

Slit sense organs of *Comaroma simonii* Bertkau: a morphological atlas (Araneae, Anapidae)

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Summary

Based on scanning electron and compound light microscopy, a morphological atlas of c. 250 slit sense organs (SSOs) of the spider *Comaroma simonii* from Styria, Austria, is presented. The SSOs of the body are single slits and show low variability, except behind the pedicel, where two lyriform organs are situated. On prosomal appendages, single slits and lyriform organs occur. Single SSOs generally show high variation in size, number and position. No two specimens with the same number and position of single SSOs, nor any specimen with the same distribution of SSOs on both sides of the body, could be found. No general pattern of variation is recognizable. This situation could be due to dwarfism of this species, leading to a random reduction of most of an originally much higher number of slit sense organs.

Introduction

The slit sense organs (SSOs) of spiders are mechanoreceptors measuring strains in the cuticle (Barth, 1978). They were discovered by Bertkau (1878) and studied quite intensively by many authors in the following decades (review in Barth, 1967). They are stimulated by a compression perpendicular to the long axis of the slit (Barth, 1972a,b, 1973). The fine structure of slit sensilla is well known (Barth & Deutschländer, 1970; Barth, 1971, 1981), but relatively few data exist about their distribution and arrangement on the body surface of spiders (McIndoo, 1911; Vogel, 1923; Barth & Libera, 1970; Peters & Pfreundt, 1985). The discovery of high variability of these organs in the small anapid spider, *Comaroma simonii* Bertkau, 1889 (body length 1.6 mm), and our lack of knowledge about the distribution of slit sense organs in small spiders, stimulated this study.

Material and methods

Seventeen males and 26 females of *C. simonii* were collected in a Beech (*Fagus sylvatica*) forest in upper Styria (Austria). For compound light microscopy, parts of the bodies of these

individuals were embedded in Hoyer's mixture (Kraus, 1984) or Swan's mixture. Additional specimens (1♂, 1♀) from the same locality were used for SEM studies; the specimens were air-dried or prepared using the critical point method, and coated with gold.

Results

Prosoma

The prosoma bears few SSOs. The carapace, clypeus, labium and the pleurae are free of slit sensilla. Only on the sternum can 3 SSOs be found at each side (Fig. 1). Variation is low: one male showed no anterior SSO on the right hand side, one female had a double slit posteriorly on the left hand side.

Chelicera

Two pairs of SSOs are situated on each side of the insertion point of the fang (Fig. 2). One pair is oriented in the long axis of the basal segment, the other perpendicular to it. A single slit is found on the outer side in a rather consistent position (Fig. 2). On the inner side of the basal segment are 3 single slits oriented in an oblique

