

Spatulaphorus RACK gen. n. and three new species
of pygmephorid mites associated with scarab
beetles in Botswana and Vietnam
(Acari: Heterostigmata)

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ABSTRACT: A new genus of mite, *Spatulaphorus* RACK gen. n. (Acari: Heterostigmata, Pygmephoridae) and three new species phoretic upon scarab beetles are described. *Spatulaphorus camerikae* sp. n. and *S. foliatus* sp. n. originate from Botswana, *S. langi* sp. n. from Vietnam. *Spatulaphorus* gen. n. is closely related to *Pygmephorellus* CROSS & MOSER, 1971, but differs from all pygmephorids through its peculiar spatulate setae on the femora of legs I. Illustrations of the new taxa including SEM micrographs are provided. Some morphological adaptations of the new genus to phoresy are discussed.

KEYWORDS: Acari (Heterostigmata), phoretic *Spatulaphorus* gen. n., three new species, Botswana, Vietnam.

Introduction

Mites of the family Pygmephoridae (Heterostigmata) are often phoretic upon various arthropods, but are especially frequently taken from beetles, flies and hymenopterans. Ten of the 38 known nominal genera of Pygmephoridae have been found associated with beetles, but only three genera - *Geotrupophorus* MAHUNKA, 1970, *Guttacarus* MAHUNKA, 1973 and *Sasadania* KUROSA, 1989 - were recorded exclusively from these insects. To our knowledge, only one pygmephorid species, *Pseudopygmephorus stercoricola* (BERLESE, 1911) has been reported from scarab beetles. The taxon specified by KRCZAL (1959) as *nomen dubium*, has been recently redescribed by MAHUNKA (1980).

Recently we have studied a collection of pygmephorid mites found on scarabs in Botswana, kindly provided by late Dr. F. S. LUKOSCHUS several years ago and deposited in the Zoologisches Museum, Universität Hamburg. This material turned out to be congeneric with one mite from another scarab beetle originating from Vietnam and collected by J. D. LANG in 1967. All these mites closely resemble the genus *Pygmephorellus* CROSS & MOSER, 1971. However, the analyse of their taxonomic characters has shown that they belong to a new genus, represented in our material by three new species. The taxa are described in the present paper.

Materials and Methods

The paper is based on 237 pygmephorid mites collected from scarab beetles in Botswana and Vietnam, with 236 specimens found in the former and one in the latter country. As far as the African material is concerned, unfortunately it was impossible to reconstruct how many beetles and which parts of their bodies were infested by the mites (K. Camerik, in litt., 1979). The mites were mounted as permanent slide preparations in gum chloral (Berlese's medium) and ringed with varnish several years ago. Observations were carried out using phase- and interference contrast microscopy. Material for SEM observations was recovered from some microslides by the method described in Dastych & Rack (1993). All together 14 specimens were recovered for that purpose. Micrographs were made using the scanning electron microscope CamScan S4.

Setal notation and terminology of structures, with some small modifications, follow Lindquist (1986). The arithmetic mean (\bar{x}) of morphometric data is valid for $n = 30$, unless otherwise indicated. All measurements are in micrometers (μm).

Abbreviations used in micrographs are as follow: *cl* = tibiotarsal claw, *d* = spatulate seta on femur of leg I, *ps*₂ = caudal seta, *pv'* and *pv''* = primiventral setae, *s* = subunguinal seta, *so* = solenidion on tarsus of leg II, ω_1 and ϕ_2 = solenidia on tibiotarsus I. Other abbreviations are explained in text.

Type material is deposited in the Zoological Museum Hamburg (ZMH), in the National Museum of Natural History, Budapest (NMNH), and Canadian National Collection, Ottawa (CNC).

Descriptions of new taxa

Spatulaphorus RACK gen. n.

Diagnosis (Females): Small phoretic mites of the family Pygmephoridae (subfamily Pygmephorinae CROSS, 1965), pale in colour, ranging from whitish to yellowish. There are 3 pairs of dorsal and 3+2 pairs of ventral propodosomal setae. The remaining opisthosomal chaetotaxy of *Pygmephorus*-type. Peritremes round or roundish, with a small stigmal slit. Three pharyngeal pumps. Femoral setae *d* on the first pair of legs (= *FeI d*) uniquely spatulate, i.e. shaped as a flat, elongated structure with a round distal tip. The setae are provided with a tiny asymmetrical tooth. Distal parts of several tarsal setae (chiefly primiventrals) on legs I to III transparent in light microscopy, more or less expanded, flattened and foliose. Genua of legs I to IV with 2, 1, 1, 0 setae, respectively.

