrmeco- philus</i>	France	Vaucluse	Mornas	44° 12' N	04° 44' E	C. Roesti, T. Stalling	CTS	4	3	4	6
<i>myrmeco- philus</i>	Italy	Bari	Sannicandro	41° 00' N	16° 48' E	C. Baroni Urbani	MSNG	1	0	1	2
<i>myrmeco- philus</i>	Italy	Firenze	Firenze	43° 46' N	11° 15' E	C. Baroni Urbani	MSNG	1	0	1	0
<i>myrmeco- philus</i>	Italy	Genoa	Genoa	44° 26' N	08° 51' E	G. Mantero	MSNG	1	0	1	1
<i>myrmeco- philus</i>	Italy	Genoa	Genoa	44° 24' N	08° 58' E	G. Mantero	MSNG	1	0	1	0
<i>myrmeco- philus</i>	Italy	La Spezia	Fiascherino	44° 04' N	09° 55' E	G. Gianotti	MSNG	2	0	2	4
<i>myrmeco- philus</i>	Italy	Livorno	Montecristo	42° 20' N	10° 18' E	-	MSNG	1	0	1	0
<i>myrmeco- philus</i>	Italy	Napoli	Portici	40° 48' N	14° 20' E	F. Silvestri	MSNG	1	0	1	2
<i>myrmeco- philus</i>	Italy	Rome	Rome	41° 44' N	12° 24' E	-	MSNG	1	0	1	0
<i>myrmeco- philus</i>	Italy	Salerna	Castelcivita	40° 29' N	15° 13' E	M. Franciscolo	MSNG	1	0	1	2
<i>myrmeco- philus</i>	Italy	Savona	Spotorno	44° 13' N	08° 25' E	S. Zoia	MSNG	1	0	1	0
<i>myrmeco- philus</i>	Italy	Savona	Andorra	43° 57' N	08° 10' E	G. Gardinia	MSNG	2	0	2	4

Characters used in the identification key

Body surface, hairs

The SEM images show that there are considerable differences in the body surface structures and the shapes of the hairs in the species examined.

Myrmecophilus aequispina has two different types of hairs, i.e., a small number of distant hairs and many short, close-fitting hairs. The close-fitting hairs are large, complanate, carinate, with about 50 costae on each side. The distant hairs are longer, pointed and circular, with about 50 costae. The cuticle is sparsely covered with protuberances.

Myrmecophilus acervorum has only one type of hairs, which is inclined, distant, relatively short and shiny, with about 35 costae on each side. They are pointed, although the apex is not highly acute. The cuticle is densely covered with overlapping protuberances.

Myrmecophilus myrmecophilus has only one type of hairs, which is inclined, distant and relatively long, with about 35 costae on each side. They are pointed and the apex is highly acute. The cuticle is sparsely covered with protuberances.

Myrmecophilus hirticaudus was not examined by SEM photography; however, optical microscopy at 1000x magnification detected the same type of hairs that were observed in *M. aequispina*, i.e., large, complanate and carinate hairs with costae on each side.

Shape of the female subgenital plate

The females of *M. myrmecophilus* and *M. aequispina* have a subgenital plate that is rounded or slightly emarginated distally on occasions, whereas it is emarginated in *M. acervorum* and *M. hirticaudus*.

Colouration

The most important characteristic is the contrasting pale ochreous posterior border on the pronotum of *M. acervorum*, which is absent or faint in the other three species. In addition, *M. hirticaudus* has a darker colour than *M. myrmecophilus* and *M. aequispina*.

Number and positions of the spines on the hind leg metatarsi

In general, only *M. hirticaudus* has three spines on the metatarsus on the hind legs, which are positioned on the proximal, medial and distal parts of the metatarsus. Only this species always has a spine in the distal position. *M. acervorum* and *M. aequispina* never have spines in the distal position. In *M. myrmecophilus* the spine in the distal position is usually absent, but rarely three spines occur.

Abnormal specimens

Two females from southern France appeared to be conspecific with *M. aequispina* but they differed because of their darker colour, and the subgenital plate was slightly to distinctly emarginated. At present, it has not been possible to identify these specimens definitively.

