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On two cases of male dimorphism in dwarf spiders (Araneae: Linyphiidae)

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Abstract. *Diplocephalus cristatus* (Blackwall, 1833) is confirmed as a dimorphic species, having two morphs: *cristatus* and *foraminifer*. This view was first proposed by Georgescu (1969), but not supported in the literature. *Diplocephalus foraminifer* (O. Pickard-Cambridge, 1875), *D. bicephalus* (Simon, 1884), *D. rectilobus* (Simon, 1884), *D. foraminifer thyrsiger* (Simon, 1884) and *D. arvernus* (Denis, 1948) are here considered **junior synonyms** of *D. cristatus* (Blackwall, 1833). *Diplocephalus bicephalus* belongs to the morph *cristatus*, *D. rectilobus*, *D. thyrsiger* and *D. arvernus* to the morph *foraminifer*. A lectotype (♂) is designated for *Diplocephalus bicephalus* Simon, 1884; the paratype female of *D. bicephalus* was incorrectly identified and actually belongs to *Dicymbium nigrum* (Blackwall, 1834). *Savignia harmsi* Wunderlich, 1980 is another dimorphic species, with the two strongly differing male morphs: *typica* and *cor*.

Keywords: Araneae, dimorphic Linyphiidae, *Diplocephalus, Savignia*

Zusammenfassung. Zwei Fälle von Dimorphismus bei Zwergspinnen (Araneae: Linyphiidae) *Diplocephalus cristatus* (Blackwall, 1833) wird als dimorphe Art bestätigt, mit zwei Formen: *cristatus* und *foraminifer*. Diese Meinung wurde erstmals von Georgescu (1969) vertreten, aber in der Literatur nicht unterstützt. *Diplocephalus foraminifer* (O. Pickard-Cambridge, 1875), *D. bicephalus* (Simon, 1884), *D. rectilobus* (Simon, 1884), *D. foraminifer thyrsiger* (Simon, 1884) und *D. arvernus* (Denis, 1948) werden nun als **jüngere Synonyme** von *D. cristatus* (Blackwall, 1833) betrachtet. *Diplocephalus bicephalus* gehört zur Form *cristatus*, *D. rectilobus*, *D. thyrsiger* und *D. arvernus* zur Form *foraminifer*. Ein Lectotypus (♂) wird für *Diplocephalus bicephalus* Simon, 1884 ausgewiesen; der weibliche Paratypus von *D. bicephalus* ist fehlbestimmt und gehört zur Art *Dicymbium nigrum* (Blackwall, 1834). *Savignia harmsi* Wunderlich, 1980 ist eine weitere dimorphe Art mit zwei sich deutlich unterscheidenden Männchen-Formen: *typica* und *cor*.

For a long time, dimorphic erigonid spiders were not recognised as such and considered separate species. Only when morph differences were small, for example in the size of the cephalic tubercle or the post-ocular sulci, were these sometimes considered variations. Holm (1979: p. 269) wrote about *Pelecopsis mengei* (Simon, 1884): "The males occur in two different forms, the one, which is the most frequent, with a high cephalic lobe and large sulcal orifice, the other with lower lobe and with much smaller orifice. … As no intermediate forms have been found and moreover, the two types of males have quite similar palpal tibiae and bulbs and are found together, the males of *P. mengei* seem to be dimorphic". Similarly, Bosmans & Abrous (1992) considered the specimens of *Pelecopsis oranensis* (Simon, 1884) with small and large postocular sulci, but having identical palpal tibiae and bulbs, as morphs of the same species. *Diplocephalus marijae* Bosmans, 2010 from Spain is another species occurring in two morphs (Bosmans et al. 2010). The decision to recognise species as being dimorphic is not easy or consequent. Roberts (1987) proposed *Troxochrus scabriculus* (Westring, 1851) and *T. cirrifrons* (O. Pickard-Cambridge, 1871) to be one, dimorphic species, but this is not followed in the World Spider Catalog (2018) where they are still considered two separate species. On the contrary, when the same author (Roberts 1987) proposed *Diplocephalus connatus* Bertkau, 1889 and *D. jacksoni* (O. Pickard-Cambridge, 1904) to be forms of the same species, this opinion was accepted in the World Spider Catalog (2018).

