

Variability and fluctuating asymmetry of mid tibial spurs in *Eucremastus Szépligeti* (Hymenoptera, Ichneumonidae, Cremastinae)

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Abstract

The presence of one or two spurs on the mid tibia has been widely used as a diagnostic character in many taxa, but it has been discovered to be a highly variable character in the Cremastinae genus *Eucremastus*. Variation in the number of mid tibial spurs and occurrence of asymmetry in this genus was studied. The anomalies observed in this character are classified into three categories. Other non-cremastine genera traditionally characterized by having a single mid tibial spur were studied, but no anomalies were found. The taxonomic implications of this variation are discussed.

Keywords

Eucremastus, spurs, morphological traits, fluctuating asymmetry

Introduction

Fluctuating asymmetry refers to the random deviation from perfect symmetry in bilateral traits (Van Halen 1962, Parsons 1990). It is more frequent in sexually selected traits, and it has been proposed as an important force for sexual selection (Moller and Pomiankowski 1993). Fluctuating asymmetry in morphological traits has been suggested to be the result of environmental (Silva et al. 2009) or genetic stress (Smith et al. 1997) during ontogeny, although this relationship remains unclear (Bjorksten et al. 2000).

When asymmetry affects morphological characters with taxonomic importance, its diagnostic value is reduced since it gives rise to different states of that character, sometimes in the same individual, and contributes to potentially misleading taxonomic descriptions and identifications.

The number and relative size of mid tibial spurs in Ichneumonidae has been considered a relatively invariant taxonomic character. The presence of a single mid tibial spur has been used in the diagnostic description of a tribe, Exenterini, of the subfamily Tryphoninae (Townes 1969a), but mostly at the generic level, e.g. *Metopius* Panzer (Townes 1971, Gauld et al. 2002), *Acerataspis* Uchida (males) (Townes 1971) (METOPHIINAE); *Anomalon* Panzer (Gauld 1997), *Liopterna* Townes, *Calcaneum* Townes and *Ophionellus* Westwood (Townes 1971) (ANOMALONINAE), or even at species level in Ophioninae (Gauld and Mitchell 1978).

As a general rule, the Cremastinae, a cosmopolitan group rather common in dry open areas (Gauld 2000) have two spurs on both the mid and hind tibiae. However, there is one genus, *Eucremastus* Szépligeti, which is characterized by having only one mid tibial spur (Fig. 1) (Townes 1971). Some authors (Ceballos 1921, Sedivy and Narolsky 2001) pointed out the presence of two spurs in several specimens of *E. manni* (Tschek). Moreover, *E. villiersi* (Benoit) form *turkmeniensis* was described as having two distinct mid tibial spurs in the female (Narolsky 2001), which highlights how variable the presence of one or two spurs is in this genus. Nevertheless, the occurrence of asymmetry in this character has not been reported, but it was found in some specimens of *E. manni* and *E. collaris* Narolsky from different collections.

These circumstances suggest not only that the presence of one or two spurs on the mid tibiae of *Eucremastus* may be a more variable feature that was considered until now, but also that this genus may present fluctuating asymmetry associated with this character. The aim of this paper is to demonstrate the variability of this character particularly in *Eucremastus* but also in other genera characterized by having a single mid tibial spur, and to investigate the occurrence of fluctuating asymmetry in this genus.

Material and methods

Studied material of this genus belongs to the following institutions:

CEUA University of Alicante, Alicante, Spain.

- ZISP** Zoological Institute of Russian Academy of Sciences, Saint Petersburg, Russia.
BMNH Natural History Museum, London, United Kingdom.
HNHM Hungarian Natural History Museum in Budapest, Hungary.
MNCN Museo Nacional de Ciencias Naturales, Madrid, Spain.

In order to establish the importance of variability, we also studied some material belonging to other Ichneumonidae genera which traditionally have been separated by having a single mid tibial spur. This material is preserved in the following institutions:

- 1) University of Alicante, Alicante, Spain (CEUA).
- 2) Zoological Museum of University of Turku, Turku, Finland (ZMUT).
- 3) Colección Entomológica Regional of Universidad Autónoma de Yucatán, Mérida, Mexico (CER-UADY).
- 4) Smithsonian Institution, Washington D.C., USA (USNM).