Unusable characters

Morphology of the ovipositor: the differences shown in the drawings of BACCETTI (1966), which were repeated in HARZ (1969), have no diagnostic value. In particular, the space between the dorsal epiphysis of *M. myrmecophilus* could not be recognised. A constant difference in the shape of the apex of the dorsal epiphysis of *M. acervorum* and *M. aequispina* was used in the key of HARZ (1969), but we were also unable to confirm this.

Number of apical post-tibial inner spurs: in contrast to HARZ (1969), there were no differences in this trait. GOROCHOV (1984a) studied the type material of *M. hirticaudus* and also mentioned that this criterion was incorrect.

Post-tibial spines: the constant differences in the proportions (slender vs. robust) and length reported by BACCETTI (1966) and HARZ (1969) could not be confirmed.

Key to the ant-loving crickets, *Myrmecophilus* spp., of Central Europe and the northern Mediterranean Basin

This key includes all species of the genus *Myrmecophilus* that are known from Central Europe and France, and the northern Mediterranean Basin between the Pyrenees and Croatia, including northern Italy. It is designed for the identification of imagines, although the criteria for the body surfaces are also valid for nymphs. Specimens should be identified by examination under a dissecting microscope using 40–60x magnification. Males of *M. acervorum* are not known so the species is assumed to reproduce parthenogenetically. Thus, criteria related to the male genitalia are not considered.

1 Pronotum and tergites densely covered with only one type of inclined, distant hairs (best distinguished in lateral view). Distances between hairs are narrower than their length or the same size (Figs. 5, 6, 7, 8). **2**

1* Pronotum and tergites with two types of different hairs: relatively few, protuberant hairs and many short, close-fitting hairs (best distinguished in lateral view, but sometimes difficult to see depending on the light). Distance between the protuberant hairs is wider than their length (Figs. 9, 10). **3**

2 Pronotum and tergites densely covered with inclined, distant, relatively short and shiny hairs. The alignment of hairs appears regular and proper. Distance between the hairs is almost as long as their length (Figs. 5, 6). Body dark brown with pale ochreous posterior border on the pronotum and tergite I (Fig. 1). Female with a distinctly emarginated subgenital plate (Fig. 11 A). ***M. acervorum***

2* Pronotum and tergites densely covered with inclined, distant, relatively long hairs. The alignment of hairs appears scrubby. Distance between the hairs is about half the size of their length in dorsal view (Figs. 7, 8). Body pale brown, with no or only inconspicuous pale ochreous posterior border on the pronotum and tergite I (Fig. 2). Female with a subgenital plate that is not emarginated (Fig. 11D). ***M. myrmecophilus***

3 Metatarsus of the hind legs with two dorsal spines in the proximal and medial positions, but never in the distal position (spine in the medial position sometimes absent). Female with a subgenital plate that is rounded or seldom distally slightly emarginated (Fig. 11C). Body colouration pale brown (Fig. 3).

M. aequispina

3* Metatarsus of the hind legs with three dorsal spines, positioned in the proximal, medial and distal parts of the metatarsus (spine sometimes absent in the medial position, whereas spine in the proximal and distal position always present). Female with the subgenital plate emarginated distally (Fig. 11B). Body dark brown (Fig. 4).

M. hirticaudus



Fig. 1: *Myrmecophilus acervorum*, female. Karlsruhe, Baden-Württemberg, Germany, 24.02.2008. Photo: T. Stalling.



Fig. 2: *Myrmecophilus myrmecophilus*, female. Mornas, Vaucluse, France, 30.12.2006. Photo: T. Stalling.



Fig. 3: *Myrmecophilus aequispina*, male. Mornas, Vaucluse, France, 29.09.2008. Photo: T. Stalling.



Fig. 4: *Myrmecophilus hirticaudus*, male. Cres, Primorje-Gorski Kotar County, Croatia, 02.10.2010. Photo: T. Stalling.