The best documented case of dimorph linyphiid spiders is that of *Oedothorax gibbosus* (Blackwall, 1841) and *O. tuberosus* (Blackwall, 1841) having very different cephalic tubercles and because of that considered separate species in older identification books (e.g., Locket & Millidge 1953, Wiehle 1960, Palmgren 1976). After a detailed study of the male palps of several *Oedothorax* species, Bosmans (1985) concluded that all palpal sclerites of *O. gibbosus* and *O. tuberosus* were completely identical and the two species names were synonymized. De Keer & Maelfait (1988) provided further evidence from breeding experiments. They reared spiderlings from the same egg sac and obtained both forms. In our opinion, when palpal sclerites are identical, specimens should be treated as belonging to the same species.

The aim of the present paper is to discuss two more cases of male dimorphism in Linyphiidae.

Material and methods

The material studied was collected by the authors or loaned from museum collections. Species were examined by mean of a Nikon SMZ1270 stereo microscope. Details of male palps and female epigynes were studied with an Olympus CH-2 microscope with a drawing tube. Left palps are illustrated.

Male palps were detached and transferred to glycerol for examination under the microscope. Female epigynes were excised using sharpened needles. These were then transferred to clove oil for examination under the microscope. Later, palps and epigynes were returned to 70% ethanol.

Abbreviations: CAR-S = Personal collection of Antony Russell-Smith (UK), CPO = Personal collection of Pierre Oger (Belgium), CRB = Personal collection of Robert Bosmans (Belgium), CSD = Personal collection of Samuel Danflous (France), MNHN = Muséum National d'Histoire naturelle, Paris, France (curator: C. Rollard).

A forgotten case of dimorphism

Males and females of *Diplocehalus cristatus* (Blackwall, 1833) were first described by Blackwall (1833) from England as *Walckenaeria c*. Subsequently, O. Pickard-Cambridge (1875) described *Erigone foraminifera* Pickard-Cambridge, 1875 from France. Differences between the two species were based on differently shaped cephalic lobes. Pickard-Cambridge (1875: p. 208) stated that "*E. foraminifera* is also allied to *E.*

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cristata, but the very different form of the caput and its cleft … will distinguish it at once".

Later, Simon (1884, 1926) also gave considerable importance to the shape of cephalic lobes in describing several (sub) species in the genus *Prosoponcus*: *P. bicephalus* Simon, 1884, *P. rectilobus* Simon, 1884 an *P. thyrsiger* Simon, 1884. None of these species was matched to a female, except for *P. bicephalus bicephalus*; yet the female of the latter species appeared to be that of *Dicymbium nigrum* (Blackwall, 1834). Denis (1948) added one more species to this species group, *D. arvernus*, from France, Auvergne. He stated that this species was closely related to *D. foraminifer*, but slightly differed in the shape of cephalic lobe.

Georgescu (1969) was the first author to propose that *D. cristatus*, *D. foraminifer*, *D. bicephalus*, *D. rectilobus* and *D. thyrsiger* all belong to the same species, occurring in two morphs: *cristatus* and *foraminifer*. She also included *Diplocephalus crassilobus* (Simon, 1884) in that list, but the conformation of the male palp of the latter species is completely different (cf., Millidge 1979, Pesarini 1996). The suggestion by Georgescu has not been followed and in the World Spider Catalog (2018), these names are currently listed as separate species. We have been able to re-examine the material of all these *Diplocephalus* species, including the types of *D. bicephalus* and *D. rectilobus*, and can confirm Georgescu's proposal.