Etymology: The name of the new genus is indicative of the presence of distinct spatulated seta *d* on femora of legs I [*spathe* (Gr.) = a blade, *spatha* (L.) = a flat, apically rounded implement; *phorus* (Gr.) = bearing].

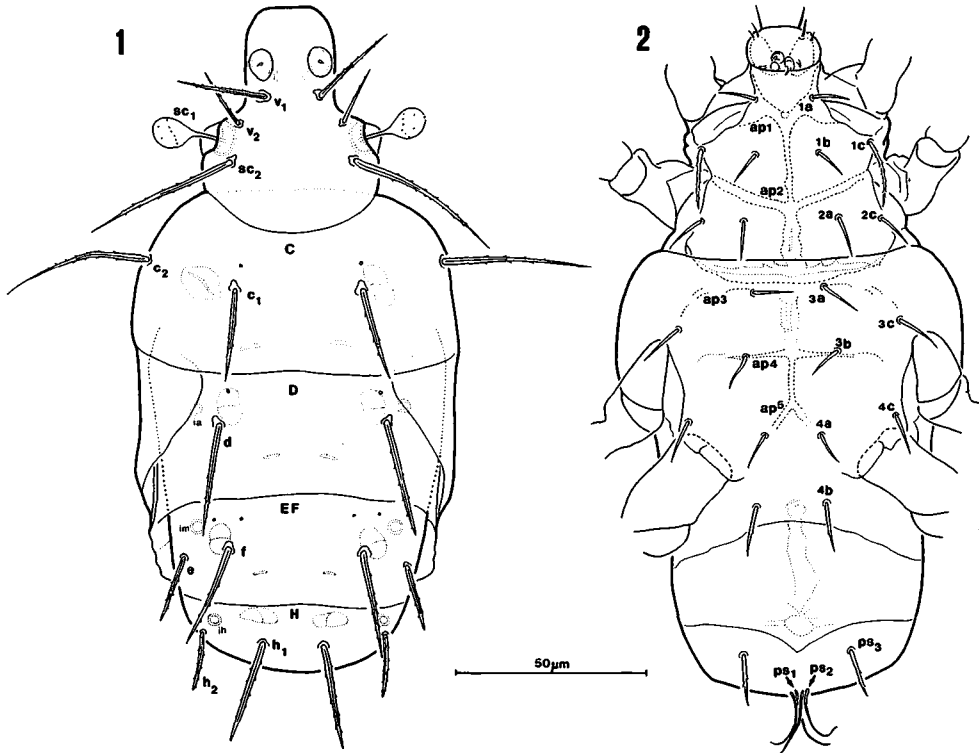
Type species: *Spatulaphorus camerikae* sp. n.

The species list: *S. camerikae* sp. n., *S. langi* sp. n., *S. foliatus* sp. n.

Remarks: The peculiarly shaped seta *FeI d* distinguishes the new genus well from all other pygmephorid genera. The new taxon is similar to the genus *Pygmephorellus* (sensu CROSS 1974) and, in some aspects, to *Elattoma* Mahunka, 1969 (sensu CROSS 1974). *Pygmephorellus* differs from *Spatulaphorus* gen. n. because of its seta *FeI d* which is of *Pygmephorus*-type, i.e. shaped as a short, flat and leaf-like structure (Fig. 7), usually terminated distally with a large, asymmetrical spine. Moreover, genua on legs I to IV in *Pygmephorellus* have different number of setae (4, 2/3, 2, 1, respectively). In the genus *Elattoma*, the seta *FeI d* is of *Bakerdania*-type (hook-like), i.e. has relatively long and straight style and a distinct lateral spine (Fig. 11). However, the general setal formula for legs I to IV is the same as in *Spatulaphorus* gen. n. (= 2, 1, 1, 0). No member of *Pygmephorellus* and *Elattoma* has tarsal setae on legs I to III terminated with expanded, membranous endings, as are some of them in the genus *Spatulaphorus* gen. n.

The phylogenetic relationships within the Pygmephoridae, including the position of *Spatulaphorus* gen. n. are problematic at present, as the entire family badly needs revision. Nevertheless, it can be supposed that the new genus is related to the above two genera, in particular to *Pygmephorellus*, as it shares with the latter similar overall idiosomal chaetotaxy and with *Elattoma* apomorphic reduction of some genual setae. In this respect *Spatulaphorus* gen. n. might have an intermediate position between these genera, i.e. more ancestral *Pygmephorellus* and derived *Elattoma*. On the other hand, the new genus is additionally characterized by its apomorphic, more or less

modified several "foliose" setae on tarsi I to III, roundish peritremes and spatulate setae *Fel d*, i.e. a set of characters indicating its relatively derived rank.