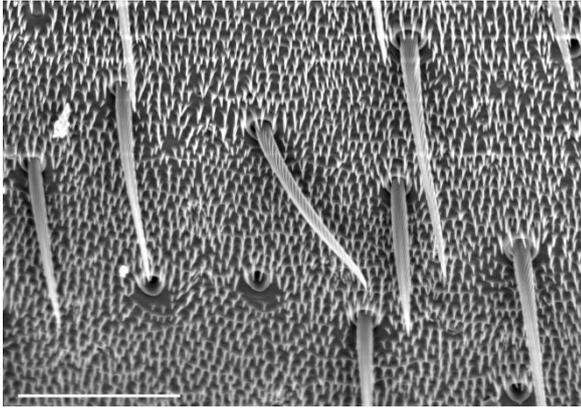


Fig. 5: *Myrmecophilus acervorum*, female. Body surface of sternum III showing the characteristic hairs. Karlsruhe, Baden-Württemberg, Germany, 07.05.2007. Photo (SEM): Claudia Gack. Scale bar: 30 μ m.



Fig. 6: *Myrmecophilus acervorum*, female. Body surface showing the sternites with characteristic hairs. Karlsruhe, Baden-Württemberg, Germany, 04.09.2011. Photo: Thomas Stalling. Scale bar: 0.1 mm.

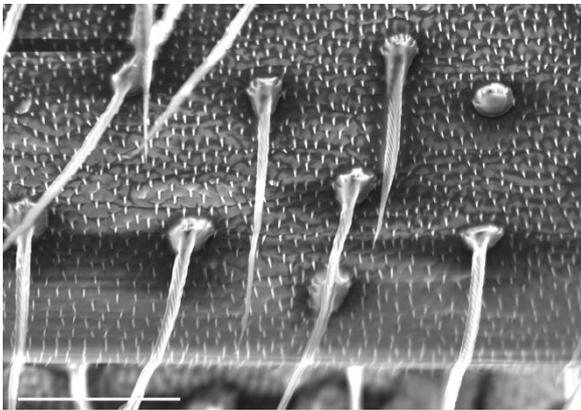


Fig. 7: *Myrmecophilus myrmecophilus*, female. Body surface of sternum III showing the characteristic hairs. Mornas, Vaucluse, France, 30.12.2006. Photo (SEM): Claudia Gack. Scale bar: 30 μ m.

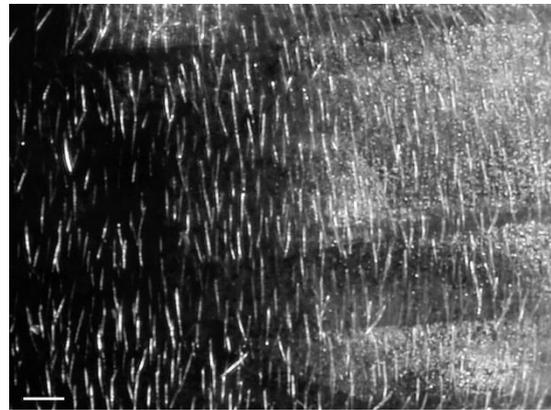


Fig. 8: *Myrmecophilus myrmecophilus*, male. Body surface of the sternites showing the characteristic hairs. Mornas, Vaucluse, France, 26.09.2008. Photo: T. Stalling. Scale bar: 0.1 mm.

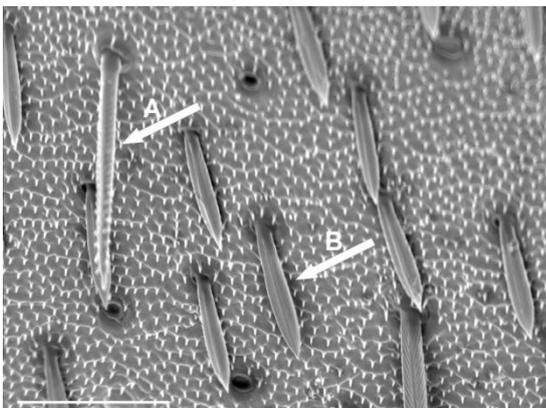


Fig. 9: *Myrmecophilus aequispina*, female. Body surface of sternum III; A: distant hair; B: close-fitting hair. Cassis, Bouches-du-Rhône, France, 15.03.2003. Photo (SEM): Claudia Gack. Scale bar: 30 μ m.