We considered the morphological structure to be anomalous when deviations from normality occurred in any specimens belonging to one species, which usually did not possess these anomalies. Normality is the commonest state of the character, and is defined as Type 0, as follows:

Type 0: both mid tibiae with a single long spur.

The variability of anomalies found in the studied material was classified into 3 categories, as follows:

Type 1: both mid tibiae with two unequal spurs.

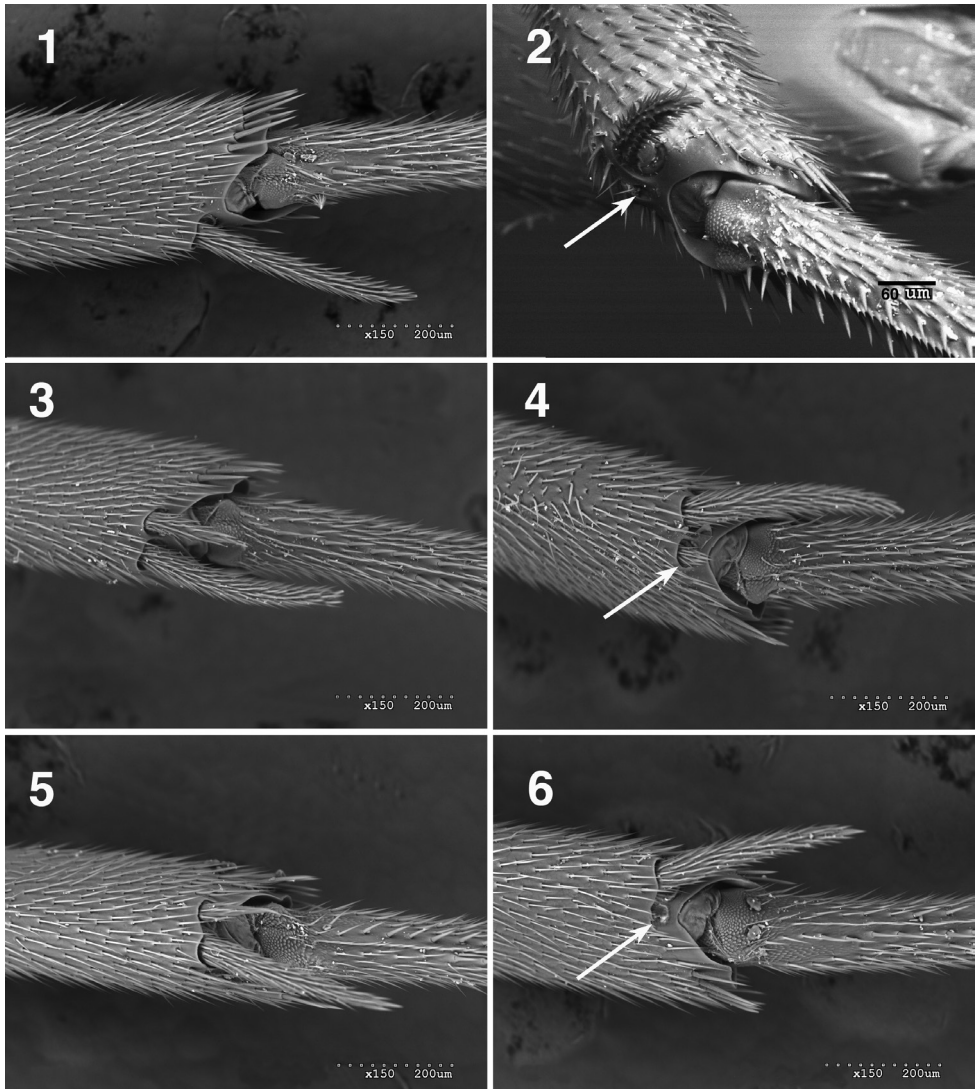
Type 2: one single spur on a mid tibia and a long spur clearly developed jointly with a very small stump on the other mid tibia (Fig. 2).

Type 3: two distinct spurs on a mid tibia (Figs 3 and 5) and a long spur clearly developed jointly with a short stump on the other mid tibia (Figs 4 and 6).

Type 1 is a symmetric anomaly, while types 2 and 3 are asymmetric anomalies.