Figs. 1-2. *Spatulaphorus camerikae* sp. n.: 1- dorsal view of female; 2- ventral view of female.

Spatulaphorus camerikae sp. n.
(Figs. 1-6, 8-11, 12-22)

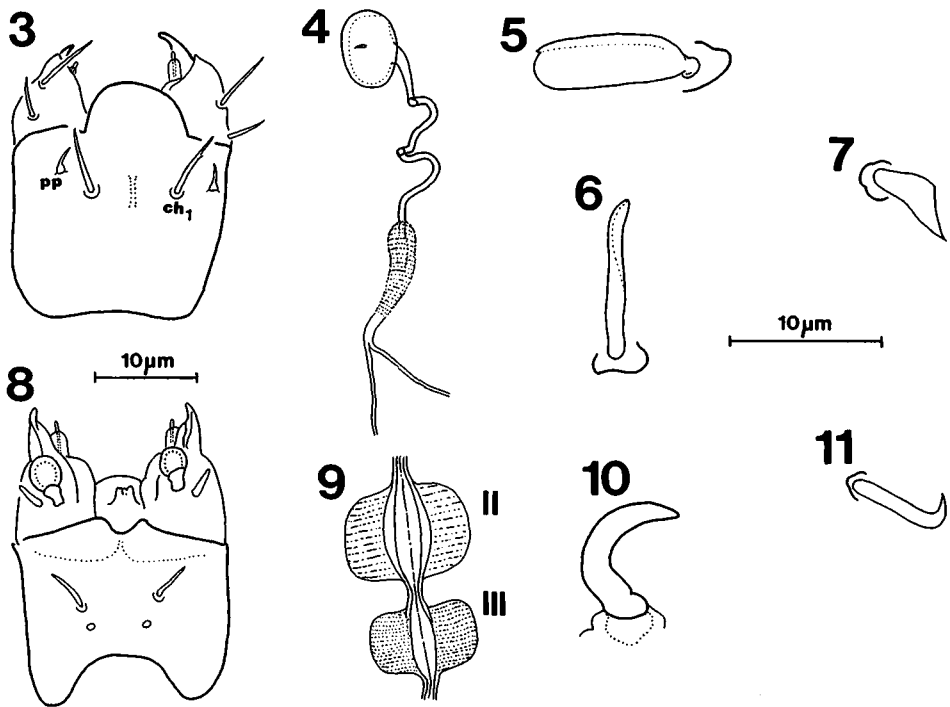
Holotype: Female, 193 µm long, 98 µm wide, ZMH No. A28/92; 21 March 1979, coll. K. CAMERIK.

Type locality: Botswana, Mahalapye, on a specimen of *Catharsius ulysseus* BOHEMAN, 1875 (Coleoptera, Scarabaeidae, Coprinae).

Paratypes: 178 females, locality data as for the holotype. - 174 paratypes deposited in the ZMH No. A28/92, two paratypes in NMNH, and two paratypes in the CNC.

Diagnosis: A median sized species with moderately long, barbed dorsal idiosomal and relatively short ventral setae, most of which are smooth. Hysterosomal setae h_2 about 1/2 of the length of setae h_1 . Distance between setae e and f relatively large. Ventral setae $2a$ and $2c$ of almost equal size. Caudal setae ps_3 displaced on ventral side and slightly shorter than setae ps_1 and ps_2 . Tibiotarsal claw on leg I and its counterpart (= subunguinal seta s) well formed. All tarsal setae on legs II and III more or less setose, i.e. none is shaped as a short, thick spine. Some tarsal setae on legs I to III blunt-tipped, their distal tips more or less transparent in light microscopy.