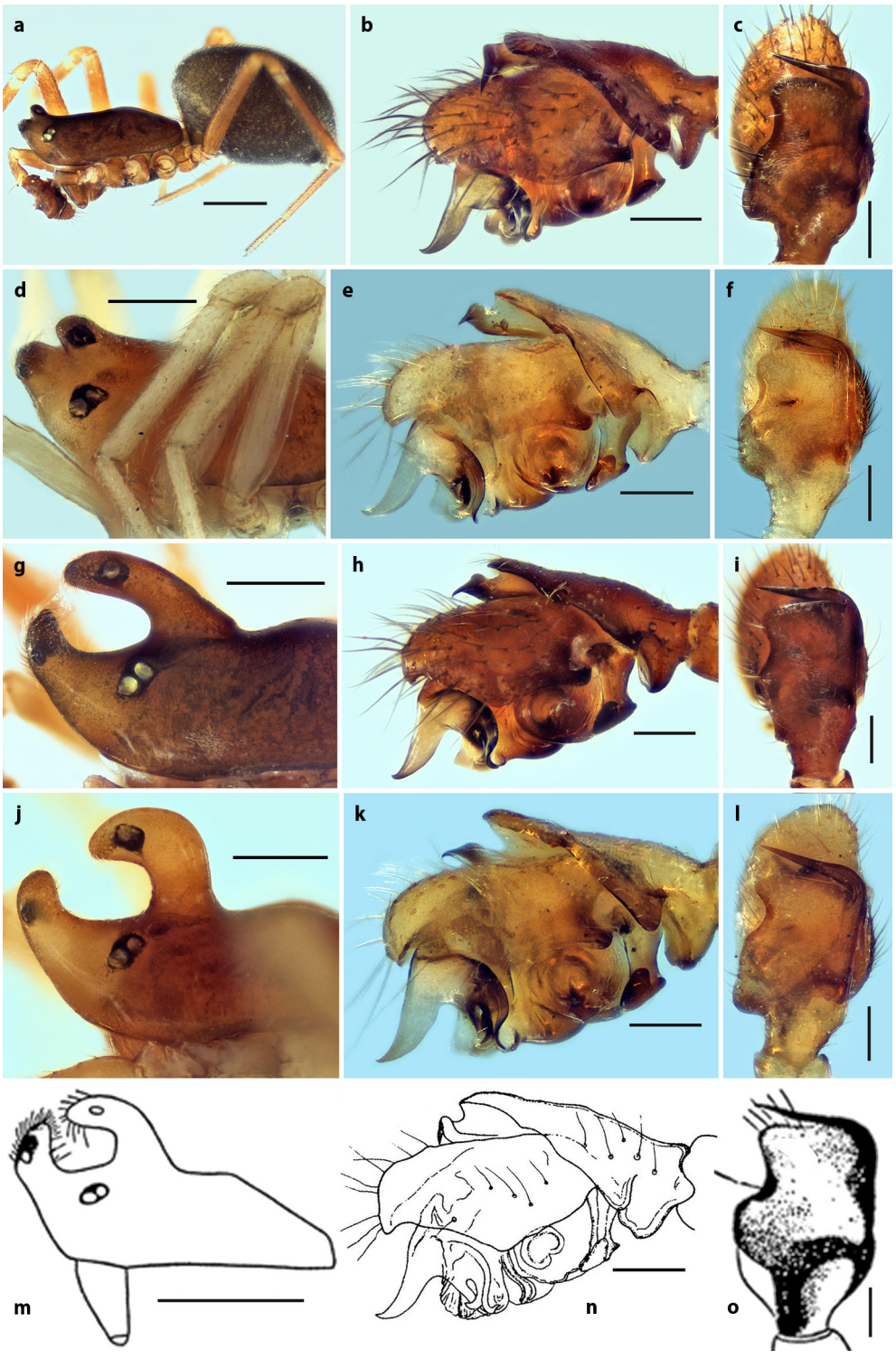

Fig. 1: a-c. *Diplocephalus cristatus* (Blackwall, 1833) (Belgium), **d-f.** *D. rectilobus* (Simon, 1884) (the holotype), **g-i.** *D. foraminifer* (O. Pickard-Cambridge, 1875) (Greece), **j-l.** *D. bicephalus* (Simon, 1884) (the lectotype), **m, o:** *D. arvernus* Denis, 1948 (from Denis 1948, figs 1-8); **n.** *D. foraminifer* (O. Pickard-Cambridge, 1875) (from Deltshev, 1985, fig. 7); **a, d, j, m.** Male prosoma, lateral view; **b, e, h, k, n.** Male palp, lateral view; **c, f, i, l, o.** Male palpal tibia, dorsal view.