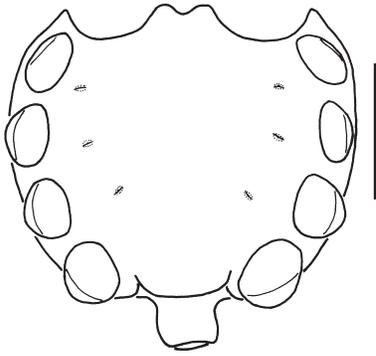
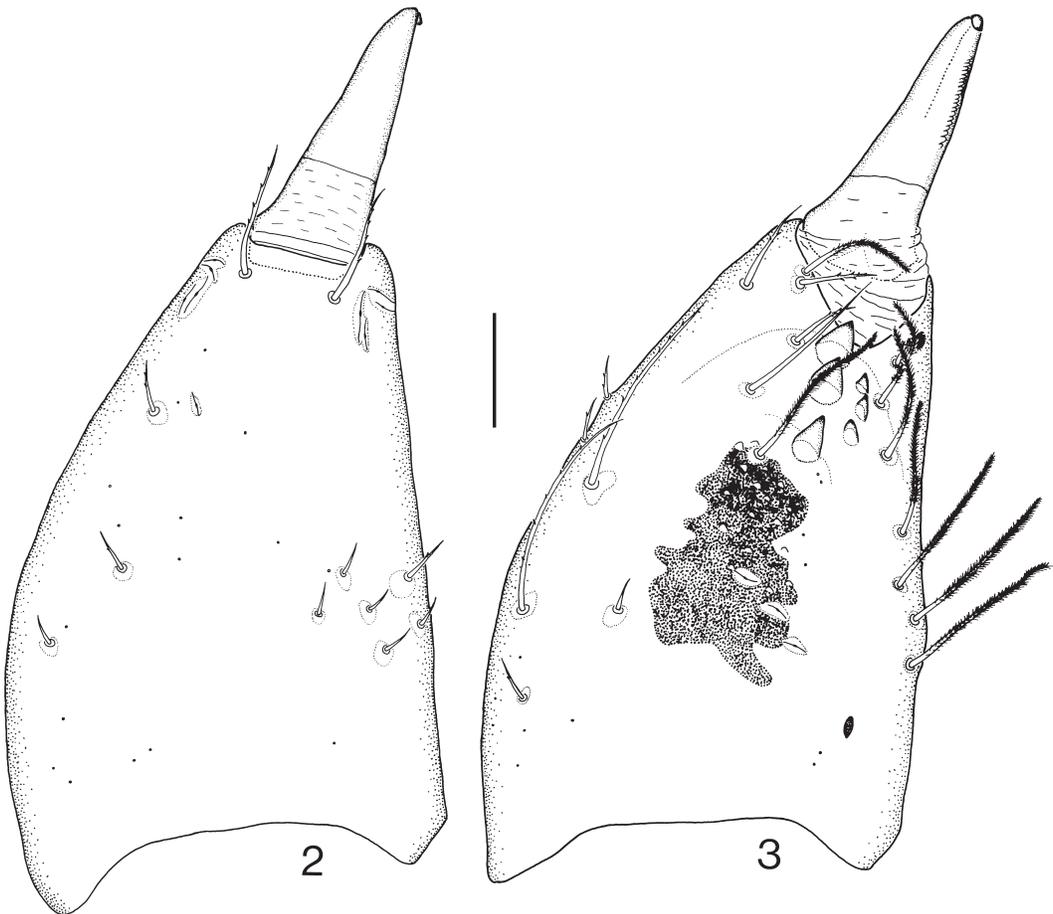
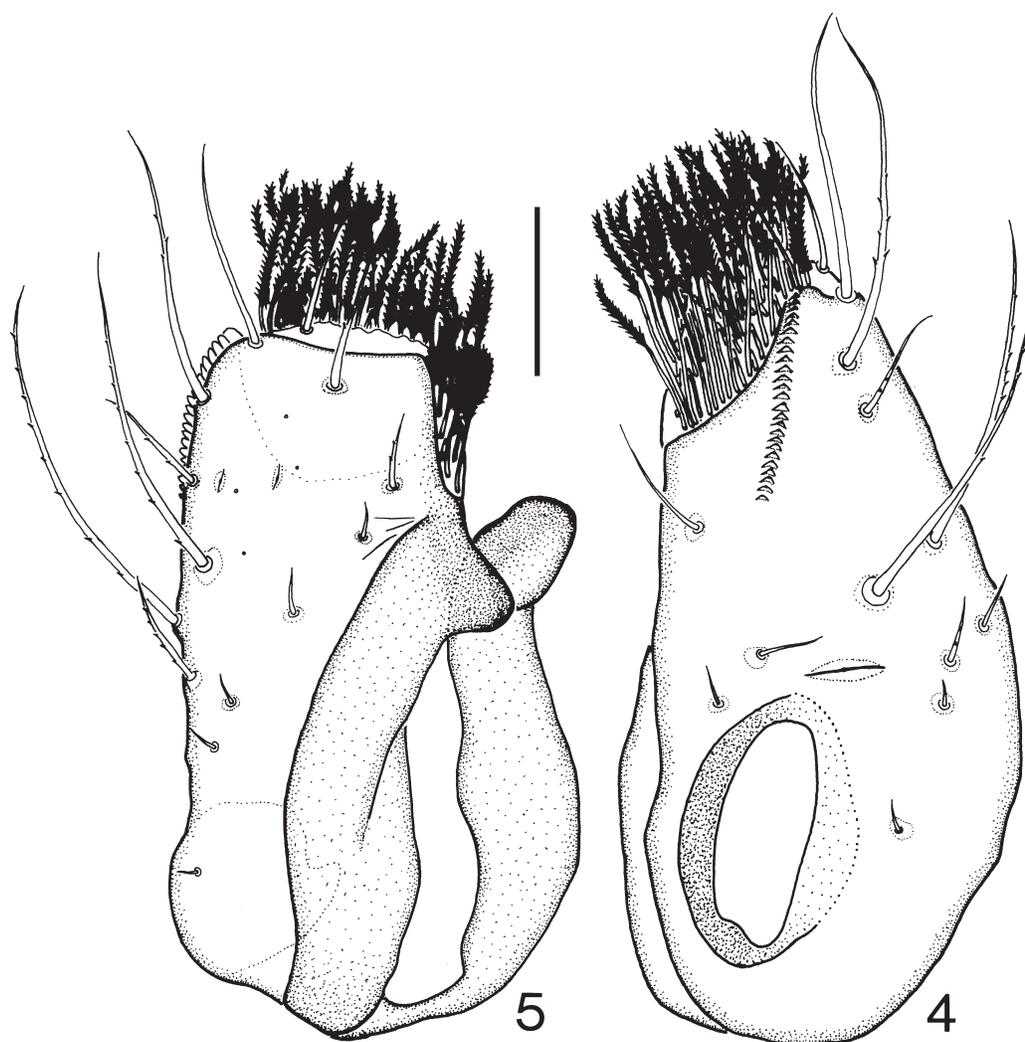