Since anomalies have been found only in two species (i. e. *E. manni* and *E. collaris*), we will report only the material belonging to these two species, although some individuals of *E. villiersi* (Benoit) (11 specimens, including holotype, ZISP) and *E. parvipes* (Morley) (holotype, BMNH) were also checked. *Eucremastus villiersi* form *turkmeniensis* may be considered to represent an anomaly type 1; however, we did not see any material belonging to this form, thus it is not included in the material studied. As for the other non-cremastine genera, we only report data from specimens at the genus level, since most of the material we examined was only sorted to genera.

Fluctuating asymmetry is usually measured as the mean difference between right and left sides (Palmer and Strobeck 1986). However, since we measured the mid tibia spurs asymmetries qualitatively (i.e., type 2 and 3 anomalies), we present the frequency distribution of asymmetry by considering type 2 and 3 anomalies as both sides' asymmetries, respectively, and both type 1 and type 0 anomalies as bilateral symmetries.



Figures 1–6. Mid tibial spurs of *Eucremastus manni*: **1** mid tibia without anomalies **2** type 2 anomaly in specimen from Turkey, right leg **3–6** type 3 anomalies in specimens from Spain: **3–4** right leg and left leg, respectively, of specimen from Fresneda **5–6** right leg and left leg, respectively, of specimen from Raña del Pocico. The white arrows point to the stump of the spur.

Scanning Electron Microscopy studies were done using a Hitachi S-3000N (University of Alicante, Spain) and a LEO 1455VPL (Natural History Museum, United Kingdom), both in low vacuum mode.

Results

In this paper we examined a total of 60 specimens belonging to *Eucremastus manni* and *E. collaris*. We found mid tibial spur anomalies in seven specimens. These are detailed below and summarized in Table 1. We also examined 347 specimens belonging to other genera with a single mid tibial spur, but no anomalies were found.

Asymmetries (i.e. type 2 and 3 anomalies) were only found in *E. manni*. About 90% of *E. manni* individuals were symmetrical, and asymmetries occurred at very low frequency (Fig. 7).

Material studied belonging to *Eucremastus*

Eucremastus manni: SPAIN (HNHM): Genotype, "Murcia", Staud., 1895, *Eucremastus brevicornis* Szépligeti 1905, 1 ♀. SPAIN (CEUA): Alicante: Sierra Mariola, Foia Amplá, 4-17/VI-2002, 1 ♀, Malaise trap; Font Roja, Mas de Sant Ignaci, 17-VI/2-VII-2002, 1 ♀, Malaise trap. Ciudad Real: Fresneda, 29-V/17-VI-2004, 1 ♀, TM; 17-VI/5-VII-2004, 1 ♀, Malaise trap (**anomaly type 3**); Raña del Pocico, 18-V-2004, in *Thapsia villosa*, 1 ♂ (**anomaly type 3**). SPAIN (MNCN): Ávila: Navalperal (no date), 1 ♀. Alicante: Alicante (no date), 1 ♂; Orihuela / Arneva, VI-1925, 1 ♀. Asturias: Villaviciosa (no date), 1 ♀ (**anomaly type 3**). Ciudad Real: Pozuelo, 1897, 1 ♀. Madrid: Buitrago, 24-VI-1984, 2 ♂♂; El Pardo, 16-VI-1941, 2 ♀♀; El Escorial (no date), 2 ♀♀ 2 ♂♂; 6-VII-1914, 1 ♀; 17-VI-1915, 1 ♀ 2 ♂♂; 14-VI-1916, 1 ♂; 19-VI-1918, 1 ♀; 14-VI-1922, 1 ♀; 8-IV-1929, 1 ♂; 8-VI-1929, 1 ♀ 2 ♂♂; Alcalá (no date), 1 ♀ (**anomaly type 1**); Madrid (no date), 8 ♀♀ 1 ♂; VI-1993, 1 ♂; San Agustín, 8-VI-1912, 1 ♀; Sierra de Guadarrama, 25-VI-1910, 1 ♀; 21-VI-1911, 1 ♀; 25-VI-1916, 1 ♂; 23-VI-1932, 1 ♂; Torrelaguna, 3-VI-1986, 2 ♂♂. Segovia: La Granja (no date), 1 ♀. Valladolid: Tordesillas, 26-VI-1930, 1 ♀ (left leg missing, right leg with two unequal spurs). TURKEY (BMNH): Adana, Ciftehan, 26-V-1960, Guichard & Harvey, 1 ♀ (**anomaly type 2**); Amasya, 31-V-1959, K.M. Guichard, 1 ♀ (**anomaly type 2**), 1 ♀; Erzurum, Kandil, 11-VI-1962, Guichard & Harvey, 1 ♀. GREECE (BMNH): near Keffisia, 18/VI/1957, G. Mavromoustakis, 2 ♀♀. One specimen (ZISP) labeled "Escorial, Dusmet", 1 ♀.

