

Eukoenenia florenciae (Arachnida: Palpigradi): Lessons from a newcomer to Central Europe and the island of Tenerife

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Abstract: We report on occurrences of the subcosmopolitan palpigrade *Eukoenenia florenciae* (Rucker, 1903) in a hothouse in Bratislava and in a dry river bed on Tenerife. We redescribe this probably parthenogenetic species, provide information on the thick setae of the coxae and the forked setae on the terminal segment of the first leg, and discuss the significance of these previously disregarded characters for species delimitation and systematics of the Palpigradi.

Key words: Palpigradi; *Eukoenenia florenciae*; redescription; introduced species; first record; Slovakia; Canary Islands; Spain

Introduction

Eukoenenia florenciae (Rucker, 1903) was introduced under the original genus name *Koenenia* by Texan zoologist and later pioneer in pediatrics, Augusta Rucker (1873–1963). Her comprehensive and largely accurate description of the species was based on as many as 182 individuals, which had been collected by Florence Rhine in the soil of a cedar hedge in Bonham, north-eastern Texas. Since the habitat is clearly anthropogenic, the abundant all-female population of the type locality may be due to unintentional introduction. No doubt *E. florenciae* has achieved the widest distribution of any palpigrade species through human agency. Apart from the USA (Texas, Louisiana, Hawaii), the species has been recorded from Colombia, Paraguay, Argentina, Australia, Nepal, and France (Barranco & Harvey 2008). Additionally, Condé (1981) referred all non-Mexican records published as *E. hanseni* (females without exception) to *E. florenciae*: Bermuda, Réunion, Egypt, Morocco, Madagascar, and Mauritius (Harvey 2003), but this needs to be reassessed. Not a single male of *E. florenciae* has been detected so far, whereas the closely related *E. hanseni* (Silvestri, 1913) rests upon a male from Veracruz, Mexico. Another bisexual species of the same complex, *E. chilanga* Montaña, 2012, was recently described from the Mexico City region. In this paper, Montaña-Moreno (2012) also re-described *E. hanseni* as heterospecific to *E. florenciae*. The lack of males in *E. florenciae* may either indicate obligate parthenogenetic reproduction, or ignorance of bisexual (possibly spanandric) populations. Spanandry, i.e. extremely low frequency of males, was considered



Fig. 1. Habitat of *Eukoenenia florenciae* in a greenhouse in Bratislava, Slovakia.

typical of *E. mirabilis* (Grassi and Calandruccio, 1885), before Christian et al. (2010) reported on a population with balanced sex ratio.

Here, we compile the scattered morphological data on this classic palpigrade species (Rucker 1903; Berland 1914; Remy 1948, 1962; Condé 1951, 1981, 1984, 1988) and incorporate new information into a redescription at modern standards. We also call attention to chaetotactic characters which might help uncover relationships within the large genus *Eukoenenia*.