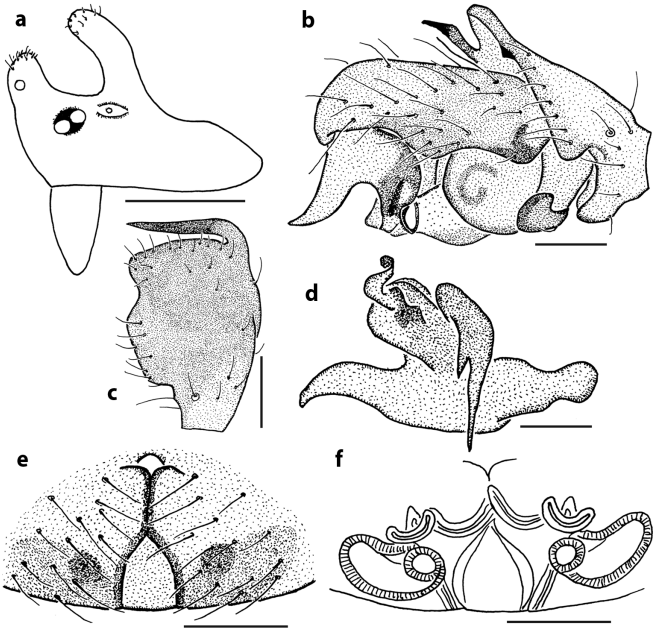

Fig. 2: *Diplocephalus cristatus* morph *foraminifer* (Pickard-Cambridge, 1875) (Greece, Lefkada). **a.** Male prosoma, lateral view; **b.** Male palp, lateral view; **c.** Male palpal tibia, dorsal view; **d.** Embolic division, antero-lateral view; **e.** Epigyne, ventral view; **f.** Vulva, ventral view.

***Diplocephalus cristatus* (Blackwall, 1833)** (Figs 1a-n, 2a-f)

Walckenaeria cristatus Blackwall, 1833: 107 (♂♀); the type from England, Manchester, Cheetham, not examined.

Erigone foraminifera O. Pickard-Cambridge, 1875: 207, pl. 28, fig. 15 (♂); the type from France, Hautes-Alpes, Col de Natoya; not examined. **N. Syn.**

Prosoponcus foraminifer; Simon 1884: 572, 382-383, figs 672, 673.

Prosoponcus bicephalus Simon, 1884: 575, figs 388, 389 (♂). **N. Syn.**

Prosoponcus thyrsiger Simon, 1884: 574, figs 386-387 (descr. ♂); not examined. **N. Syn.**

Prosoponcus rectiloba Simon, 1884: 573, figs 384-385 (♂); examined. **N. Syn.**

Diplocephalus rectilobus; Simon 1926: 377, 495.

Diplocephalus bicephalus; Simon 1926: 495, figs 672-673 (♂ only, ♀ = *Dicymbum nigrum*).

Diplocephalus foraminifer; Simon 1926: 377, 495, figs 667-668.

Diplocephalus foraminifer thyrsiger; Simon 1926: 378, 495, figs 669-671.

Diplocephalus arvernus Denis, 1948: 238, figs 1-8 (♂♀); not examined. **N. Syn.**

Type material. Lectotype ♂ of *Diplocephalus bicephalus* Simon, 1884 (designated here) from France, Pyrénées-Orientales, between Prats-de-Mollo and La-Preste, Coll. Simon 4914 AR 12084 (MNHNP); 2 ♀ paralectotypes of *D. bicephalus* belonging to *Dicymbium nigrum* (Blackwall, 1834). – Holotype ♂ of *Prosoponcus rectiloba* Simon, 1884 from France, Haute-Savoie, Les Contamines, Coll. Simon 25107 AR12085 (MNHNP); examined.