Fig. 1: Sternum, ventral view. Scale line = 0.2 mm

row (Fig. 3), such that the slit situated most distally occupies the most frontal position. Variation: length and inclination of the SSOs that are arranged in pairs vary slightly; the relative positions of the 2 slits forming a pair is highly variable, a “tandem position” even occurred in one female. Three males and one female showed an additional third slit; one female had one pair replaced by a single slit. One male had a slit shaped like the letter Y, and a normal one, together forming the longitudinally oriented pair in a frontal position on both chelicerae. The 3 SSOs at the inner side vary in their position and inclination, one female had only 2 of them.



Figs. 2–3: Chelicera. **2** outer (retrolateral) view; **3** inner (prolateral) view. Scale line = 0.05 mm.



Figs. 4–5: Gnathocoxa. **4** outer (retrolateral) view; **5** rear view. Scale line = 0.05 mm.

Gnathocoxa

The gnathocoxa has only a large single SSO in many specimens. It is situated on the outer (retrolateral) surface beneath the attachment of the trochanter and oriented perpendicular to the long axis of the gnathocoxa (Fig. 4). In addition, 1 or 2 small, single slits can occur on the rear side in the distal half (Fig. 5) in both sexes.

Female pedipalp

SSOs are found on trochanter, femur and patella (Fig. 6). On the trochanter and femur, they are oriented with the long axis of the segment or slightly obliquely to it. The trochanter bears a group of 3 or 4 SSOs retrolaterally; in one specimen, an additional prolateral slit was seen distally.



Fig. 6: Female pedipalp, tibia and tarsus omitted; coxa in back side view, other segments in retrolateral view. Scale line = 0.1 mm.