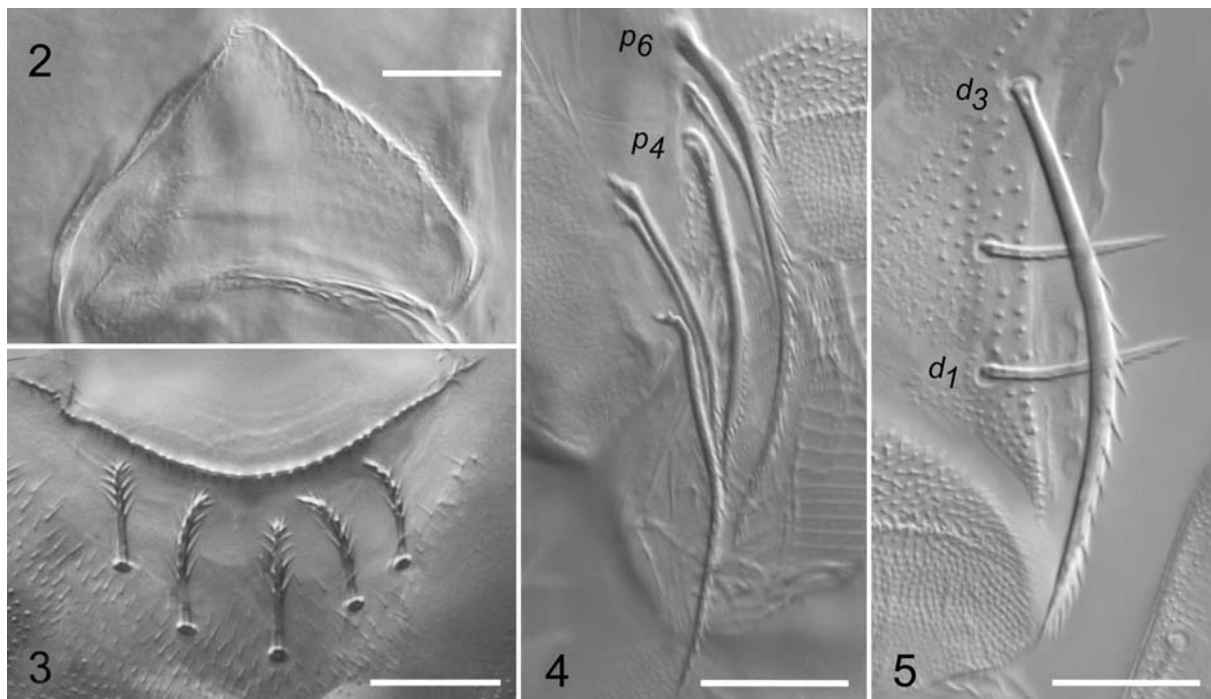
Material and methods

One adult female and one juvenile female (7 June 2012), one adult female (22 Nov. 2012) and one larva (12 Dec. 2012),

Table 1. Morphometry of the adult female of *Eukoenenia florenciae* from Bratislava.

L	1235	I ta3	109	III ti	66	<i>esd</i>	51	Indices	
B	262	I ta2	34	III cx <i>c l</i>	38	<i>desd</i>	54	Ch d_3/d_1	2.63
Prop <i>l</i>	32	I ta1	22	III cx <i>l</i>	118	IV ti	125	G2 x/z	0.44
LatO <i>l</i>	21	I bta4	49	IV ta2	54	Mp <i>t</i> ₁	80	I bta3/a	2.04
Ch <i>p</i> ₆	77	I bta3	53	IV ta1	42	Mp <i>t</i> ₂	69	I bta3/r	1.13
Ch <i>d</i> ₁	30	a	26	IV bta	103	G1 <i>a</i> ₁	18	I bta3/dr	4.08
Ch <i>d</i> ₃	79	<i>r</i>	47	a	23	G1 <i>a</i> ₂	24	I bta3/ti	0.44
P ta3	43	<i>dr</i>	13	<i>r</i>	57	G1 <i>a</i> ₃	28	I bta3/B	0.20
P ta2	38	<i>grt</i>	71	<i>dr</i>	54	G2 <i>x</i>	11	IV bta/a	4.48
P ta1	26	<i>dgrt</i>	10	<i>rt</i>	71	G2 <i>y</i>	30	IV bta/r	1.81
P bta2	58	I bta1+2	85	<i>dgrt</i>	38	G2 <i>z</i>	25	IV bta/dr	1.91
P bta1	43	I ti	121	<i>esp</i>	52/47	St VI <i>a l</i>	50	IV bta/ti	0.82
P ti	126	II ti	66	<i>desp</i>	14	Seg XI <i>l</i>	76	IV bta/B	0.39

Explanations: The terminology of the setae (typeset in italics), if not in line with common usage (e.g., Condé, 1977), is explained in the text. L – body length; B – length of the propeltidium; Prop *l* – longest seta of the propeltidium; LatO *l* – longest blade of the lateral organ; Ch – chelicera; P – pedipalp; I–IV – first to fourth leg; ta – (telo)tarsus; bta – basitarsus; ti – tibia; cx – coxa; III cx *c l* – longest thick seta on the coxa of the third leg; III cx *l* – longest of all setae on the coxa of the third leg; a – width of the basitarsus immediately distal of the insertion of *r*; *dr*, *dgrt*, *desp*, *desd* – distance from the base of the basitarsus to the insertion of the respective seta; Mp – metapeltidium; G1, G2 – first and second genital lobe; St VI *a l* – longest seta *a* on the sixth sternite; Seg XI *l* – longest seta on the eleventh opisthosomal segment. All measurements are given in micrometers.



Figs 2–5. *Eukoenenia florenciae*, adult female: 2 – Contour of the mouth cone, showing the conical upper lip; 3 – Deuto-tritosternum; 4 – Proximal series of setae (p_{1-6}) on the basal segment of the chelicera; 5 – Distal series of setae (d_{1-3}) on the basal segment of the chelicera. Scales 20 μ m.

all leg. J. Christophoryová, were collected from soil samples from the heated greenhouse (about 26°C) in the Botanical Garden of the Comenius University in Bratislava, Slovakia (Fig. 1): 48°08'49" N, 17°04'20" E, 148 m a.s.l., grid reference number of the Databank of Slovak Fauna 7868. One adult female (13 June 2012, leg. N. Szucsich, D. Bartel, M. Resch & G. Timelthaler) was collected in the nearly dry channel of River Tomadero, Barranco del Río, near Punta del Hidalgo, Tenerife, the Canary Islands, Spain: 28°33'59" N, 16°18'26" W, 40 m a.s.l.