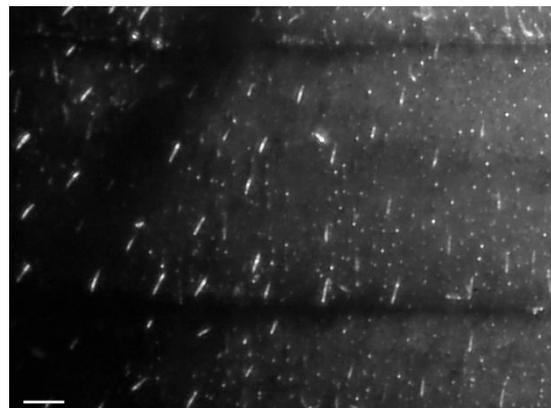


Fig. 10: *Myrmecophilus aequispina*, female. Body surface of sternites showing the characteristic hairs. Mornas, Vaucluse, France, 07.04.2009. Photo: Thomas Stalling. Scale bar: 0.1 mm.

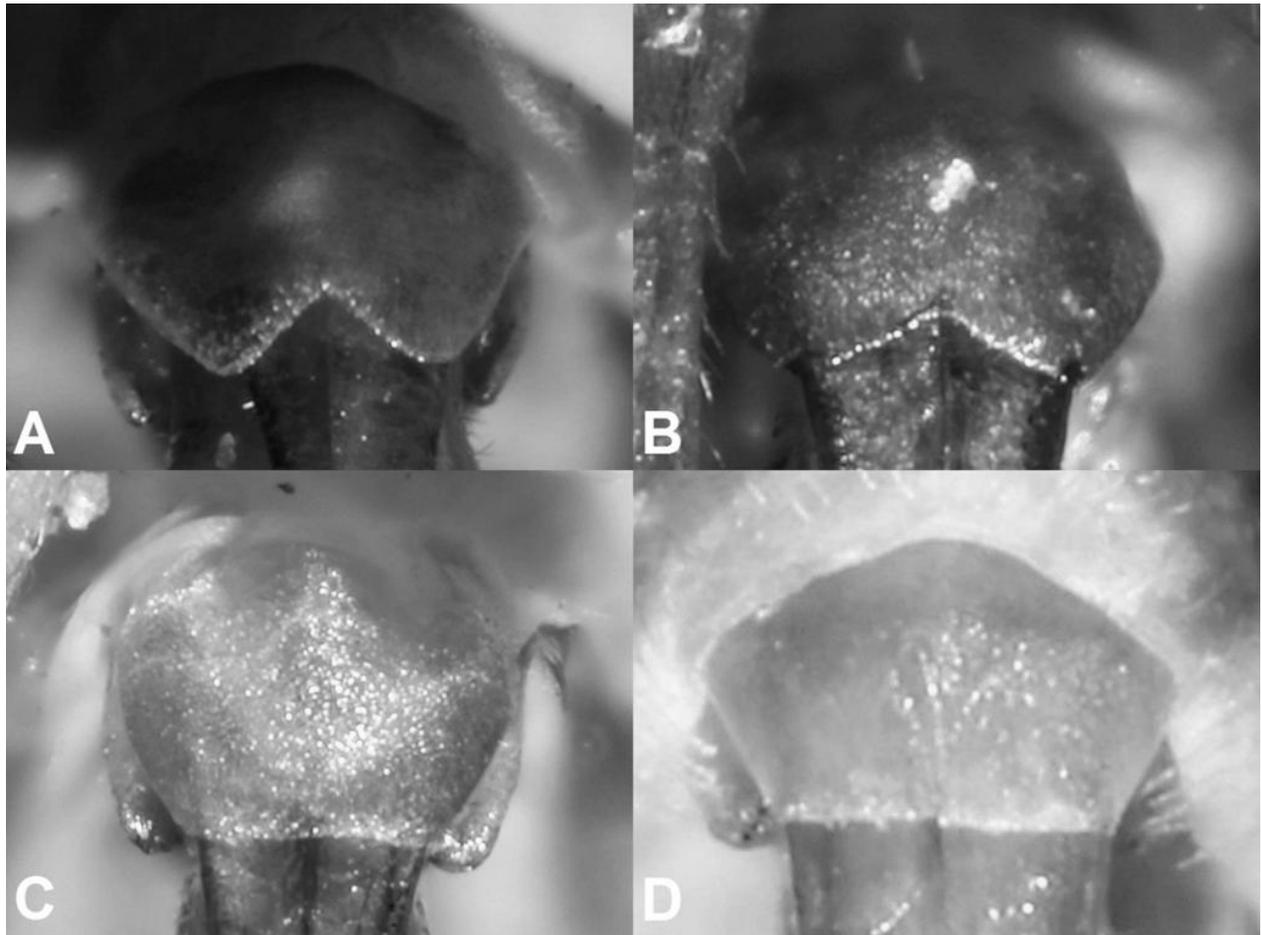


Fig. 11: Shape of the female subgenital plate (Photos: Thomas Stalling).
 A: *Myrmecophilus acervorum*, Karlsruhe, Baden-Württemberg, Germany, 07.05.2007;
 B: *Myrmecophilus hirticaudus*, Dzoraget, Lori, Armenia, 04.08.2011;
 C: *Myrmecophilus aequispina*, Mornas, Vaucluse, France, 07.04.2009;
 D: *Myrmecophilus myrmecophilus*, Mornas, Vaucluse, France, 07.04.2009.

Discussion

One of the most important criteria for the identification of *Myrmecophilus* species is the body surface (structure of body surface and shape of hairs), which was reported previously for some Japanese species by MARUYAMA (2004). In the current study, there was no intraspecific variation among the specimens investigated. Other important criteria are the colouration of the body and the shape of the female subgenital plate.

The most common criteria related to the inner spines of the post-tibia were first reported by BACCETTI (1966) and copied by later authors (e.g., HARZ 1969, DEFAUT 2004). Obviously they have never been checked critically because they were not constant, so they were misleading. The counts and measurements made in the current study showed no more than weak tendencies, which were not sufficiently reliable to be used as criteria. The identification key of HARZ (1969) cites further erroneous criteria that can be traced back to a misinterpretation of BACCETTI (1966). Although the identification of European *Myrmecophilus*

