



A new species of *Eukoenenia* (Palpigradi: Eukoeneniidae) from Brazilian iron caves

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Abstract

Eukoenenia ferratilis sp. n. is described from 7 adults (6 females and 1 male) and 1 immature (stage A) collected in iron caves in the municipalities of Moeda and Brumadinho, Minas Gerais, Brazil. The new species shares characteristics with several species of the genus *Eukoenenia* Börner, 1901 being related to the species *Eukoenenia mirabilis* (Grassi & Calandruccio, 1885) and *Eukoenenia berlesei* (Silvestri, 1903), but the shape and chaetotaxy of the male and female genitalia are distinctive

Key words: Neotropics, taxonomy, Arachnida

Introduction

The order Palpigradi is represented by three species of the genus *Eukoenenia* (Börner, 1901) in Brazil. *Eukoenenia janetscheki* Condé, 1993 and *Eukoenenia roquetti* (Mello-Leitão & Arlé, 1935), from the states of Amazonas and Rio de Janeiro, respectively, are edaphomorphic. *E. janetscheki* is a relatively well-known and well-studied species. Condé (1997) published a complementary description of this species. Adis *et al.* (1997) studied the phenology of this species in Central Amazon forests, sampling 745 individuals in a period of 12 months. On the other hand, *E. roquetti* is poorly known and has not been recorded since its description. Condé (1996) considers this species to be taxonomically uncertain. *Eukoenenia maquinensis* Souza & Ferreira, 2010, found in Maquiné cave, represents the first troglobiotic species of this order described from South America, presenting very advanced troglomorphic traits.

There are large gaps concerning the knowledge of Palpigradi in Brazil, since the existing information is restricted to the papers mentioned above. Up to the present moment, these arachnids have been considered rare organisms in this country. This scarcity of records is due to a lack of interest in these small arachnids, or even negligence in the study of their natural habitats. Brazilian caves are certainly included in this group of different habitats, as demonstrated by Souza & Ferreira (2010).

Although the Brazilian caves are related to many different lithologies, biological studies have focused on limestone caves. Only a few studies have included caves of different lithologies, such as quartzites, sandstones and granites (Souza-Silva 2008). Until recently, caves related to ferruginous rocks were not included in biospeleological studies due to their reduced dimensions, which leads to the erroneous assumption that they could only present low biological diversity (Ferreira 2005). However, studies performed by the latter author in some iron caves have revealed extremely complex communities living under peculiar conditions, including many troglomorphic species that have evolved in these systems.

The present study describes a new species of *Eukoenenia*, found in iron caves located in the municipalities of Moeda and Brumadinho (iron quadrangle: *quadrilátero ferrífero*, state of Minas Gerais, southeastern Brazil).

The Palpigrades were found by visual searching of the ground and under rocks in the caves, captured with a fine brush and placed in vials with 70% ethanol. The material examined for this study was cleared in Nesbitt's fluid and then mounted on glass slides in Hoyer's medium. Measurements and drawings were made with a phase con-

trast microscope and are given in micrometers (μm); the body length was measured from the apex of the propeltidium to posterior margin of the opisthosoma.

The following abbreviations are used, in accordance with Barranco & Mayoral (2007): L, total length of body (without flagellum which is lost in all specimens); B, length of dorsal shield; P, pedipalpus; I and IV, legs I and IV; ti, tibia; bta1, basitarsus 1; bta2, basitarsus 2; bta3, basitarsus 3; bta4, basitarsus 4; ta1, tarsus 1; ta2, tarsus 2; ta3, tarsus 3; a, width of basitarsus IV at level of seta *r*; *er*, distance between base of basitarsus IV and insertion of seta *r*; *grt*, length of tergal seta; *gla*, length of lateral seta; *r*, length of stiff seta; *t/r*, ratio between length of basitarsus IV and stiff seta length; *t/er*, ratio between length of basitarsus IV and distance to insertion of stiff seta; *gla/grt*, ratio between lengths of lateral and tergal setae; B/bta, ratio between lengths of prosomal shield and basitarsus IV; bta/ti, ratio between lengths of basitarsus IV and tibia IV. Setal nomenclature follows Condé (1974, 1988, 1989, 1993, 1994).