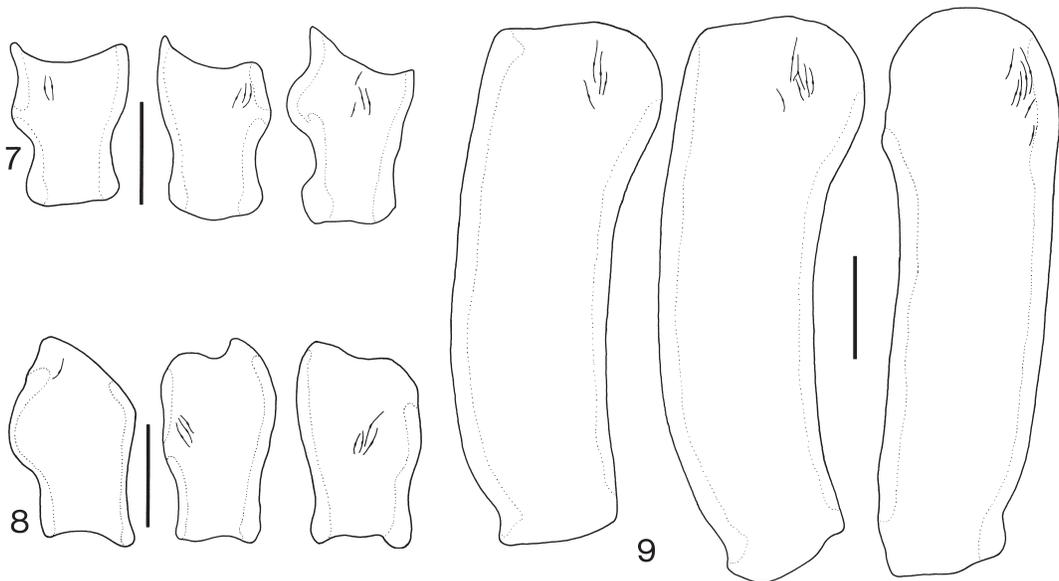
The femur shows 1–3 slits prolaterally and distally close to the patella joint. There are 2 more SSOs situated retrodorsally and most distally in parallel arrangement. They may be of equal length, but generally the more dorsally situated slit is shorter.

The prolateral side of the patella shows 1–3 SSOs. They are situated distally, run in parallel, and are oriented more or less obliquely to the long axis of the patella. One or 2 similar slits are found on the retrolateral side.

Male pedipalp

The SSOs of the male pedipalp are highly variable. No specific “typical” arrangement of SSOs can be detected, but the range of variation can be estimated. Every individual shows a different complement of SSOs on the left and the right palpus. The variation of SSOs exceeds that on the female pedipalp. All slits are more or less arranged in the long axis of the segment or obliquely to it.

The trochanter shows 2–3 (in two cases, 4) slits prolaterally in a distal position (Fig. 7) and 1–4 slits retrolaterally (Fig. 8). The slits also vary in their length and position.



Figs. 7–9: Male pedipalp. **7** trochanters, prolateral view; **8** trochanters, retrolateral view; **9** femora, prolateral view, note the inverted-Y-shaped slit on the central drawing. Scale lines = 0.05 mm.

The femur shows 2 parallel slits in a retro-dorsal position. They vary slightly in length and relative position. In the prolateral–distal region, the femur bears 4–7 SSOs (Fig. 9), 3–5 of them arranged in a group (lyriform organ). The remaining single slits vary in every possible respect. In one specimen, a slit approximating in shape to the letter Y was found.

The SSOs of the patella do not vary. On the prolateral side there are 2 slits in parallel and another slit more dorsally. On the retrolateral side, a single slit is found distally. The tibia has no SSOs, but in one specimen a small slit was found in a prolateral–proximal (!) position. The cymbium normally bears no SSOs, but in some specimens a small single slit can be found at different positions.

Walking legs

All segments of the walking legs bear SSOs; they show high variation, like the male palp. The length, number and arrangement of the slit sensilla are never the same on the left and the right hand side of one specimen. No significant sexual dimorphism was recognizable; however, males tend to have more slits than do females. No significant differences between legs I–IV could be found. All SSOs are oriented more or less longitudinally, with the exception of the metatarsal lyriform organ and 2 single slits distally on the tarsus, which are oriented at right angles to the long axis of the segment.