Further material examined. BELGIUM: Antwerpen: Mol, 7 ♂♂ (morph *cristatus*), 6 ♀♀, 15.vi.1973, R. Bosmans leg. (CRB). – FRANCE: Savoie: St-Julien-Molin-Molettes, 1 ♂ (morph *cristatus*), in litter, 28.x.2014, P. Dubois leg. (CPO). Haute-Garonne, Le Plan, 1 ♂ (morph *foraminifer*), 9.v.2015, Samuel Danflous leg. (CSD). – GREECE: Ionian Islands: Lefkada: Nidri, 2 ♂♂ (morph *foraminifer*), 1 ♀, under rocks below waterfall, 26.v.1993, A. Russel-Smith leg. (CAR-S). – SPAIN: Cantabria: Lebeña, 1 ♂ (morph *foraminifer*) 1 ♀, 16.vii.1985, R. Bosmans leg. (CRB).

Comments on the type material

The only material of *Diplocephalus bicephalus* (originally as *Prosoponcus b.*) that is available in MNHNP is the male,

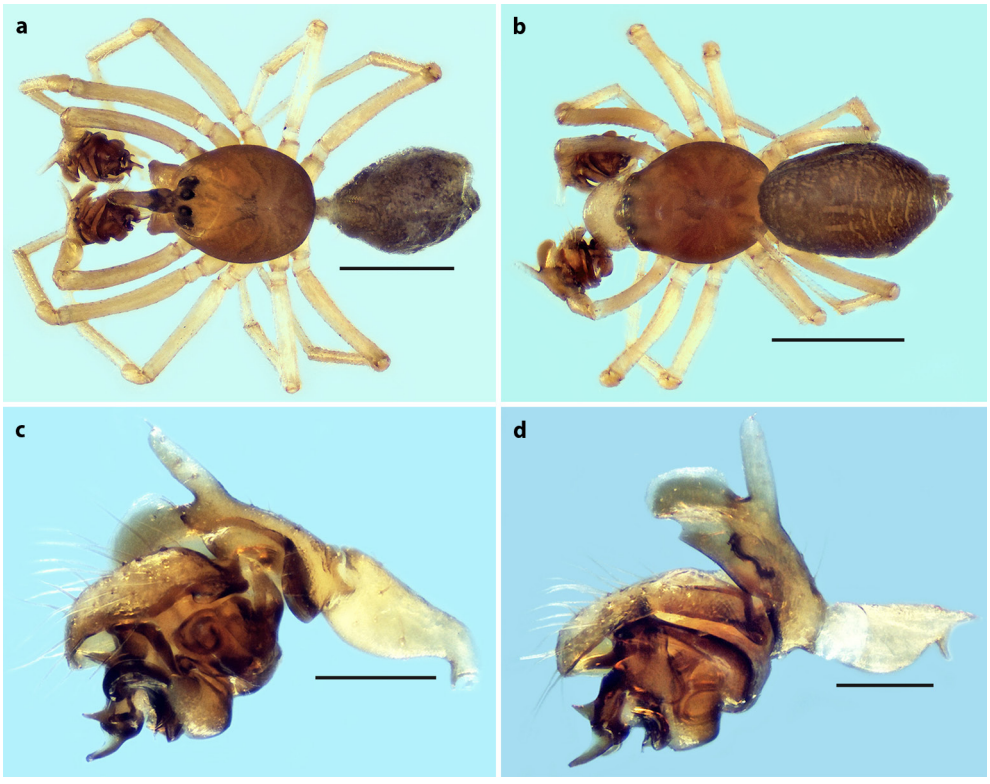

Fig. 3: *Savignia harmsi* Wunderlich, 1980. **a.** Morph *typica*, dorsal view; **b.** Morph *cor*, dorsal view **c.** Male palp of morph *typica*, lateral view, **d.** Ibid. of forma *cor*.

which is therefore designated as the lectotype. The two accompanying females belong to *Dicymbium nigrum* (Blackwall, 1834), and Simon's figure 674 (Simon 1884) obviously shows the epigyne of this species. The only material of *Prosoponcus rectilobus* available in the MNHNP is the male holotype.