Eukoenia ferratilis sp. n.

(Figs 1–17)

Material examined. Holotype: adult male from PBR 16 cave, Brumadinho (607268 mE/7770965 mN), Brazil, 28/III/2009, *leg.* R. Bessi *et al.* Paratypes: 4 adult females from SMS29 cave, Moeda (20°18'45"S, 44°03'45"W), Brazil, 03/XI/2005, *leg.* R. L. Ferreira; 1 female from PBR07 cave, Brumadinho (607042 mE/7770056 mN), Brazil, 28/III/2009, *leg.* R. Bessi *et al.*; 1 female from PBR22 cave, Brumadinho (607324 mE/7771362 mN), Minas Gerais, Brazil, 15–20/III/2010, *leg.* R. Bessi *et al.*; 1 immature A, from PBR18 cave, Brumadinho (607199 mE/7769951 mN), Minas Gerais, Brazil, 15–20/III/2010, *leg.* R. Bessi *et al.* Holotype (ISLA1198) and 5 paratype (ISLA1199–1203) deposited in the Coleção de Invertebrados Subterrâneos do Laboratório de Ecologia Subterrânea do Departamento de Biologia da Universidade Federal de Lavras (UFLA), Lavras, MG, Brazil; 2 paratypes deposited in Instituto Butantan, São Paulo, SP, Brazil (IBSP03–IBSP04).

Etymology. The specific name *ferratilis* refers to the presence of this species in iron caves.

Diagnosis. This species differs from all others of the genus *Eukoenia* by the following combination of characteristics: presence of a single blade on the prosomal lateral organs, presence of nine deuto-tritosternal setae in two rows: first with three setae in V arrangement and second with six setae in linear arrangement, presence of 2 + 2 thickened setae in middle of opisthosoma (a_1 and a_2) between two normal slender setae (s_1 and s_2) in the opisthosomal sternites IV–VI, tergite II with two pairs and a central seta (t_3, t_1, t) in a transverse row between a pair of slender setae (s) and the characteristic chaetotaxy and shape of the genitalia in females and male.

Description of adults. *Prosoma.* Frontal organ with two branches distally pointed and basally expanded, each 2.6 times longer than wide (16.25 μm /6.25 μm) (Fig. 1). Lateral organ with a single blade, granulate and distally pointed, 2.6 times longer than wide (20/7.5 μm) (Fig. 2). Propeltidium with 10 + 10 short setae in five rows, outer setae of last row longer than others (Fig. 3). Metapeltidium with 3 + 3 setae (t_1, t_2, t_3), each of different length, outer seta shortest (82.5 μm , 85 μm , 50 μm) (Fig. 4). Nine deuto-tritosternal setae in two rows: first with three setae in V arrangement and second with six setae in linear arrangement (Fig. 5).

Chelicerae with nine teeth on each finger, with four dorsal setae, a single ventral seta inserted next to the mobile finger, a middle seta, and a seta inserted near the tooth of the fixed finger (Fig. 6).

Leg I: Basitarsus 3 short, 1.5 times longer than wide, with three setae (*grt*: 67.5 μm ; *r*: 62.5 μm). Seta *r* longer than the segment (47.5 μm / 62.5 μm , *t/r* = 0.72), inserted in proximal half and reaching distal margin of basitarsus 4 (45 μm / 10 μm , *s/er* = 4.5). Leg I with 7 trichobothria in usual arrangement and 9 forked setae: 5 on ta3 and 1 on ta2, bta 4, bta2 and bta1 each (Fig. 7).