The ventral sides of all coxae show 1 or 2 slits distally (Fig. 10). At the proximal border of the coxa a tiny groove can sometimes be found, situated close to the pleural membrane; however, it could not be identified as a SSO with certainty. The trochanter bears, on its ventral side, a lyriform organ consisting of 8–9 slits. It is situated on a girdle-like elevation (Fig. 10). There is another group of 4–5 SSOs in retrodistal position which converge distally. Close to this group, 1–3 single slits can be found. On the prolateral side, a single slit can occur distally, but may be lacking.

Femur I bears a group consisting of 4 slits on its prolateral side, femora II–IV one of 3–4 slits (one male had 5 on femur II). In addition, short, single slits can occur prolateral–dorsally (length: 8–14 μm). They are variable in number and position, and, to a lesser degree, in length and inclination. Femora I–III show 0–2 of them,

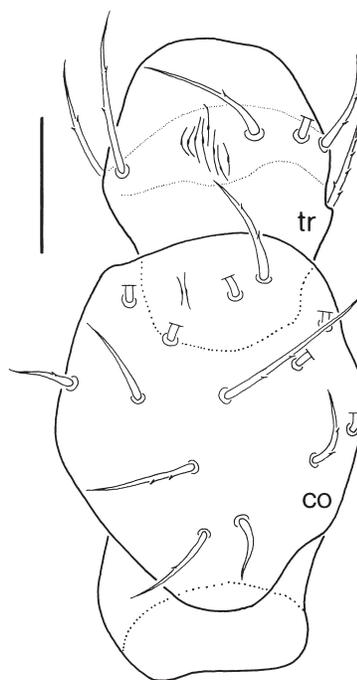


Fig. 10: Walking leg III, coxa and trochanter, ventral view. co = coxa, tr = trochanter. Scale line = 0.05 mm.

femur IV 1–5. Retrolaterally, the cuticle appears slightly invaginated in the most distal area. There, a group of 5 slits is shown (one male has only 4 on femur III). In addition, variable small SSOs, similar to those on the prolateral side, can be seen. Their number varies between 1 and 5; their position is highly variable (Fig. 11).

The patella shows two lyriform organs ventrally, the retrolateral one consisting of 9–10, the prolateral one of 7–8 single slits (Fig. 12). In addition, there is a group of 3–4 SSOs, situated prolaterally in the distal half of the patella.

The tibia shows only few SSOs. Prolaterally, it has a single slit in the most distal part; retrolaterally, a similar one may be present or absent. Situated ventrally of this slit, 2 SSOs are present, sometimes only 1; 3 of them were found in one female on tibia III. On tibia IV, a single small slit can be present retrodorsally between the two retrolateral trichobothria.

The metatarsus shows a single SSO retrodistally, and a similar one ventrally and prolaterally, but both may be lacking. The metatarsal lyriform organ consists of 9–11 slits