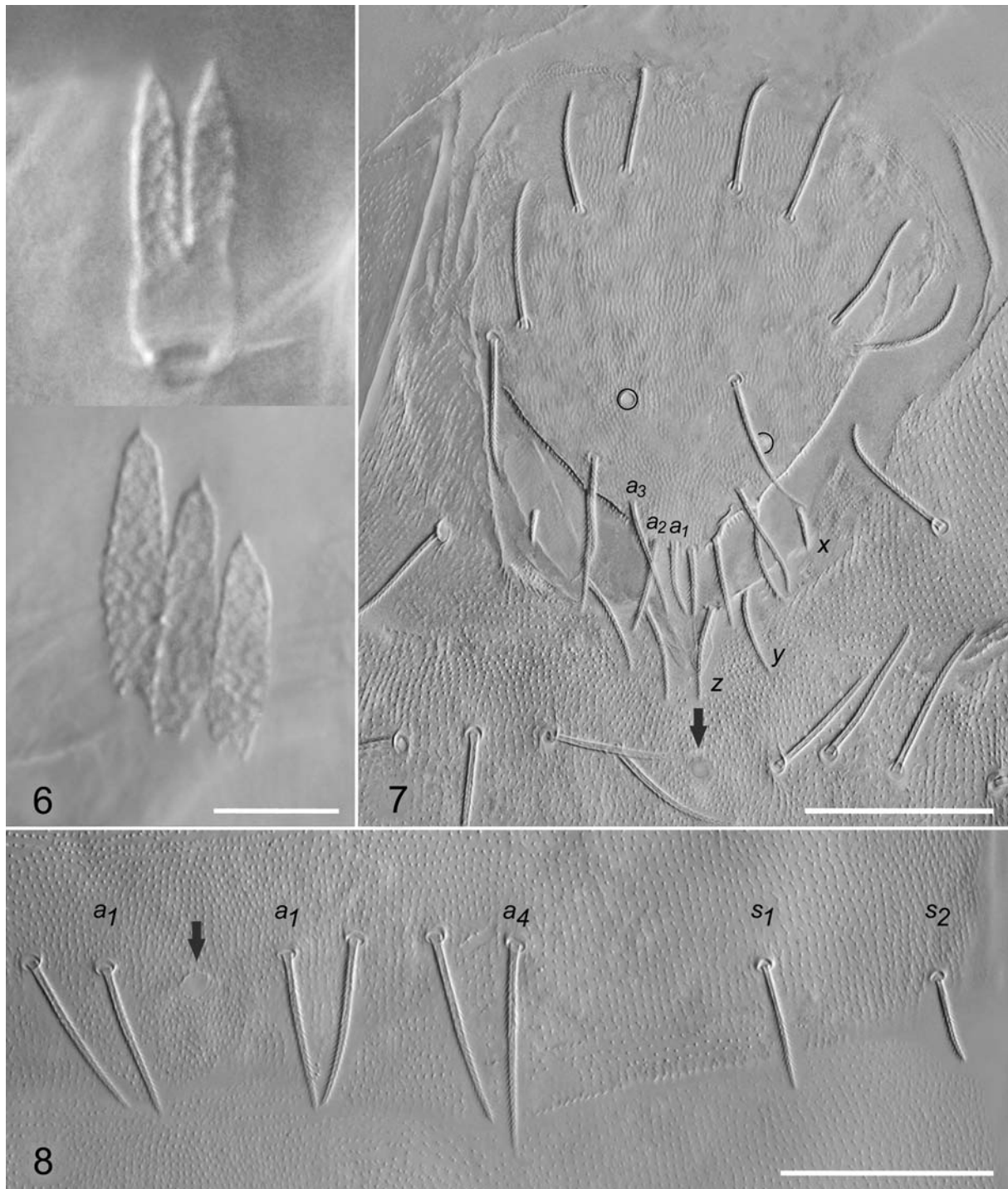
The specimens were fixed and stored in ethanol, cleared in Marc André I, mounted in the water soluble Marc André II medium (Massoud 1967), and studied under a Nikon E 600 microscope with DIC optics and a measuring eyepiece. Photo-micrographs for stacked images (Figs 2–14)

were taken with a Nikon 1 camera and edited with Photoshop CS5. For Fig. 9, the paste-in-place function was used to assemble sharp details from several exposures of the focus series. Setal terminology and abbreviations are explained in the text and in the legend to Table 1.