Leg IV: basitarsus with seven setae (2 *esd*, 2 *esp*, *gla*, *grt* and *r*), *bta/ti* 0.82. Stiff seta *r* 1.1 times shorter than the tergal edge of segment (115 μm /97.5 μm , *t/r* = 1.1) and inserted in its proximal third (115 μm /12.5 μm , *t/er* = 9.2); *esp*, *gla* and *grt* proximally inserted, *gla* level with *esp*, *grt* more basal (Fig. 8).

Coxal chaetotaxy: coxa I with 14 setae, coxae II and III with 3 thick and 9 normal setae each and coxa IV with 2 thick and 8 normal setae (Figs. 9–12).

Opisthosoma. Tergite II with 3 + 1 + 3 dorsal setae, two pairs and a central seta (t_3, t_1, t) between a pair of slender setae (s). Tergites III–VI with 4 + 4 setae, three pairs of setae (t_1, t_2, t_3) between slender setae (s) (4+3 in the tergite III of the female 5; asymmetry caused by the lack of *t* seta) (Fig. 13). Sternite III with 2 + 2 setae. Sternites IV–VI each with 2 + 2 thickened setae in middle of opisthosoma (a_1 and a_2) between two normal slender setae (s_1

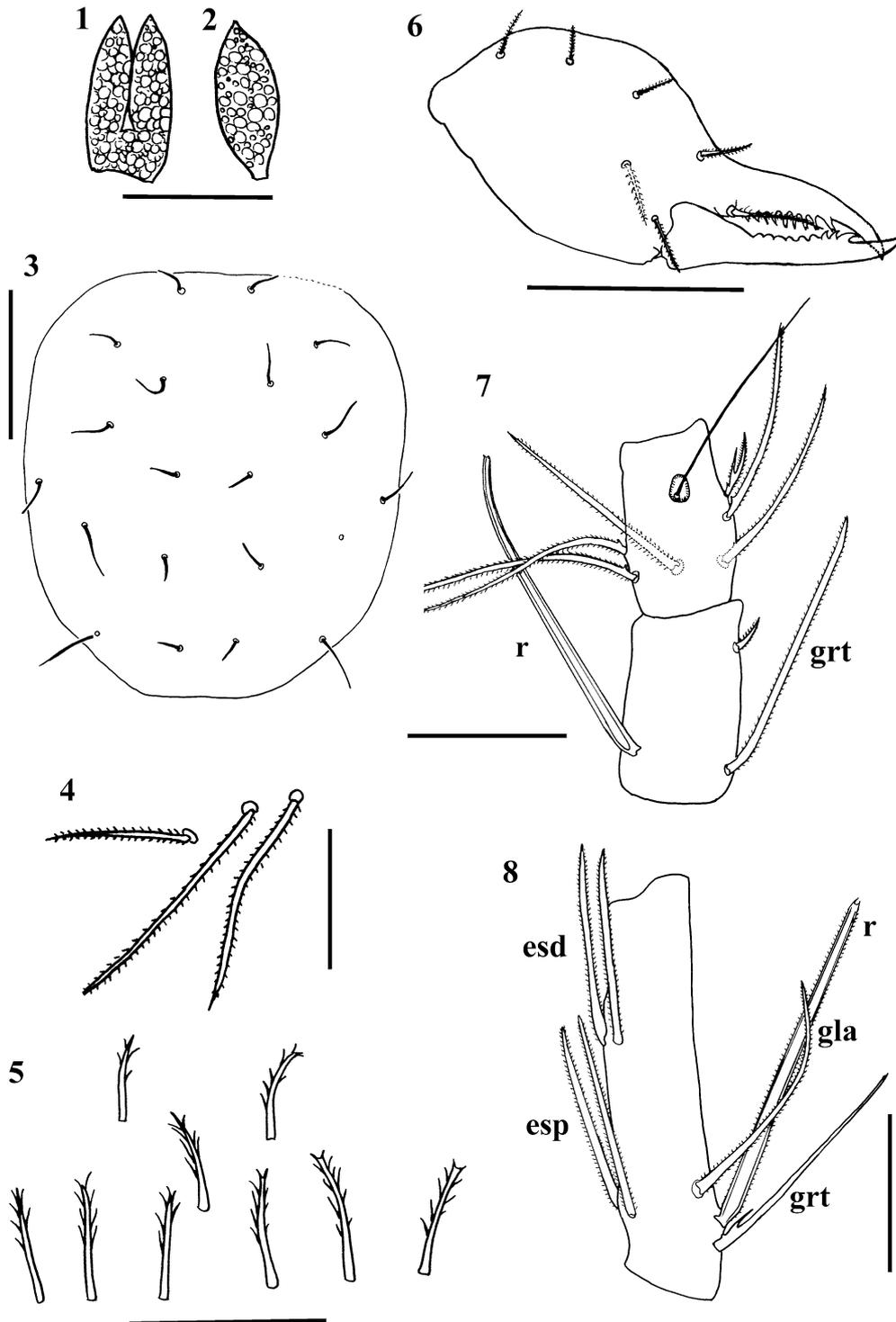
and s_2) on each side (2+3 s setae in sternite IV of the female 6; asymmetry caused by the presence of an additional s seta); a pair of glandular pores can be observed between the a_1 setae from these segments on the male and the immature specimen. All setae a of same size, setae s slightly shorter (Fig. 14). Segments VII–XI with 13–15, 14–16, 9–11, 9 and 8–10 setae respectively.