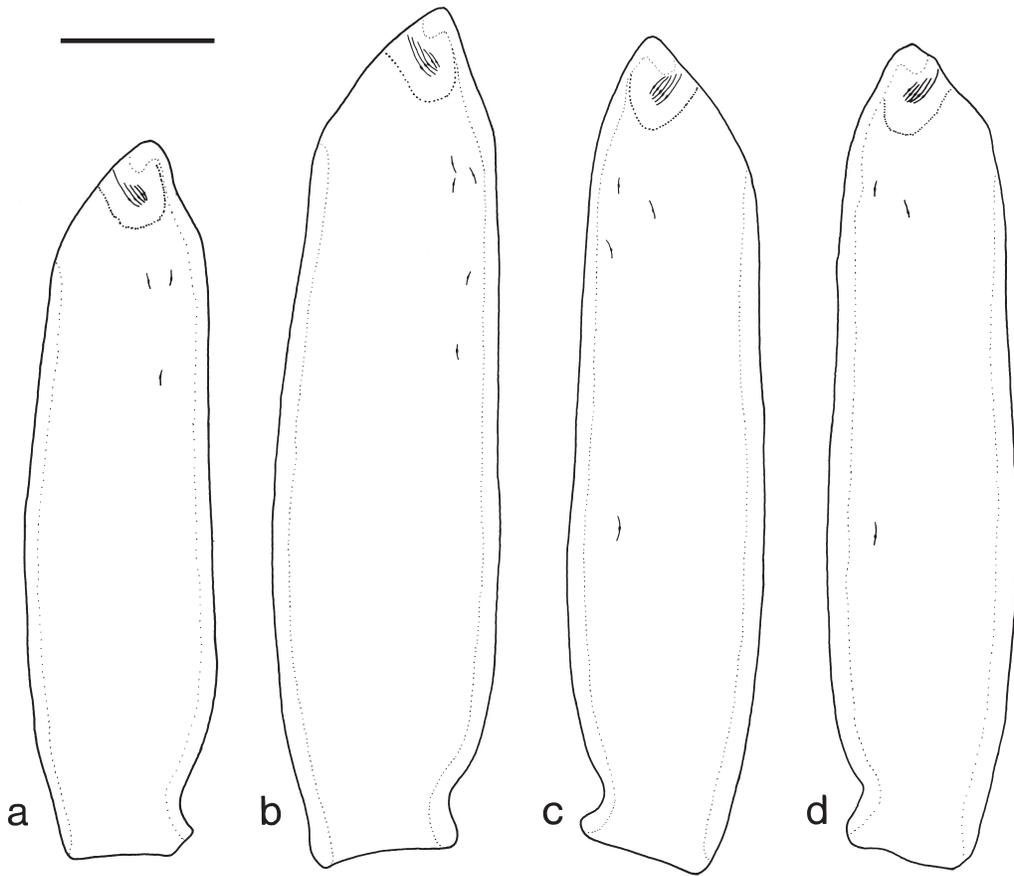


Fig. 11: Walking leg femora, retrolateral view. **a–b** left femora II; **c–d** right femora I. Scale line = 0.1 mm.

(Fig. 13). The tarsus has 2 SSOs ventrodistally and oriented at right angles to the long axis of the tarsus, one situated more prolaterally, the other more retrolaterally (Fig. 14). In addition, small, single slits can occur in variable retro- or prodorsal positions, or be lacking.

Opisthosoma

The pedicel is heavily sclerotized and free of SSOs. However, there are two longitudinal sclerites situated in the arthrodial membrane connecting pedicel and opisthosoma; their anterior ends are bent upwards. Each sclerite shows a row of 4–6 SSOs. They are arranged at right angles to the long axis of the pedicel (Fig. 15).

The opisthosomal cuticle is characterized by longitudinal rows of sclerotized plates. Two

isolated cuticular platelets, each bearing a single, small SSO, occur between the most dorsally and second most dorsally situated row of these plates on each side in females. In males, a large dorsal scutum covers large areas of the opisthosoma. There, small SSOs are situated in positions corresponding to those of the slits in females. In addition, the ventral scutum, present in both sexes, shows 2 small slits in the posterior region. Another small single SSO can occur in the anterior region of the ventral scutum in a variable position. The ring-like scutum surrounding the spinnerets bears 8–10 single slits in variable positions, directed toward the spinnerets. The spinnerets and the anus seem to lack slits; however, tiny grooves, which could not be identified as SSOs with certainty (either by compound light microscopy or by SEM), were observed.

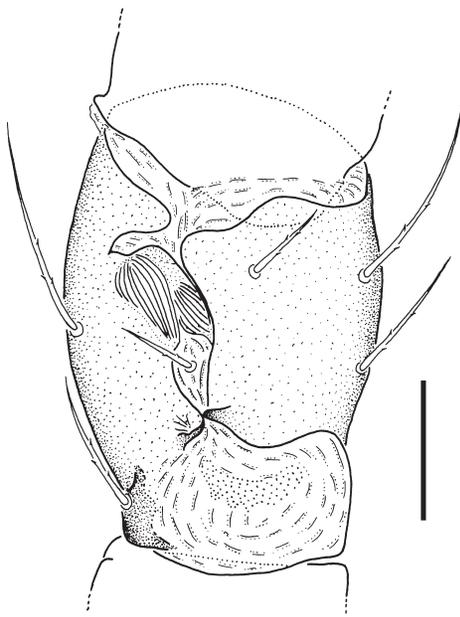


Fig. 12: Patella III, ventral view. Scale line = 0.05 mm.

