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Authors: Weiss, Ingmar, and Sarbu, Serban M.

Source: Arachnologische Mitteilungen: Arachnology Letters, 61(1) : 73-76

Published By: Arachnologische Gesellschaft e.V.

URL: <https://doi.org/10.30963/aramit6112>

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***Porrhomma frasassianum* spec. nov. from a sulfidic cave, Italy (Araneae: Linyphiidae)**

Ingmar Weiss & Serban M. Sarbu



doi: 10.30963/aramit6112

Abstract. *Porrhomma frasassianum* spec. nov., a blind troglobitic spider from the sulfidic Grotta del Fiume – Grotta Grande del Vento cave system (Italy), is described and illustrated. The relationship between this new species and other European species of *Porrhomma* is discussed, its distribution in the Frasassi cave system is analysed and the spider species cohabiting with the newly described species are listed.

Keywords: blind, cave-spider, chemo-autotrophically based ecosystem, endemic, new species, troglobites

Zusammenfassung. *Porrhomma frasassianum* spec. nov. aus einer Schwefelhöhle, Italien (Araneae: Linyphiidae). *Porrhomma frasassianum* spec. nov., eine blinde, troglobionte Spinnenart aus den Schwefelhöhlen Grotta del Fiume – Grotta Grande del Vento in Italien, wird beschrieben und abgebildet. Die Beziehung dieser neuen Art zu europäischen *Porrhomma*-Arten wird diskutiert, ihre Verbreitung im Höhlensystem von Frasassi analysiert und die dort bisher nachgewiesenen Spinnenarten aufgelistet.

Miller & Kratochvíl (1940) began their investigation of the genus *Porrhomma* by stating: “there are only a few genera of spiders, that present so many difficulties in systematic terms”. This assessment can be found in a similar way in all later taxonomic studies of the genus. In discussing *Porrhomma* species, Thaler et al. (2003) began with the quote from Tretzel (1956) that the “danger of a subjective interpretation” is very great. Today this is less due to the sparse observation material but, on the contrary, the difficulties continue to increase with new discoveries outside of Central Europe. The discovery of a remarkable *Porrhomma* population in the karst area of Frasassi in central Italy, raises old and new questions. The valuable revision of the genus *Porrhomma* by Růžicka (2018) facilitated this present description.

Biological investigations performed in the deep sulfidic sections of several caves located in the Frasassi Gorge in Italy (1996 to the present) led to the discovery of a rich and abundant cave-dwelling invertebrate fauna. The food base for this trophically and genetically isolated community is produced chemoautotrophically in situ by sulfide oxidizing microorganisms (Sarbu et al. 2000).

Material and methods

All specimens were collected by hand in the Grotta del Fiume – Grotta Grande del Vento cave system (geographical coordinates: 43.40065°N, 12.96493°E, 203 m a.s.l.), located in the Frasassi Gorge (Genga, Ancona, Marche, Italy), conserved in 70% ethanol and deposited in the following institutions:

MHNG: Muséum d'histoire naturelle de la ville de Genève, Geneva, Switzerland

MSNVR: Museo Civico di Storia Naturale, Verona, Italy

OLML: Biologiezentrum Linz/Oberösterreichisches Landesmuseum, Linz, Austria

SMF: Senckenberg Research Institute, Frankfurt am Main, Germany

ZMB: Museum für Naturkunde, Berlin, Germany

Ingmar WEISS, Rehtränke 1, 94481 Grafenau, Germany;

E-mail: mail@arachnologie.info

Serban M. SARBU, California State University, Chico, Department of Biological Sciences, Chico CA 95929-515, Holt Hall 205, USA and Institute of Speleology “Emil Racovitza”, Calea 13 Septembrie Nr. 13, 050711 București, Romania;

E-mail: serban.sarbu@yahoo.com

Academic editor: Theo Blick

submitted 28.2.2021, accepted 30.3.2021, online 27.4.2021

Nomenclature follows the World Spider Catalog (2021). Terminology for the copulatory organs follows Růžicka (2018). Measurements are given in millimeters (mm).

Comparative material analysed: *P. rosenhaueri* (L. Koch, 1872), Germany, Bavaria, Frankenalb (Johann-Georg-Wundershöhle at Muggendorf: 49.79940°N, 11.27215°E, 473 m a.s.l.) 22. Mar. 1980 – 2 ♂♂, 3 ♀♀, leg. Plachter, det. Thaler, coll. Thaler Nr. 6717 (Thaler & Plachter 1983).