Female genitalia. With two lobes; first lobe with 11 + 11 setae in 5 transverse rows (10+11 in the female 2 and 3; asymmetry caused by the lack of regular seta), 4 sternal 2 + 2, 2 + 2, 2 + 2, 1 + 1 and distal 4 + 4, of which a_1 , a_2 , a_3 and a_4 measure 12.5–17.5, 12.5–17.5, 17.5–20 and 22.5 μm respectively. Second lobe with 3 + 3 setae (x , y , z), measuring 17.5–20, 15–20 and 15–20 μm respectively; 4 glandular orifices. Spermathecae formed by two oval portions joined by a triangular central region, which is more sclerotized (Fig. 15).

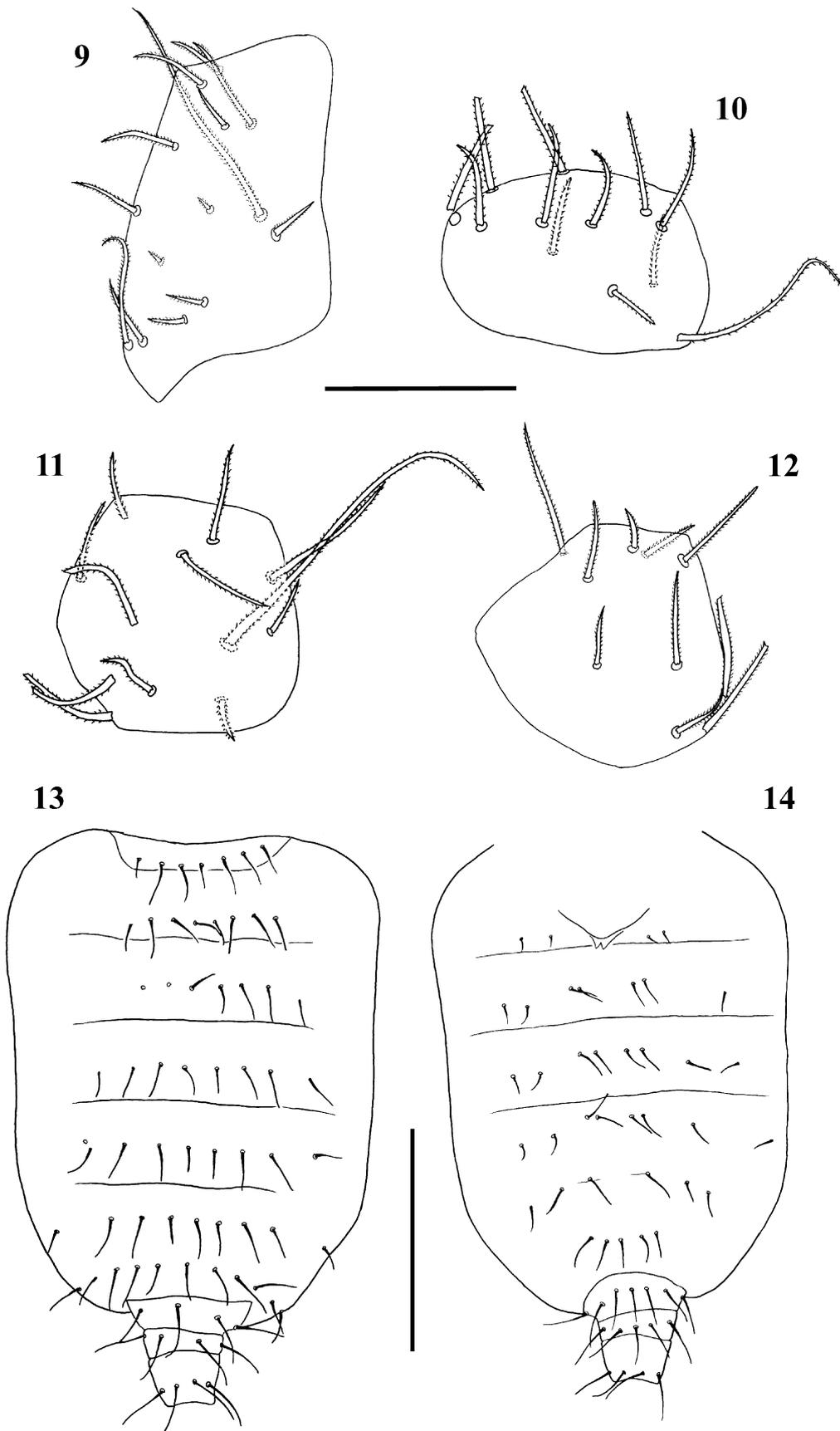
Male genitalia. With 2+2 external setae (st_1 and st_2) and 37 setae distributed in the three lobes. First lobe wider than long, with a clear separation in the central region; with 11 + 11 setae (including 2+2 fusules on distal margin). Second lobe subtriangular, with a rounded apex and with 5+4 setae (a , b , c , c' , d) (asymmetry caused by the lack of regular seta). Third lobe also subtriangular, well developed, with 4+4 setae (w , x , y , z), with a large, sharp and simple apical region (Fig. 16).

TABLE 1. Measurements (in μm) and ratios of selected body parts of *Eukoenia ferratilis* sp. n.