Comments on the synonymy

We first became interested in the *Diplocephalus cristatus* complex, while studying specimens collected by Antony Russell-Smith from Lefkada, Greece (Fig 2). A number of males and females were collected from near a spring and they are illustrated in Fig. 2. Having tried to identify these specimens, we found out that their palps and epigynes were completely similar to those of the common European species *D. cristatus*, but the males had very different cephalic lobes. Further research showed a clear match with *D. foraminifer* and *D. arvernus*, as illustrated by Deltshev (1985), Denis (1948) and Georgescu (1969) – compare above the section "A forgotten case of dimorphism".

Figs 1b-c, e-f, h-i, k-l and n, o show the male palps and palpal tibiae of respectively *D. cristatus*, *D. rectilobus*, *D. foraminifer*, *D. bicephalus* and *D. arvernus*. Detailed examinations of all palpal sclerites and palpal tibiae revealed no differences. Simon (1926: p. 495) already wrote about *D. rectilobus* in a footnote: "Peut-être une forme ou variété de *D. cristatus*". Thus, in our opinion, the males of *D. cristatus* occur in two morphs: viz., Figs 1a, d show the morph *cristatus* with a low cephalic lobe, and Figs 1g, j, m and 2a show the morph *foraminifer* with a high cephalic lobe.

Distribution and habitat

Specimens of *Diplocephalus* morph *cristatus* occur all over Europe (Nentwig et al. 2017). On the contrary, the morph *foraminifer* has a much smaller distribution: northern Spain, southern France, Switzerland and northern Italy in the western part of Europe, and Bosnia and Hercegovina, Macedonia, Montenegro, Bulgaria, Serbia and Romania in the eastern part (Nentwig et al. 2017).

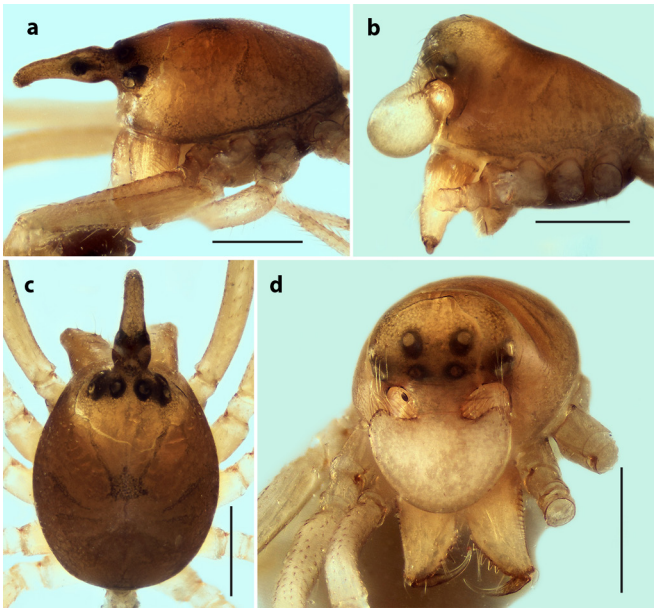

Fig. 4: *Savignia harmsi* Wunderlich, 1980. **a.** Morph *typica*, lateral view of prosoma; **b.** Morph *cor*, lateral view of prosoma; **c.** Morph *typica*, dorsal view of prosoma; **d.** Morph *cor*, anterior view of prosoma.

The morph *cristatus* occurs in a variety of habitats: "in grass, straw, moss, etc." (Locket & Millidge 1953), "auf offenen Flächen, an Waldrändern, in Gärten" (Heimer & Nentwig 1991). The morph *foraminifer* occurs in a much narrower range of specialized habitats. These spiders are frequently found under stones at high altitudes in the Cantabrian Range, the Pyrénées, the Massif Central and the Alps (Simon 1884, 1926, Bosmans & de Keer 1985, Denis 1953, 1955, Hänggi & Stäubli 2012, Müller 1985). At lower altitudes, these spiders occur in more restricted habitats such as caves, near springs and rivulets and in screes and cracks (Denis 1934, Georgescu 1969, Deltshev 1985), rarely in deciduous woodlands (Grbic & Savic 2010).