Taxonomy**Family Linyphiidae****Genus *Porrhomma* Simon, 1884*****Porrhomma frasassianum* spec. nov. (Figs 1-3)**

Type data. SMF: Holotype: 1 ♂, 7. May 1997, paratypes: 7. May 1997, 2 ♂♂, 7 ♀♀, 1 j; 8. May 1996 – 4 ♀♀, 2 jj; 15. Feb. 1998 – 5 ♂♂, 11 ♀♀, 5 jj; 7. Sep. 1998 – 6 ♀♀, 2 jj; 23. Nov. 1998 – 5 ♂♂, 15 ♀♀. MSNVR: paratypes: 23. Nov. 1998 – 2 ♂♂, 4 ♀♀, 8 jj; 8. Mar. 2014 – 1♀. ZMB: paratypes: 1. Dec. 1997 – 2 ♂♂, 4 ♀♀ (Nr. 31149). MHNG: paratypes: 5. Apr. 1996 – 3 ♂♂, 4 ♀♀, 2 jj. OLML: paratypes: 15. Nov. 1996 – 1 ♂, 5 ♀♀, 6 jj. ITALY. Grotta del Fiume, only in Ramo Sulfureo and at Rinoceronte Lake, legit S. Sarbu and S. Galdenzi.

Etymology. The specific name is derived from the Frasassi Gorge, where this species was found, adjective.

Diagnosis. Completely eyeless, depigmented, troglobitic spider, with very long legs. The species can be distinguished from all other European species of the genus by the characteristic, obliquely flattened shape of the clypeus as viewed laterally, the absence of the prolateral spine on tibia I and by genital characters, especially the long, slender and conspicuously wavy embolus and the rectangular plate of the epigyne.

Description of male

Total length: 1.75 mm; prosoma length: 0.78 mm; width: 0.60 mm.

Colour: light yellow, chelicerae somewhat darker, opisthosoma grey-white.

Prosoma in lateral view with obliquely flattened clypeus, eyes absent (Fig. 1a, b).

Legs very long and thin; ratio femur I/prosoma length = 1.5; ratio metatarsus I/prosoma width = 1.66. Ventral side of the legs with long hairs. The male possesses retrolaterally on coxa I stridulating files, resulting in 7 slightly visible grooves. Femur I with a dorsal spine located in the proximal half, at 0.43;

femur II only with one dorsal spine (at 0.40); femur III and IV with no spines. Patella I–IV with a long spine. All tibiae with two dorsal spines, I and II with one additional retrolateral spine. The specific, prolateral spine on tibia I is absent. Metatarsi with no spines, I–III with trichobothrium (positions: I = 0.57; II = 0.60; III = 0.50).

Tab. 1: Leg measurements male (mm)

	Femur	Patella	Tibia	Meta-tarsus	Tarsus	Total
I	1.12	0.23	1.05	0.90	0.64	3.94
II	1.04	0.23	0.91	0.86	0.57	3.61
III	0.92	0.19	0.74	0.66	0.45	2.96
IV	1.13	0.22	1.06	0.91	0.60	3.92

Pedipalp: Cymbium 0.32 mm long, retrolaterally with an extended paracymbium and a characteristic embolic division: the embolus is longer than in other European species, more slender and wavy on its convex margin (Fig. 1a-c).

Description of female

Size, colour and characteristics of the legs identical with the male.

Tab. 2: Leg measurements female (mm)

	Femur	Patella	Tibia	Meta-tarsus	Tarsus	Total
I	1.17	0.26	1.12	1.02	0.65	4.22
II	1.08	0.26	0.97	0.88	0.56	3.75
III	0.94	0.22	0.78	0.76	0.48	3.18
IV	1.22	0.25	1.11	1.03	0.62	4.23

Epigyne/vulva: 0.075 mm wide, anterior rim delimited by an arch, posterior with a rectangular, not trapezoidal plate (Fig. 2a, b).

Of the 15 species of *Porrhomma* in Europe (Nentwig et al. 2021) 12 also occur in Italy and 5 of them are considered troglophilic (Pantini & Isaia 2021). *Porrhomma frassianum* is closest to *P. rosenbaueri* (L. Koch, 1872), a cave-adapted species known particularly from Central Europe, England and to date only from northern Italy (Lombardia, Trentino-Alto Adige, Veneto). The two species differ particularly by the shape of prosoma (Bourne 1977), the number of spines and subtle details of the genital morphology.