Eucremastus collaris: Arm. CCP (ZISP): Paratype, "Hosrovskii zap-k, Bediiskii uzh. arzhovoe redkolesye", A. Kotenko, 29-VI-1981, 1 ♀ (**anomaly type 1**); Paratypes, 2 ♀♀.

Material studied belonging to other genera

Anomaloninae

Anomalon spp.: ECUADOR (USNM, currently on loan to ZMUT): Dept. Orellana: Tiputini, 1998, 22 ♀♀ 9 ♂♂, Leg. T. Erwin; Onkone Gare, 1998, 1 ♀, Leg. T.

Erwin. Dept. Zamora-Chinchipe: Reserva Biológica San Francisco, 2009, 13 ♀♀ 1 ♂, Leg. M. Pollet & A. Braekeleer. PERU (ZMUT): Dept. Madre de Dios: Los Amigos, 2008, 37 ♀♀, Leg. Gómez; Iquitos, 1998-2000, 73 ♀♀, Leg. Ilari Sääksjärvi et al. PERU (USNM, currently on loan to ZMUT): Tambopata River, 1998, 2 ♀♀, Leg. T. Erwin; Manu River, 1998, 2 ♀♀ 1 ♂, Leg. T. Erwin. Dept. Loreto: Napo River, 1998, 1 ♀, Leg. T. Erwin; SPAIN (CEUA): Alicante: Mariola Mountain, 2001-2002, 15 ♀♀, Leg. CIBIO; Carrasqueta Mountain, 2001-2002, 7 ♀♀, Leg. CIBIO. Ciudad Real: Cabañeros National Park, 2004, 64 ♀♀, Leg. CIBIO.

Ophionellus sp.: ECUADOR (USNM, currently on loan to ZMUT): Dept. Orellana: Onkone Gare, 2005-2006, 8 ♀♀ 7 ♂♂, Leg. T. Erwin. PERU (ZMUT): Dept. Loreto: Iquitos, 2000, 1 ♀, Leg. Ilari Sääksjärvi. Dept. Madre de Dios: Los Amigos, 2008, 30 ♀♀, Leg. Gómez.

Metopiinae

Metopius sp.: ECUADOR (USNM, currently on loan to ZMUT): Dept. Orellana: Tinputini, 1998, 1 ♀ 1 ♂, Leg. T. Erwin. MEXICO (CER-UADY): Yucatán: El Cuyo, 2009, 3 ♂♂, Leg. A. González. PERU (ZMUT): Dept. Loreto: Iquitos, Alpahuayo I, 2000, 12 ♀♀ 4 ♂♂, Leg. Ilari Sääksjärvi et al. Dept. Madre de Dios: Los Amigos, 2008, 3 ♀♀ 1 ♂, Leg. Gómez.

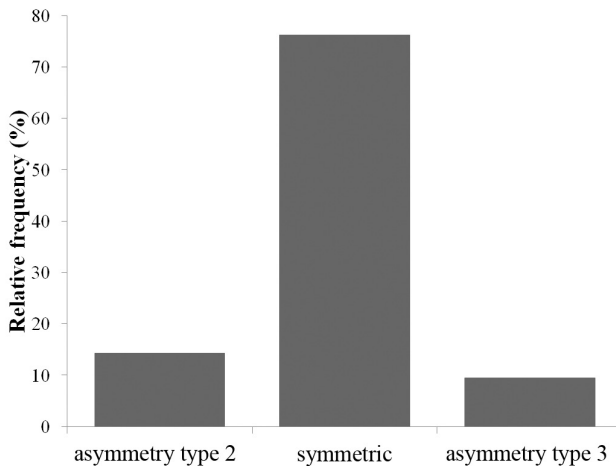


Figure 7. Frequency distribution of fluctuating asymmetries of mid tibial spurs in *E. manni*. Symmetric means both type 0 and anomaly type 1.