Discussion

Morphological atlas

Detailed descriptions of the number and arrangement of all slit sense organs on a spider's body were given by Vogel (1923) for the araneid *Larinioides sclopetarius* (Clerck, 1757), and by Barth & Libera (1970) for the ctenid *Cupiennius salei* (Keyserling, 1877). Compared with these large spiders, *Comaroma* has far fewer SSOs (about 3300 in *Cupiennius*, more than 4000 in *Larinioides*, approximately 250 in *Comaroma*). Compared with *Cupiennius* and *Larinioides*, the complete lack of SSOs on the carapace and the labium (probably also on the spinnerets) of *Comaroma* is striking. This reduced number of slit sensilla can be viewed as a consequence of the small body size of *Comaroma*. For example, in both *Larinioides* and *Cupiennius*, 6 groups of large slits and many small slits can be seen on the sternum. In a position corresponding to the 6 groups, *Comaroma* shows only 6 single slits and no additional SSOs. Yet, the arrangement of sternal slit sensilla in *Larinioides* spiderlings (Vogel, 1923: fig. 19) is identical to that in *Comaroma*. Vogel (1923) suggested that the number of single slits corresponds to the

available surface area. Kropf (unpubl.) found a statistically significant sexual dimorphism in leg length in *Comaroma simonii* (all legs of males are longer than the corresponding female legs; t-test after Welch (Lorenz, 1984)). However, the sexual differences in the number of slit sense organs on the walking legs are not statistically significant.

Data on slit sense organs in "dwarf" spiders are extremely fragmentary. Forster (1967) figured a lyriform organ on the tibia of a walking leg of *Novanapis spinipes* (Forster, 1951) (Anapidae), this is neither present in *Comaroma* nor in two species of *Pseudanapis* (Kropf, unpubl.).

Variation of SSOs has been shown, for example, by Barth & Libera (1970) and Peters & Pfreundt (1985). Variation of single SSOs on prosomal appendages in *C. simonii* is high. Specimens with the same number and position of single SSOs or with the same distribution of SSOs on both body sides could not be found. No particular pattern of variation is recognizable. This situation could relate to the dwarfism of this species: a random reduction of most of an originally much higher number of slit sense organs.

Function

Slit sense organs serve different functions (Barth & Libera, 1970; Barth & Bohnenberger, 1978). A working hypothesis on the function of

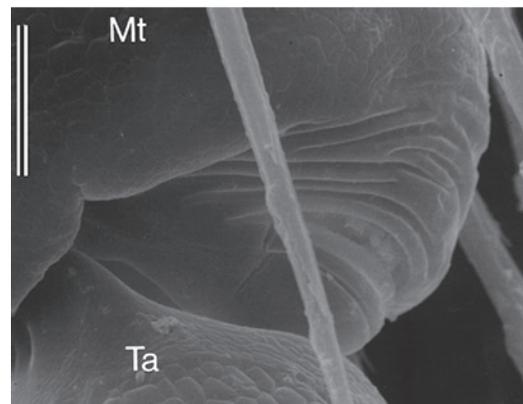


Fig. 13: Scanning electron micrograph of Leg IV, metatarsal lyriform organ, retrolateral view. Mt = metatarsus, Ta = tarsus. Scale line = 0.01 mm.