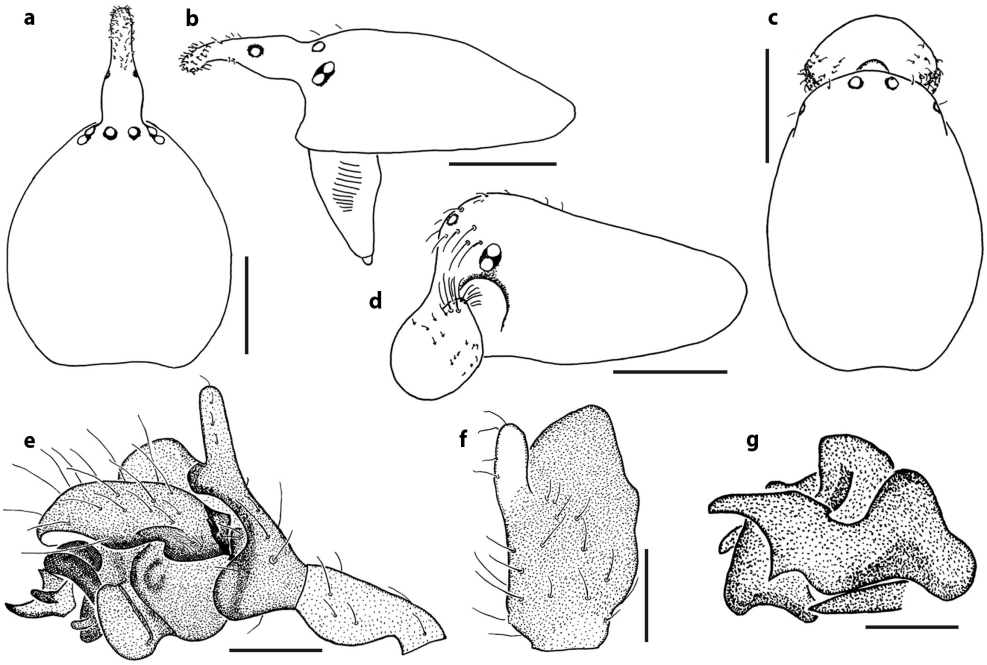

Fig. 5: *Savignia harmsi* Wunderlich, 1980. **a.** Morph *typica*, dorsal view of prosoma; **b.** Morph *typica*, lateral view of prosoma; **c.** Morph *cor*, dorsal view of prosoma; **d.** Morph *cor*, lateral view of prosoma; **e.** Male palp, retrolateral view; **f.** Male palpal tibia, dorsal view; **g.** Embolic division, prolateral view.

A new case of male dimorphism:

***Savignia harmsi* Wunderlich, 1980** (Figs 3a-d, 4a-d, 5a-g)

Savignia harmsi Wunderlich, 1980: 332, figs 45-51 (descr. ♂,♀).

Material examined. SPAIN: Granada: Baza, 5 ♂♂ 1 ♀, pitfalls in dry riverbed, 12.xi.1990, L. Zarcos coll. (CRB).

Comments. At first glance, the five studied males appear to belong to different species, because their prosomas have very different shapes (Figs 4a-c, 5a-c). However, their palp conformation is identical (cf. Figs 3e and 3d). The first morph (Fig. 4a-b) has a nose-like projection carrying the anterior median eyes, like in *Savignia frontata* Blackwall, 1833. Apparently, because of this resemblance Wunderlich (1980) placed the species in the genus *Savignia*. The second morph (Fig. 4c-d) has a completely different cephalic lobe in the form of a large, rounded lobe, heart-shaped in the anterior view (Fig. 4d). For this morph, the name *cor* (Latin for heart) is herein proposed. If this morph was found first, the species would probably have been described in *Diplocephalus*.

Distribution. *S. harmsi* was described from both sexes from Spain, in the province of Malaga (Wunderlich 1980). It was recollected from the neighbouring province of Granada. It was not yet recorded since the original description (Morano et al. 2014).

Acknowledgements

Christine Rollard (MNHN) and the individual collectors mentioned in 'Material and methods' are sincerely thanked for allowing us to study the material of *Diplocephalus* species under their care. Thanks also to Laura Zarcos for providing the specimens of *Savignia harmsi*. Finally, we wish to thank Antony Russell-Smith and an anonymous referee for their critical comments on the manuscript which helped us to improve it.

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