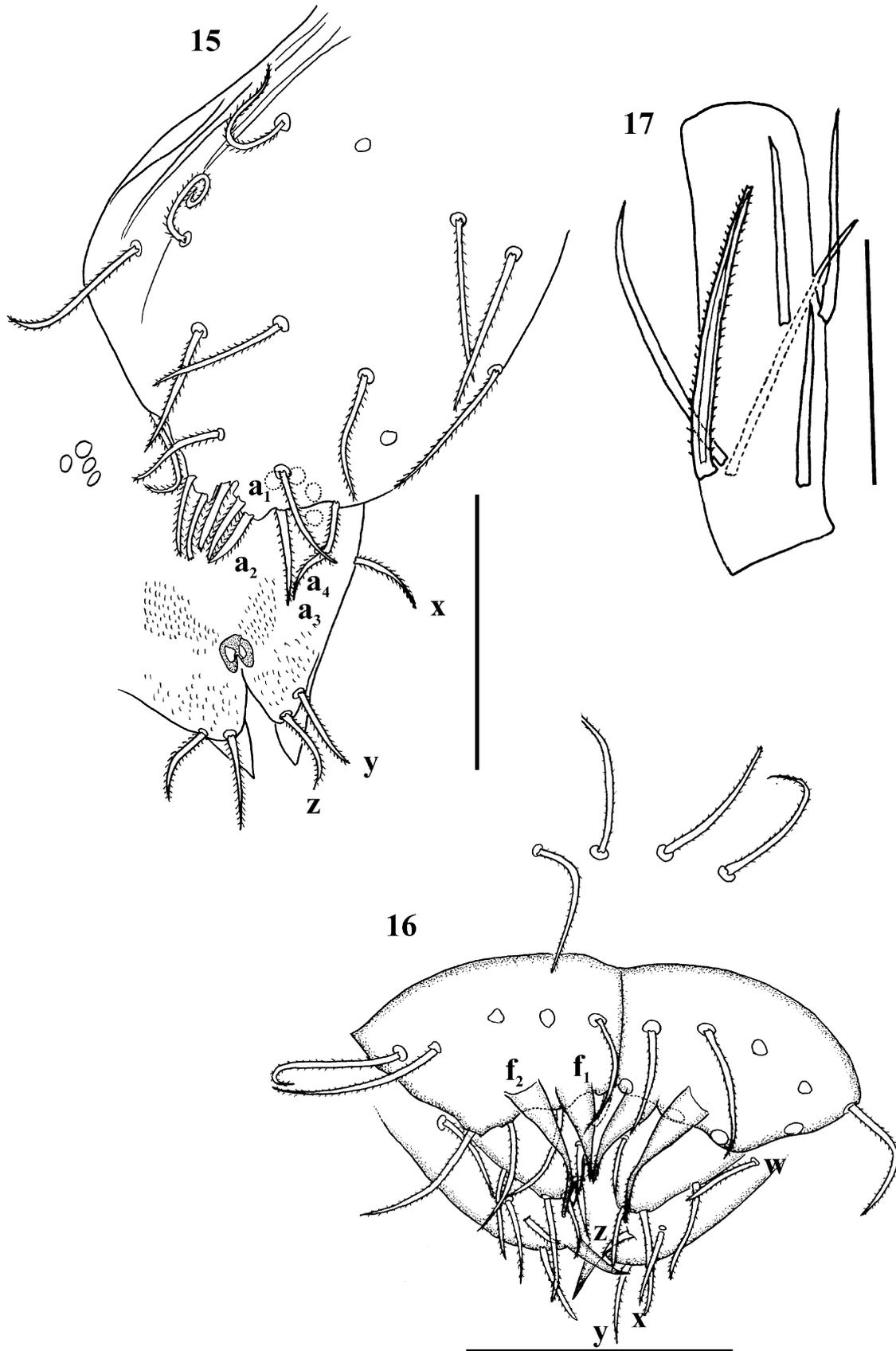
Body Part	Female 1	Female 2	Female 3	Female 4	Female 5	Female 6	Male (holotype)	Immature
L	1130	1240	1240	1200	1070	985	910	915
B	-	295	250	-	305	260	270	217.5
Pti	102.5	-	92.5	112.5	122.5	92.5	117.5	77.5
Pbta1	44	-	35	45	47.5	42.5	47.5	35
Pbta2	41	-	35	40	47.5	42.5	45	35
Pta1	32	-	28.7	30	35	35	37.5	30
Pta2	35	-	27.5	32.5	40	47.5	32.5	32.5
Pta3	-	-	45	52.5	60	50	62.5	47.5
Iti	105	110	95	117.5	120	90	120	80
Ibta1+2	82.5	87.5	67.5	87.5	92.5	72.5	87.5	67.5
Ibta3	45	45	47.5	47.5	45	45	45	30
Ibta4	40	47.5	37.5	37.5	45	45	45	47.5
Ita1	20	2.2	22.5	22.5	22.5	30	25	20
Ita2	30	37.5	32.5	35	32.5	47.5	35	30
Ita3	105	90	92.5	112.5	120	92.5	115	87.5
IVti	120	118.7	-	127.5	127.5	95	140	85
IVbta	107.5	110	-	112.5	105	87.5	115	80
IVta1	50	37.5	42.5	50	47.5	-	57.5	35
IVta2	55	62.5	55	55	52.5	2	62.5	42.5
A	20	23	-	22	22.5	-	25	25
Er	22	20	-	20	20	-	12.5	17.5
Grt	62.5	70	-	62.5	70	-	65	-
Gla	65	65	-	65	70	-	-	-
R	85	88	-	87.5	100	-	97.5	37.5
t/r	1.26	1.25	-	1.28	1.05	-	1.17	2.13
t/er	4.8	5.5	-	5.6	5.2	-	9.2	4.5
gla/grt	1.04	0.92	-	1.04	1	-	-	-
B/bta	-	2.68	-	-	2.9	2.97	2.34	2.71
Bta/ti	0.89	0.92	-	0.88	0.82	0.92	0.82	0.94