The Slovak material is deposited in the collection of the second author at the Comenius University; the specimen from Tenerife is held in the collection of the first author.

Results

The adult individuals concur in all characters. Adult measurements in the text and Table 1 refer to the female from Bratislava of 7 June 2012.



Figs 6–8. *Eukoenenia florenciae*, adult female: 6 – Frontal organ (above) and lateral organ (below); 7 – Genital lobes and median portion of sternite IV; the apical setae of the first lobe (a_{1-3}) and the setae of the second lobe (x, y, z) are labelled; circles indicate broken-off setae; 8 – chaetotaxy of sternite V. Arrows indicate the unpaired gland opening. Scales 10 μm (Fig. 6), 50 μm (Figs 7, 8).

Eukoenenia florenciae (Rucker, 1903)

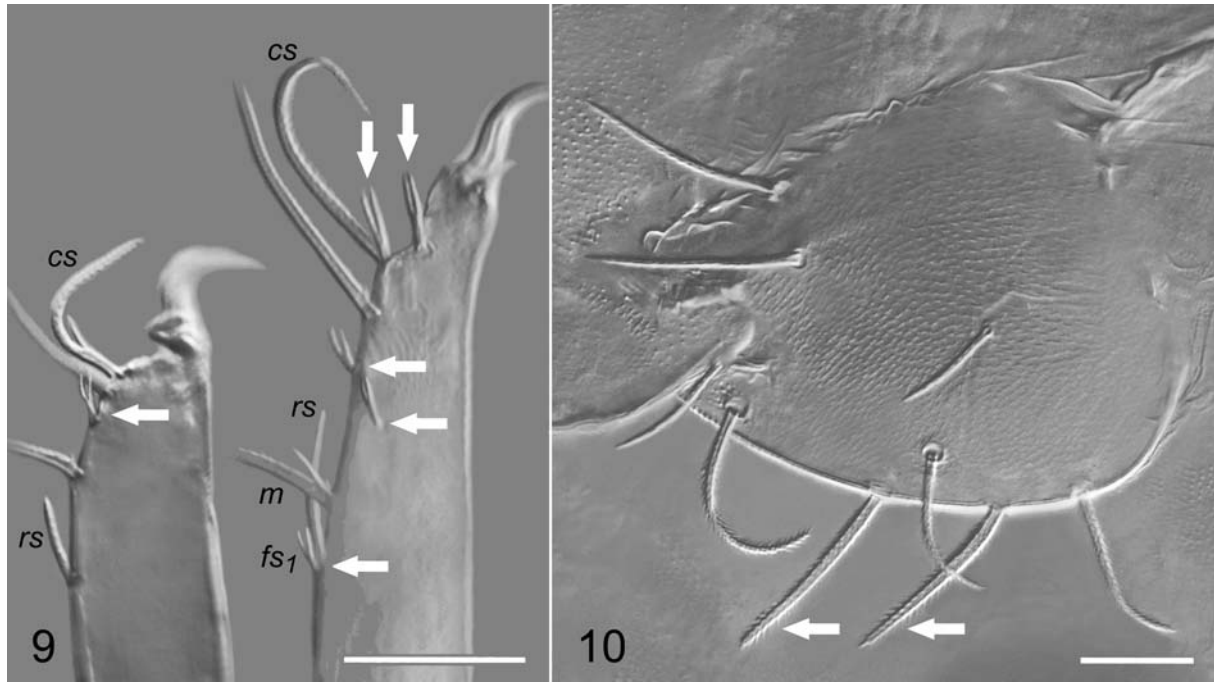
Koenenia florenciae Rucker, 1903: 217–224, Figs 1–7, 8a, 12–15

Koenenia burtoni Berland, 1914: 375–377, Figs 1–8
Extensive bibliography in Harvey (2013)