species was not based on solid characters, surprisingly few specimens had been identified incorrectly. Therefore, the distribution of the three species known in the study area was not distinctly affected by this re-evaluation; however, the specimen of *M. acervorum* reported from northern Italy (e.g. cited by FONTANA 2002) should be checked.

The record of *M. hirticaudus* from the Island of Cres is the first in the study area and in the Mediterranean Basin. The nearest known records are from Bulgaria (POPOV 2007). Previously, the species was known only from the Crimea (FISCHER VON WALDHEIM 1846, GOROCHOV 1984a) and the Caucasus (GOROCHOV 1984b, BACCETTI 1992). Thus, it is possible that the species will be found on the Croatian mainland, or even in Slovenia and Italy.

Acknowledgements

Many thanks to Dr. Claudia Gack (Institute of Biology I, D-Freiburg) for capturing the SEM images. We also thank Claude Lebas (F-Pollestres), Dr. Anne Freitag (Cantonal Museum of Zoology, CH-Lausanne), Dr. Roberto Poggi and Dr. Maria Tavano (City Museum of Natural History Giacomo Doria, I-Genoa), Christian Roesti (CH-Wasen i. E.), Dr. Stefan Schmidt and Tanja Kothe (Bavarian State Collection of Zoology, D-Munich) and Dr. Peter Schwendinger (Natural History Museum, CH-Geneva) for providing specimens for examination. We thank Dr. Arne Lehmann (D-Stahnsdorf) for reviewing the manuscript and Armin Coray (Museum of Natural History, CH-Basel) for organising literature and material from museum collections, and for fruitful discussions.

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