FIGURES 1–8. *Eukoenenia ferratilis* sp. n. 1, frontal organ of female 3, dorsal view; 2, lateral organ of female 3, dorsal view (scale bar 20 μ m); 3, propeltidial chaetotaxy of female 2 (scale bar 100 μ m); 4, metapeltidial setae of female 2 (scale bar 50 μ m); 5, deuto-tritosternal setae of female 3 (scale bar 40 μ m); 6, chelicera of female 3 (scale bar 100 μ m); 7, basitarsus 3–4 of leg I of female 4 (scale bar 40 μ m); 8, basitarsus IV of female 4 (scale bar 40 μ m).



FIGURES 9–14. *Eukoenenia ferratilis* sp. n. 9, coxa I of female 3; 10, coxa II of female 3; 11, coxa III of female 3; 12, coxa IV of female 3 (scale bar 60 μ m); 13, opisthosoma of female 1, dorsal view; 14, opisthosoma of female 1, ventral view (scale bar 300 μ m).



FIGURES 15–17. *Eukoenenia ferratilis* sp. n. 15, genitalia of female 3 (scale bar 60 μ m); 16, genitalia of male (scale bar 60 μ m); 17, bta IV of immature stage A (scale bar 40 μ m).

Description of immature (stage A). Lateral organ with a single blade, 3.5 times longer than wide (18.75 μm /5 μm). Deuto-tritosternum with 7 setae. Fingers of chelicerae each with 8 teeth. Chaetotaxy of propeltidium complete. Chaetotaxy of metapeltidium similar to the adult, with t_1 , t_2 and t_3 measuring 60, 72.5 and 37.5 μm , respectively. Coxae II–IV with 3, 3, and 0 thickened setae. In leg I trichobothria and forked setae with the same arrangement as in the adults. bta IV with 6 setae (1 *esp* missing) (Fig. 17). Tergites III–V with 2+2 setae (t_3 missing) between the setae *s*. Tergite VI with 2+3 setae between the setae *s*. Sternites IV with 3+2 setae *a* between the setae *s*. Sternites V–VI with 2+2 setae (a_1 , a_2) between the setae *s*. Sternites IV–VI with a pair of glandular pores in the center of the segments located between the two pairs of setae *a*. Segments VII–XI with 11, 12, 9, 8, and 8 setae. Segment III with 3+3 setae (st_1 , st_2 , st_3).