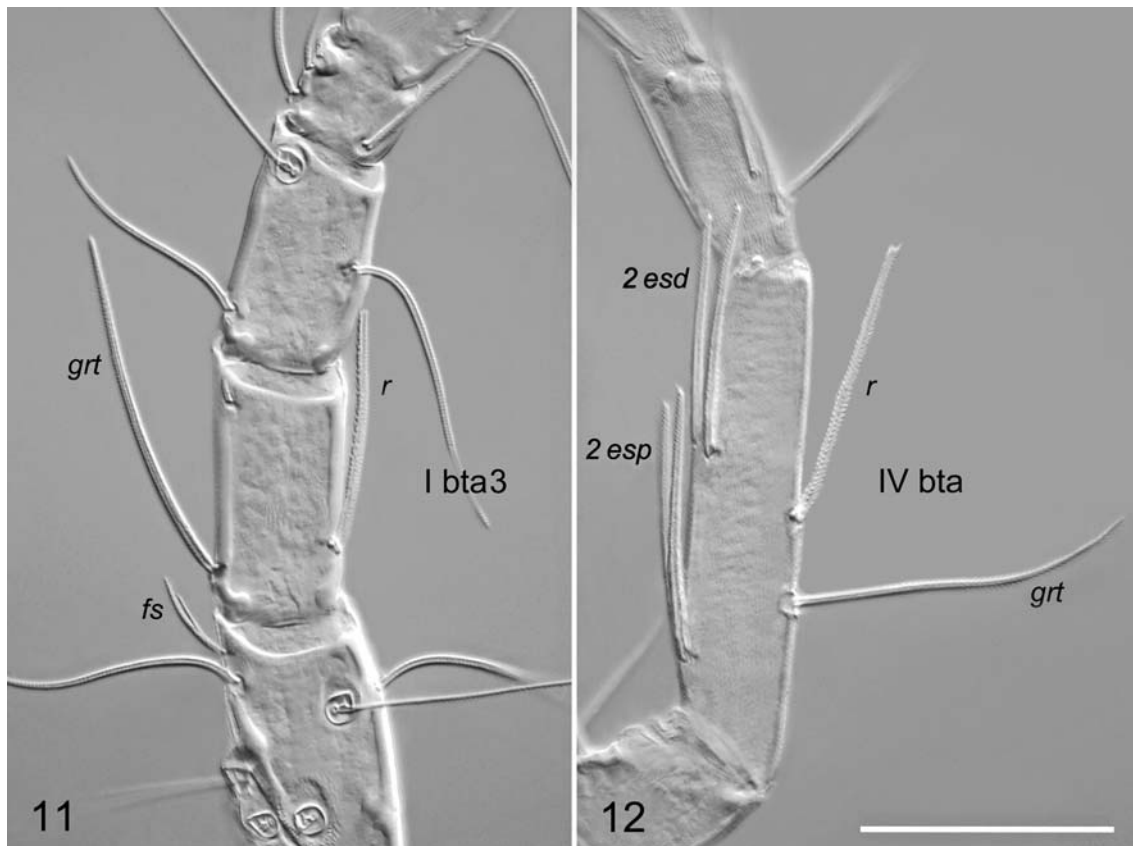
General appearance. Small *Eukoenenia* ($L = 1235 \mu\text{m}$, $B = 262 \mu\text{m}$) of edaphomorphic habitus, with short appendages and a distinct narrowing between the opistho-

somal segments VIII and IX. Pubescence uniformly short and dense.

Prosoma. Frontal organ (Fig. 6) 25 μm long, the two branches (16 μm) slender lanceolate with pointed tips. Lateral organ (Fig. 6) with 3 blades (21 μm), the blades resemble the frontal organ branches in shape and reticulation. Propeltidium with 10+10 setae, the mid-lateral setae much longer than the posterior ones (32:18 μm). Metapeltidium with 2+2 setae ($t_2 = 81$, $t_3 = 70 \mu\text{m}$). Labrum with a conical, antero-dorsal expan-