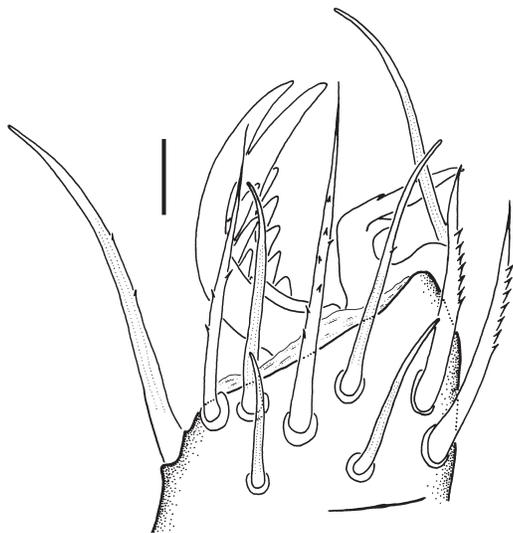


Fig. 14: Tarsus I, tip, retrolateral view. Scale line = 0.01 mm.

the different SSOs in *Comaroma* can be established by an examination of the literature. A tarsal single slit responds to airborne sound in *Cupiennius* (Barth, 1967), the metatarsal lyriform organ and the large single slits at the tarsus tip (both types of organs lying at a right angle to the long axis of the segment!) to different sorts of vibrations (Walcott & Van der Kloot, 1959; Liesenfeld, 1961; Barth, 1981, 1982; Speck & Barth, 1982). The lyriform organs close to the pedicel could detect movements of the opisthosoma relative to the prosoma (Barth & Libera, 1970); lyriform organs on the tibia detect and influence muscle reflexes in the walking legs (Seyfarth, 1978); and those of the femur and tibia play a decisive role in kinesthetic orientation (Barth & Seyfarth, 1971; Seyfarth & Barth, 1972). SSOs on the walking legs and the sternum probably function as receptors for joint movements (Barth & Libera, 1970). Moreover, slit compression can be caused by muscle activity, hydrostatic pressure change, and body weight (Barth & Pickelmann, 1975; Barth & Stagl, 1976; Barth, 1982; Blickhan & Barth, 1985). Finally, it has been shown that SSOs interact in the CNS in a complex manner with the trichobothria (Hergenröder & Barth, 1983a,b).

Blickhan & Barth (1985) showed that different tibial lyriform organs situated close to the

metatarsus joint can be compressed by both muscle (flexor) activity and hemolymph pressure. Regarding the localization of single slits at the lateral surface in the long axis of the leg segments in *Comaroma* (and many other spiders), one could speculate that they cannot be compressed by internal pressure increase, as this would possibly lead to slit dilatation (that does not represent an adequate stimulus, as far as is known (Barth, 1972 a,b, 1973)). If these organs respond to hemolymphic pressure change, they should instead respond to a pressure decrease. As the mechanism for fine regulation of the movements of the tibia–metatarsus and the femur–patella joints (that both lack extensor muscles) is still obscure, it is possible to suggest that this is performed by flexor activity only under a permanently high pressure during activity. Could joint extension in this way lead to a pressure decrease, and could the flexor muscles be functionally characterized as “anti-extensors”?

Acknowledgements

I thank Prof. Dr R. Schuster (Institute of Zoology, Karl-Franzens-University Graz, Austria) for his considerable help and the supervision of my work at Graz, Prof. Dr K. Thaler (Institute of Zoology, University of Innsbruck, Austria) and Dr P. Horak (Thalwinkel, Austria) for their continuous support and fruitful discussions, and an anonymous reviewer for comments on an earlier version of the typescript.

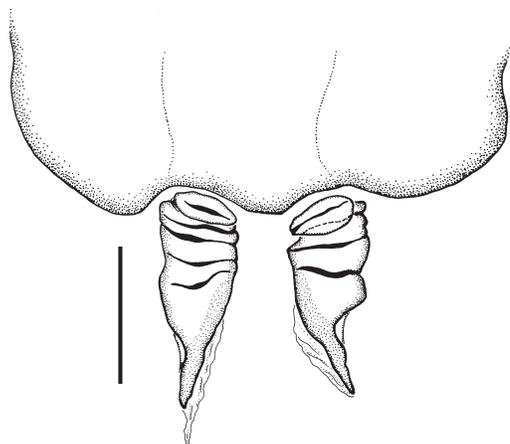


Fig. 15: Posterior end of pedicel, with two sclerites behind, bearing slits, dorsal view. Scale line = 0.03 mm.

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