Distribution. Known only from the type locality.

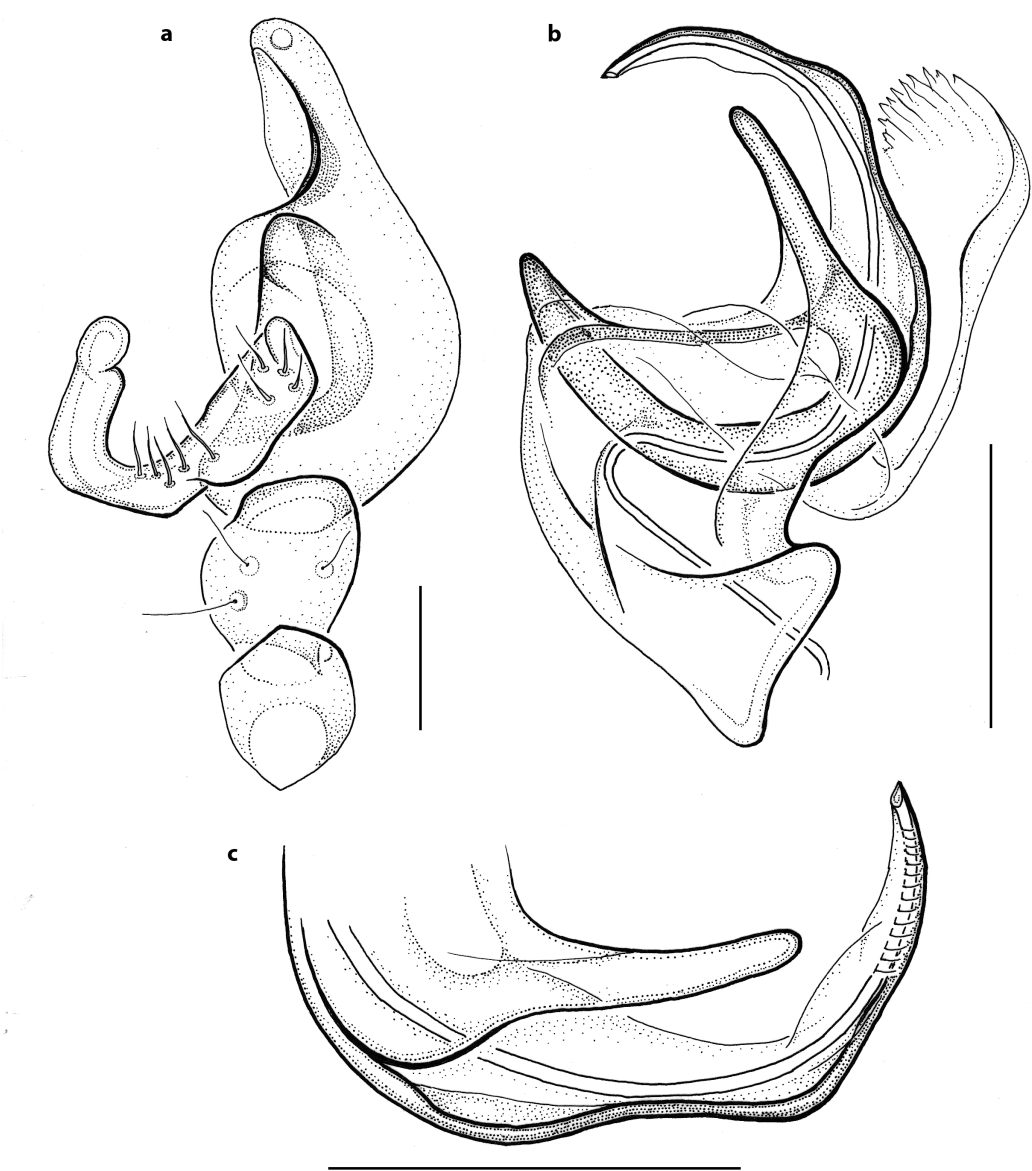


Fig. 1: *Porrhomma frassianum* spec. nov., male pedipalp. **a.** cymbium and paracymbium, retrolateral view; **b.** prolateral view of the embolic division with posterior apex, anterior process of the embolic plate, embolus and embolic membrane; **c.** anterior process of the embolic plate and embolus. Scale line = 0.1 mm