Table 1. Sample size of examined material and proportions of anomaly occurrence (between brackets), by species and by sex.

	Sex	Individuals	Anomaly occurrence
<i>E. manni</i>	Female	41	5 (12.2%)
	Male	16	1 (6.3%)
<i>E. collaris</i>	Female	3	1 (33.3%)

Tryphoninae

Cycasis sp.: SPAIN (CEUA): Alicante: Carrasqueta Mountain, 2002, 6 ♂♂, Leg. CIBIO; Mariola Mountain, 2002, 4 ♀♀ 4 ♂♂, Leg. CIBIO. Ciudad Real: Cabañeros National Park, 2004, 10 ♂♂, Leg. CIBIO.

Exyston sp.: GREECE (CEUA): Lesbos Island, Vatoussa, 2001, 1 ♂, Leg. Rojo & Pérez.

Kristotomus sp.: SPAIN (CEUA): Ciudad Real: Cabañeros National Park, 2004, 10 ♂♂, Leg. CIBIO.

Discussion

About one in 10 individuals of *E. manni* had asymmetric spurs, more frequently in females. Since we measured a discrete variable, fluctuating asymmetry could not be tested, but the occurrence of asymmetry at this relatively high proportion would suggest this genus would be particularly sensitive to environmental or genetic stress. Therefore, given the growing interest in the use of fluctuating asymmetry as a measure of developmental instability, and hence of environmental stress during development (Hogg et al. 2001, Silva et al. 2009, amongst others), this character may be used for this purpose by measuring the relative size of each spur on each mid tibia. Despite the apparently low sample size of our study, we must underline that this frequency of anomalies is noteworthy considering that the genus *Eucremastus* is rather rare in collections. Fluctuating asymmetry has not been measured in Ichneumonidae, although isolated teratologies have been reported (Kerrich 1934, Bordera and Tormos 1986).

Not only asymmetry but the overall high rate of variation in the presence of one or two mid tibial spurs in some species of *Eucremastus* invalidates this character for taxonomic diagnosis of this genus, although not in other taxa, since anomalies were absent in other genera that usually have a single mid tibial spur. According to this, we redefine the diagnostic characters of *Eucremastus*, and provide some features that separate it from related genera (Table 2).

Table 2. Diagnostic characters to distinguish amongst some related genera in Cremastinae.

	<i>Temelucha</i>	<i>Eucremastus</i>	<i>Eucremastoides</i>	<i>Noxocre mastus</i>
Median longitudinal carina of pronotum	Weak	Absent	Strong	Absent
Mandibles	Relative size of teeth variable	Lower tooth twice as long as upper tooth	Teeth of equal length	Lower tooth clearly longer than upper tooth
Lateral carina of scutellum	Absent or weak	Reaching the apex	Absent or weak	Absent
Ovipositor tip	Straight to downcurved	Straight	Downcurved	Downcurved
Ventral edges of first tergite	Touching along a distance longer than the width of petiole	Touching along a distance longer than the width of petiole	Touching or running parallel very close along a distance longer than the width of petiole	Touching or approaching along a distance shorter than the width of petiole
Glymma	Shallow	Shallow	Distinct	Shallow

***Eucremastus Szépligeti*, 1905**

Wings moderately darkened. Occipital carina interrupted above. Frons concave. Genal carina joining oral carina very close to base of mandible. Lower tooth of mandible nearly twice as long as upper tooth. Pronotum slightly convex, without a median longitudinal carina. Scutellum rather convex, with a strong lateral carina reaching its apex. Hind femur without tooth beneath. Mid tibia with one or two spurs, when two spurs are present they are of unequal length. Ventral edges of first tergite touching each other, enclosing sternite in its middle. Glymma present, short and oblique. Ovipositor sheath about $1.5 \times$ longer than hind tibia. Ovipositor tip almost straight.

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