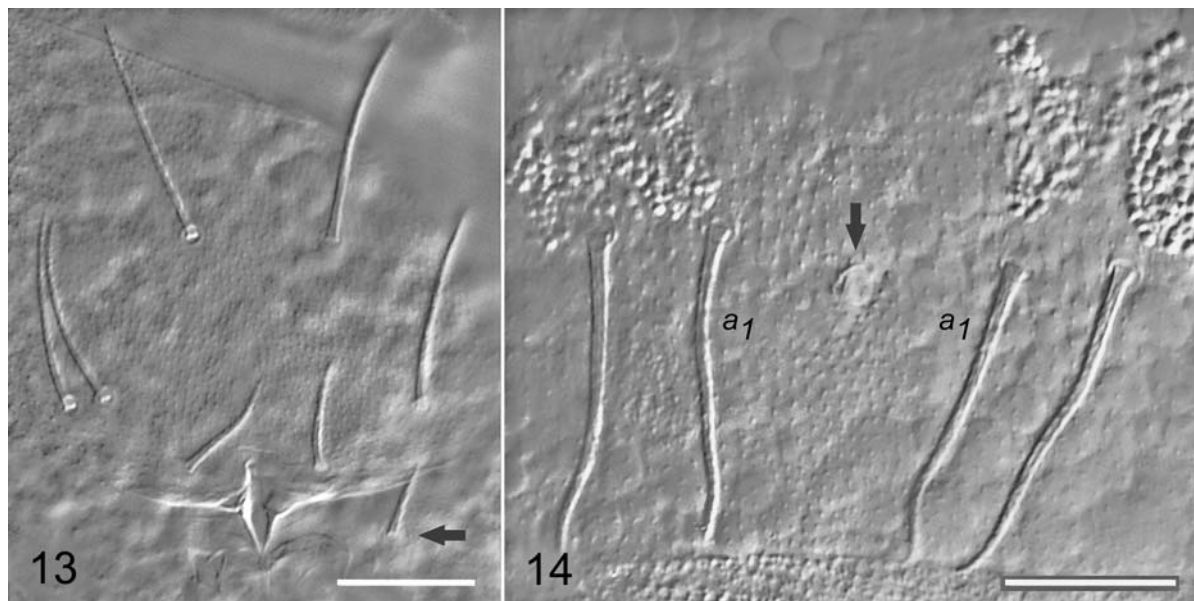
Figs 9, 10. *Eukoenenia florenciae*, adult female: 9 – Distal part of the last tarsal article of pedipalp (left) and leg I (right); arrows – forked setae, *cs* – curved seta, *fs*₁ – proximal forked seta, *m* – macroseta, *rs* – rod seta; 10 – Coxa of leg IV, showing the thick setae (arrows). Scales 20 μ m.



Figs 11,12. *Eukoenenia florenciae*, adult female: 11 – Leg I, chaetotaxy of basitarsus 3; five trichobothria and one forked seta (*fs*) are visible on the adjoining articles; 12 – Leg IV, chaetotaxy of the basitarsus. Scales 50 μ m.

sion (Fig. 2) and 5+5 short setae. Deuto-tritosternum with 5 setae (26 μ m) arranged as a wide V (Fig. 3). Basal segment of the chelicera with a proximal series of

6 setae (setae *p*₄ and *p*₆ thick, Fig. 4), a distal series of 3 aligned setae (*d*₃ = 79 μ m, barbed and strong, 2.6 \times the length of *d*₁, Fig. 5), and 1 apical seta. Hand of the



Figs 13, 14. *Eukoenenia florenciae*, juvenile female: 13 – Genital lobes; the arrowhead points to the single, asymmetric seta of the second lobe; 14 – Median portion of sternite V (setae a_3 outside of the picture frame) with the unpaired median gland opening (arrow) and glandular structures at the bases of the setae a . Scales 20 μm .

chelicera with 1 ventral and 6 dorsal setae, fingers with 8 teeth each. Tarsus 3 of the pedipalp with a rod seta rs (11 μm) and a typical forked seta fs (6 μm); the curved seta cs near the tip is asymmetrically forked and more than 4x the length of fs (Fig. 9, left). Pedipalp coxa with 19 setae, the longest one (58 μm) inserted near the base. Coxa I with 15 setae, the longest one (94 μm) in exterior position at 55% of the segment length. Coxa II with 14 setae: 4 thick (max 37 μm), 10 normal of different length (including 2 macrosetae of 73 and 84 μm). Coxa III with 13 setae: 4 thick (max 38 μm), 9 normal of very different length (including 1 macroseta of 118 μm and a basal microsaeta of 8 μm). Coxa IV with 9 setae: 2 thick (max 37 μm), 7 normal (Fig. 10). The thick coxal setae are arranged along a line, appear more cylindrical than normal setae, and bear a minute, obliquely projecting spine (slightly stronger than the adjacent barbs) at the blunt tip, thus resembling certain setae on other segments of the legs and the a -setae on the sternites. Leg I (Figs 9, 11): bta_3 approx. 2x longer than wide; r shorter than grt , a little shorter than the segment; 7 trichobothria in usual arrangement; 8 forked setae fs : bta_1 , bta_2 (fs in Fig. 11) and ta_2 each have 1 fs , ta_3 has 5 (arranged as 2+2+1: Fig. 9, right). The proximal fs of ta_3 , termed fs_1 , is inserted immediately behind the 16 μm -long rod seta rs which projects beyond the origin of the adjacent macroseta m by half of its length. The basal denticle of m is extended to a conspicuous spine. Leg IV (Fig. 12): bta about 4.5x longer than wide, with 6 setae (grt , r , 2 esp and 2 esd); $grt > r > esp \sim esd$. The seta r reaches beyond the tip of the bta ; it is inserted at 55% and a little more than half as long as the article.