Discussion. *Eukoenenia ferratilis* **sp. n.** differs from *E. janetscheki* (Condé 1993, 1997) in the number of elements forming the lateral organs, the arrangement of the deuto-tritosternal setae, chaetotaxy of the opisthosomal sternites, the shape of the first genital lobe and the form of the spermathecae in the female, and the shape and chaetotaxy of the genital lobes in the male. The first two of these traits also distinguish *Eukoenenia ferratilis* **sp. n.** from *E. roquetti* (Mello-Leitão & Arlé, 1935). Another characteristics separating the new species from *E. roquetti* is the disposition and shape of the deutotritosternal setae, the number of teeth of the chelicerae, and the shape and chaetotaxy of the male genitalia. The chaetotaxy of the opisthosoma, as well as many other characteristics of taxonomic importance, are not described by Mello-Leitão & Arlé (1935), which precludes a more detailed comparison. *Eukoenenia ferratilis* can be easily distinguished from *E. maquinensis*, since the latter is troglolobitic. All traits are completely different when comparing both species, such as the number of blades in the lateral organs (6 in *E. maquinensis* and 1 in *E. ferratilis*), the chaetotaxy of deutotritosternum, propeltidium, the shape of the genital lobes in the females and, especially, the great elongation of the appendages in *E. maquinensis*.

According to Christian (2009), the group of *Eukoenenia mirabilis* (Grassi & Calandruccio, 1885) in Europe is formed by species that present the following combination of characteristics: a single blade on the lateral organ, more than 5 setae on the deuto- tritosternum, 7 setae on the basitarsus of leg IV, and a number of more or less modified sternal setae connected with a glandular complex on one or two segments of the opisthosoma. *Eukoenenia ferratilis* presents all the above mentioned traits, thus being related to the *E. mirabilis* complex. This group was previously known in South America from immatures of the *E. mirabilis-berlesei* complex recorded in Chile (Condé 1987). However, *Eukoenenia ferratilis* **sp. n.** can be clearly distinguished from *E. mirabilis* and *E. berlesei* by the chaetotaxy of abdominal sternites IV–VI (Silvestri 1905). The chaetotaxy of sternites IV–VI in *Eukoenenia ferratilis* **sp. n.** is similar to that observed in species belonging the *austriaca* group (2+2 *a* between 2+2 *s*) (Condé 1972). It is important to emphasize that the thickened (*a*) setae on sternites IV–VI have the same form in the male and in the female. Hence, the species does not present sexual dimorphism for this trait. However, the male specimen is smaller than the immature examined, which suggests that males can be somewhat smaller than females in this species.

The female genitalia of *E. berlesei* (Silvestri, 1903) also differ from those of *Eukoenenia ferratilis* **sp. n.** in presenting a denticulate posterior margin of the first lobe and quite robust, as well as having (in *E. berlesei berlesei*) setae a_1 and a_2 considerably shorter (subcylindrical) than setae a_3 and a_4 . The genitalia of the male of *E. mirabilis* presents a very different general aspect from those of *Eukoenenia ferratilis* **sp. n.**, with the two halves that form the first lobe being fused and having a continuous border, and the second lobe presenting a pointed apex. The general aspect of the genitalia of the male of *Eukoenenia ferratilis* **sp. n.** resembles that of *Eukoenenia grassii* (Hansen, 1901) from Paraguay (Condé 1990a). However the latter differs from *Eukoenenia ferratilis* **sp. n.** mainly in presenting 3 elements forming the lateral organs, 4 pairs of thickened setae in the abdominal sternites IV–V and 3 pairs on the sternite VI, and in having the third lobe of the genitalia forked (Hansen 1901; Condé 1990a).

The new species has a singular disposition of setae on tergite II, similar only to that seen in *E. subangusta* (Silvestri, 1903) (Condé 1990b) and *Eukoenenia gallii* Christian, 2009.

Although *Eukoenenia ferratilis* **sp. n.** does not present troglomorphic characteristics—their values of the ratios bta/ti (0.88 on average) and B/btaIV (2.72 on average) are situated within of the range of endogenous species—the discovery of this new species associated with ferruginous caves is of extreme importance, given the shortage of studies on such systems in Brazil. As this new species occurs at caves located in 2 municipal districts, its distribution could still be even larger along the iron quadrangle, which makes it a potential model to study the connection of the peculiar underground system associated with ferruginous fields in this region of Brazil.

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