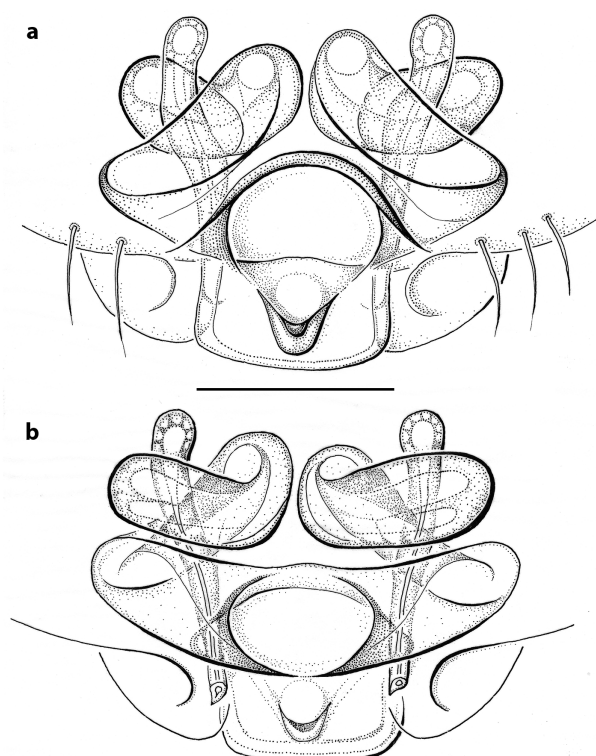


Fig. 2: *Porrhomma frasassianum* spec. nov., female. **a.** epigyne ventral; **b.** vulva dorsal. Scale line = 0.1 mm

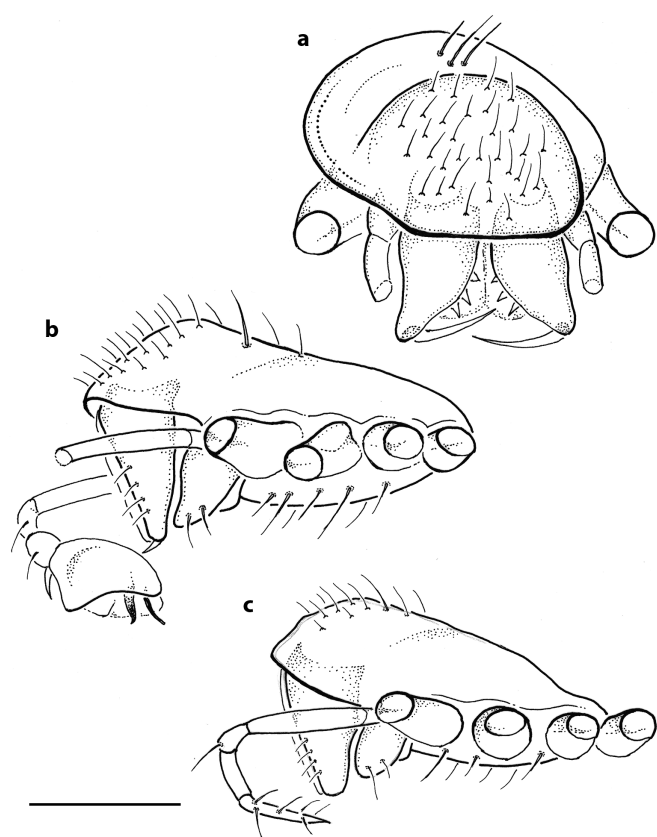


Fig. 3: *Porrhomma frasassianum* spec. nov., prosoma. **a.** male, frontal view; **b.** male, lateral view; **c.** female, lateral view. Scale line = 0.3 mm

Ecology

The vast network of cave passages explored to date in the Frasassi Gorge exceeds 35 km and is ecologically heterogeneous. The cave fauna was sampled at several different sites

within the cave system (Sarbu et al. 2000) and it is noteworthy that although *P. frasassianum* is present in very large numbers (total 114 = 22 ♂♂, 64 ♀♀, 28 jj) it has so far only been found in two locations: the Ramo Sulfureo section and the Rinoceronte Lake area in the same cave system. The shortest cave passages from here to the surface habitats are 400m long. Specimen number increases rapidly in the proximity of the thermal sulfidic waters, where the walls of the passages are covered by gypsum crusts. Collembola, which probably represent the food of these spiders, also occur in high densities in areas located close to the sulfidic lakes and streams where they feed on chemoautotrophic microbial biofilms. However, in the deep sulfidic sections of the Grotta Sulfurea, a different cave, located at a distance of only 150 m from Ramo Sulfureo and in which there are the same ecological conditions, *P. frasassianum* has not been found so far.