Opisthosoma. Tergite II with t_1 and s on each half, tergites III–VI additionally with t_2 . Sternite III with st_2 and st_3 , IV–VI with a_1 , a_2 , a_3 , a_4 , s_1 and s_2 (Fig. 8). The

distance between the setae a_1 is a little longer than the length of a_1 on sternites IV and V, and a little shorter on VI. Instead of the usual pair of circular (probably glandular) structures between the setae a_1 on the sternites IV–VI, there is a single such structure (arrows in Figs 7 and 8), as first described for *E. hanseni* (?) by Remy (1962); it lies immediately behind the line $a_1 - a_1$ on IV and V, and somewhat more caudal on VI. Segments VII–XI with 15 (11 tergal, 4 sternal), 14, 8, 6, and 8 setae. The flagellum is not preserved in any of the specimens from Bratislava.

Female genital area (Fig. 7). First lobe roughly triangular with rounded basal corners; the free margins form a right angle and are slightly emarginated in front of the pointed tip; with uniform pubescence and 10+10 setae; apical seta a_3 (28 μm , shifted a bit in anterior direction) $> a_2 > a_1$. The two flaps of second lobe with 3 setae each, x being very short. The genital lobes of our females conform to the figures of *Koenenia hanseni* in Remy (1948), Condé (1951) (probably *E. florenciae*), and the figure of *E. hanseni* in Montaña-Moreno (2012).

Juvenile female. Body length 960 μm . Lateral organ with two blades. Labrum with a conical expansion as in the adult and 4+4 setae. Deuto-tritosternum with 3 setae. Fingers of chelicera with 7 teeth. Chaetotaxy of propeltidium and metapeltidium complete. Coxae of the legs with 0–3–3–1 thick setae. Trichobothria as in adult. Number and arrangement of forked setae as in the adult, the macroseta in front of the rod seta on I ta_3 leg has also a long basal spine. IV bta with complete setation. Apart from two asymmetrically missing setae, the genital lobes of our juvenile female (Fig. 13) conform to the correspondent figure of *Koenenia hanseni* (probably *E. florenciae*) in Condé (1951): First lobe with 4+3 setae and a pair of short apical spines; second lobe with 0+1 setae. Tergites IV–VI with 1+1 setae t

between the setae *s*. Sternites IV–VI with a_1 , a_2 , a_3 and s_1 ; the single median gland orifice and the glandular masses associated with the setae *a* are well visible on IV–VI (Fig. 14). Segments IX–XI with 6, 6 and 8 setae.

Larva. Body length not determined (opisthosoma damaged). Lateral organ with one blade. Labrum with a conical expansion as in the later stages and 3+3 setae. Deuto-tritosternum with one seta. Fingers of chelicera with 7 teeth. Chaetotaxy of propeltidium and metapeltidium complete. Coxae of the legs with 0–3–3–0 thick setae. Five trichobothria, those of I bta1 absent. Number and arrangement of forked setae as in the adult, the macroseta in front of the rod seta on I ta3 has the typical basal spine. The setation of IV bta is incomplete, only 2 setae (*r* and 1 *esd*) are developed.

Discussion

Although Condé (1979, 1997) emphasized the undisturbed forest environment at a sampling site of *E. florenciae* in the Siwalik region, southern Nepal, the native range of this species is still unknown. In Central Europe, close to the northern limit of palpi-grade distribution (Kováč et al. 2002), *E. florenciae* appears incapable of establishing populations under the open sky. The occurrence in Bratislava marks the second locality of *E. florenciae* in Europe: One hundred years ago, Berland (1914) has created the name *Koenenia buxtoni* for a *E. florenciae* population (Condé 1981) in the greenhouses of the Paris Natural History Museum. The specimen from Tenerife represents the first outdoor record in Europe (in the political sense) and the first record for Spain (ditto). Only the likewise introduced *E. mirabilis* has been known from the Canary Islands (La Palma, Tenerife, Gran Canaria: Martín & García 2004).

The body length of our adult females (Bratislava 1.24 mm, Tenerife 1.09 mm) lies in the range of *Koenenia buxtoni* from Paris (0.95–1.19 mm: Condé 1981) and *Koenenia hanseni* from Lower Egypt (1.13–1.37 mm: Condé 1951), which are undisputed synonyms of *E. florenciae*. Rucker (1903) reported 2.0–2.3 mm for her Texan specimens. We cannot explain this discrepancy. Soil palpi-grades of 2 mm in length are rather uncommon. In our material the free-living female from Tenerife is even a bit smaller than the females from the greenhouse.

With respect to the morphology of juvenile and adult females, *Eukoenenia florenciae* perfectly matches the diagnosis of the *hanseni-chilanga* group presented by Montano-Moreno (2012). As assessed by this author's data on *E. hanseni* females, *E. florenciae* differs in the chaetotaxy of the opisthosoma: *E. hanseni* has (mostly) 3+3 setae *a* on the sternites IV–VI, whereas our adult females of *E. florenciae* have 4+4, in accordance with all available data from the literature. Morphological resemblance is such that *E. florenciae* doubtlessly forms a group with the two Mexican species. For reasons of priority, and in appreciation of Augusta

Rucker's monograph that substantially exceeds the description of *E. hanseni* by Silvestri (1913), we prefer to term it the *E. florenciae* group.

It is foreseeable that systematization of the palpi-grades will draw upon molecular data, just as species delimitation will probably do. However, the increasing weight of DNA-based taxonomy must not weaken the efforts to explore and exploit morphological characters such as

(1) The number of thick setae on the coxae of the legs. – Information on this character is sparse. Berland (1914), for example, reports on “une rangée régulière de cinq fortes épines égales, un peu courbées” on the coxae (which?) in *K. buxtoni* (= *E. florenciae*), while Condé (1981) ignores this character in his redescription. Our *E. florenciae* specimens have, just as *E. mirabilis*, 4–4–2 thick setae on the coxae II–IV (compare Fig. 10), whereas *E. gallii* has 3–3–2, and *E. gasparoi* 3–3–0 (Christian 2009; Christian et al. 2012). The informative value for arranging species into higher taxa is indicated by the fact that all members of the *E. spelaea* group and related species such as *E. austriaca* carry 4–4–1 thick setae (Christian et al. in prep.). The number of thick setae is easily determined, in contrast to the total number of coxal setae. *E. florenciae* shares the total of 19 (pedipalp)–15–14–13–9 coxal setae with many other palpi-grade species. Likewise common is the presence of two macrosetae of different length on coxa II, and one conspicuous macroseta, accompanied by a tiny microsaeta, on coxa III. The macroseta of coxa III is the longest seta on the body of any *Eukoenenia* we have seen so far.

(2) Number, position and relative length of the forked setae (*fs*) and the rod seta (*rs*) on the last tarsal segment of the foreleg. – Strangely enough, taxonomists have paid little attention to the phaneres of I ta3. This contrasts with the great taxonomic significance of the sensilla and bristles on the likewise sensory prothoracic leg of the Protura, as shown by Condé (1947) and in many subsequent papers. In *E. florenciae*, 5 *fs* (1+2+2 from proximal to distal) and 1 *rs* are inserted as in Fig. 9, right. *Eukoenenia* species may differ in the number of typical *fs*. For instance, *E. gallii* has 4 *fs* (1+1+2), and not 5 as stated in Christian (2009): the seta immediately behind the apical group of 2 *fs* is partly split, but it is much longer and conforms to the curved seta *cs* in our Fig. 9. The “long forked seta” of *E. gasparoi*, depicted in Christian et al. (2012), complies also with the seta *cs* which is completely split in this case; therefore in *E. gasparoi* the formula of typical *fs* is 1+2+2. A strong and partly split seta, commonly observed near the tip of the pedipalp (see our Fig. 9, left), is also a *cs* rather than a typical *fs*. The positions of the proximal forked seta (fs_1), the accompanying rod seta *rs*, and the adjacent macroseta *m* on I ta3 vary a little within *Eukoenenia* populations, whereas the length ratio fs_1/rs is fairly constant within the populations inspected so far. This ratio, however, varies considerably among species and occasionally even between populations (Christian unpubl.), thus providing a tool for alpha taxonomy. In

relation to the proximal *fs*, *E. florenaciae* has a very long *rs* (Fig. 9, right). The basal denticle of the macroseta *m* is generally inconspicuous, but in *E. florenaciae* it is elongated to form a spine. When comparing various *Eukoenenia* species, the *rs* may or may not project beyond the base of the macroseta *m*, the *fs*₁ may be inserted behind or in front of *rs*, and the *fs*₁ may be as long as *rs* or significantly shorter.

Indications that these characters may also prove powerful in palpigrade taxonomy above species level lead us to recommend consideration of the thick coxal setae and the forked setae in new descriptions and revisions.

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