Discussion

Subsurface environments can be highly stressful habitats (darkness, limited food), but in the case of sulfidic groundwater habitats, organisms must also tolerate and adapt to different stresses (high levels of toxic gases and lethally low oxygen concentrations). Nevertheless, these habitats have a diverse fauna (Engel 2007). In any case, environmental adaptation plays a more important role in the evolution of species than mutations and takes place within much shorter time periods (Franz 1995).

Accompanying spider species found during our investigations in the Frasassi caves:

Centromerus pasquinii Brignoli, 1971 (Grotta Sulfurea: 1. Dec. 1997, 1 ♀)

Palliduphantes pallidus (O. Pickard-Cambridge, 1871) (Grotta del Fiume: 8. May 1996, 2 ♀♀, 2 jj; Grotta Sulfurea: 1. Dec. 1997, 1 ♂, 4 ♀♀, 2 jj; 17. Feb. 1998, 1 ♂, 6 ♀♀, 3 jj; 7. Sep. 1998, 8 ♂♂, 25 ♀♀; 25. Nov. 1998, 6 ♂♂, 22 ♀♀, 3 jj; Pozzo di Cristalli: 5. Apr. 1996, 1 ♀; 7. Sep. 1998, 6 ♂♂, 8 ♀♀, 7 jj; 24. Nov. 1998, 22 ♀♀, 14 jj; 1. Sep. 2011, 6 ♀♀)

Porrhomma convexum (Westring, 1851) (Grotta Sulfurea: 7. Sep. 1998, 3 ♂♂, 9 ♀♀)

Walckenaeria capito (Westring, 1861) (Grotta Sulfurea: 1. Dec. 1997, 1 ♂, 1 ♀; 17. Feb. 1998, 1 ♂, 3 ♀♀; 7. Sep. 1998, 1 ♂)

Kryptonesticus eremita (Simon, 1880) (Grotta del Fiume: 15. Nov. 1996, 1 ♂, 5 jj; 6. May 1997, 2 ♂♂, 1 ♀, 3 jj; Grotta Sulfurea: 1. Dec. 1997, 5 jj; 17. Feb. 1998, 2 ♂♂, 12 ♀♀, 12 jj; 7. Sep. 1998, 3 jj; Pozzo di Cristalli: 7. Sep. 1998, 7 jj; Ramo Sulfureo: 5. Apr. 1996, 3 ♂♂, 3 ♀♀, 4 jj; 6. May 1997, 1 ♀, 5 jj; 7. May 1997, 1 ♂, 8 jj; 1. Dec. 1997, 1 ♂, 1 ♀, 2 jj; 15. Feb. 1998, 6 ♂♂, 15 ♀♀, 56 jj; 7. Sep. 1998, 2jj)

To date, only *C. pasquinii*, *P. convexum* and *K. eremita*, a very common species in these habitats, had been reported from caves in the Frasassi Gorge (Brignoli 1979, Pantini & Isaia 2021). Bertolani et al. (1994) only found the following spider species: *Meta menardi* (Latreille, 1804), *Metellina merianae* (Scopoli, 1763), *Tegenaria parietina* (Fourcroy, 1785) and *K. eremita*. It is noteworthy, that the specimens of *K. eremita* living in the Ramo Sulfureo section of the Grotta del Fiume – Grotta Grande del Vento cave system are strikingly larger than spiders from populations living outside caves. They also display reduced eyes, elongation of the legs and depigmentation.

Acknowledgements

The authors would like to thank Sandro Galdenzi, Marco Menichetti and Roberto Bambini for their help with the field research in the Frasassi caves. The junior author's field work was supported by a research grant from the Consorzio di Frasassi and by grant PN-III-P4-ID-PCE-2020-2843 (EVO-DEVO-CAVE). We thank also Theo Blick, Petr Dolejš, Vlastimil Růžicka, Konrad Wiśniewski and Andrei Tanasevitch for their helpful comments on the manuscript.

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