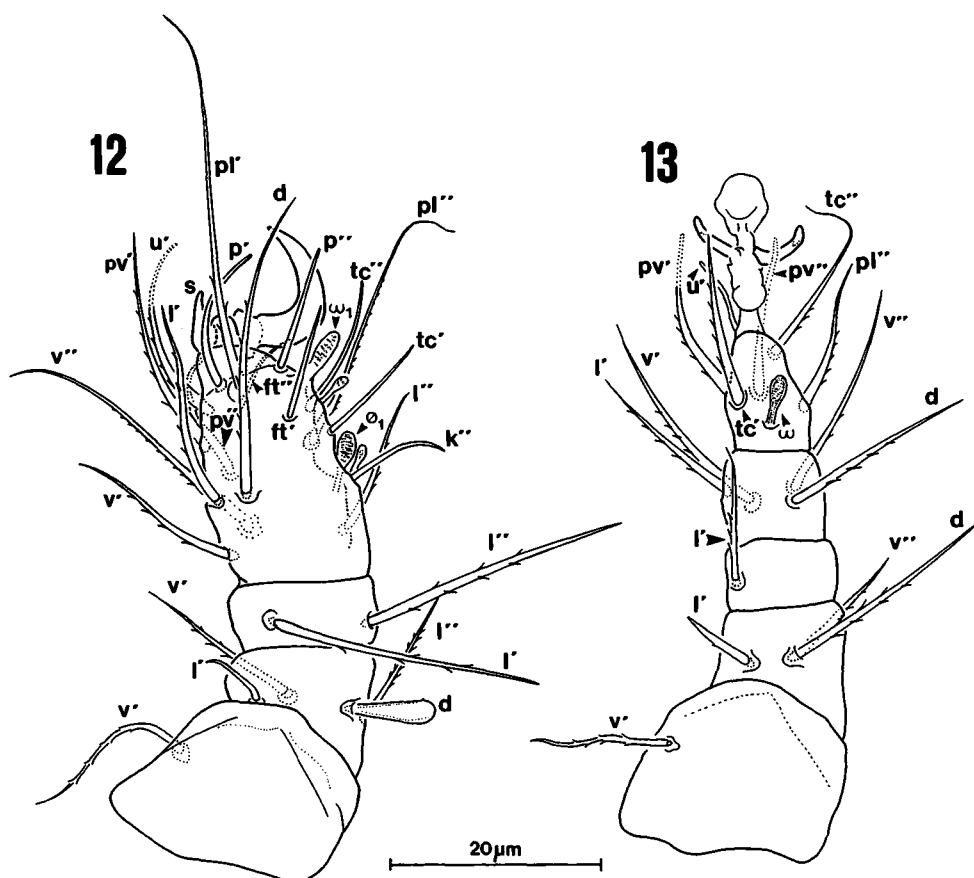
Description of adult female. Body length 159-264 µm (\bar{x} = 185.4), width 81-109 µm (\bar{x} = 94). Idiosoma finely punctuated.



Figs. 3-11. 3-6: *Spatulaphorus camerikae* sp.n.: 3- gnathosoma, dorsal view; 4- peritremal and tracheal system; 5 and 6- seta *Fel d*, dorsal and lateral view, respectively; 7- *Pygmephorus* sp., seta *Fel d*; 8-10: *Spatulaphorus camerikae* sp. n., 8- gnathosoma, ventral view; 9- second and third pharyngeal pump; 10- claw I; 11- *Elattoma* sp., seta *Fel d*.

Gnathosoma (Figs. 3, 8): Gnathosomal capsule more or less quadrangular, ventrally with a deep arch-like incision on posterior edge (Fig. 8). A small dorsomedial apodeme is present. Dorsum with one pair of cheliceral setae (ch_1) which are either smooth or with 1-2 tiny barbs. A pair of blunt-tipped, short and smooth supracoxal setae (pp) located anteriolaterally of the setae ch_1 (Figs. 39, 17). Gnathosomal venter with a pair of short, smooth subcapitular setae (su). Palpi short and terminated with small claw-like structures. Palpal bases wide. Genual setae distinctly longer than femoral setae. Venter of palpal femorogenu with a spheroidal setigenous accessory structure (sas) and short, non-striated solenidion (Fig. 8). The setigenous structure with relatively thick wall, the solenidion shorter than the structure. At the base of the tibiotarsal claw, a minute cylindrical capsule [= palpal tibiotarsal capsule (pts): see DASTYCH & RACK 1993] containing a tiny rod. Chelicerae short and unconspecific. The length of gnathosomal structures in a paratype 260 μm long: $ch_1 = 8$, $pp = 3$, $su = 4$, $sas = 4$, solenidion = 3, $ptc = 2.5 \mu\text{m}$. Femoral setae 3 μm in length, genual setae 7 μm long.

Idiosomal dorsum (Fig. 1). Prodorsal shield with roundish peritremes covered with dome-shaped but slightly flattened membrane. The membrane is provided with a tiny slit (Figs. 1, 4, 22). Peritremal tracheae continue into thicker, striated tube which terminates with two or more tracheoles (Fig. 4). The smallest pharyngeal pump located within gnathosoma, two larger ones within propodosoma (Fig. 9). All dorsal setae barbed, sensilla (sc_1) covered with several tiny teeth (Figs. 1, 16). Length formula for prodorsal setae: $sc_1 > v_1 > v_2$. Cupules ia , im , and ih distinctly formed and located anteriorly at the bases of setae d and h_2 and between setae e and f (Fig. 1). Under the

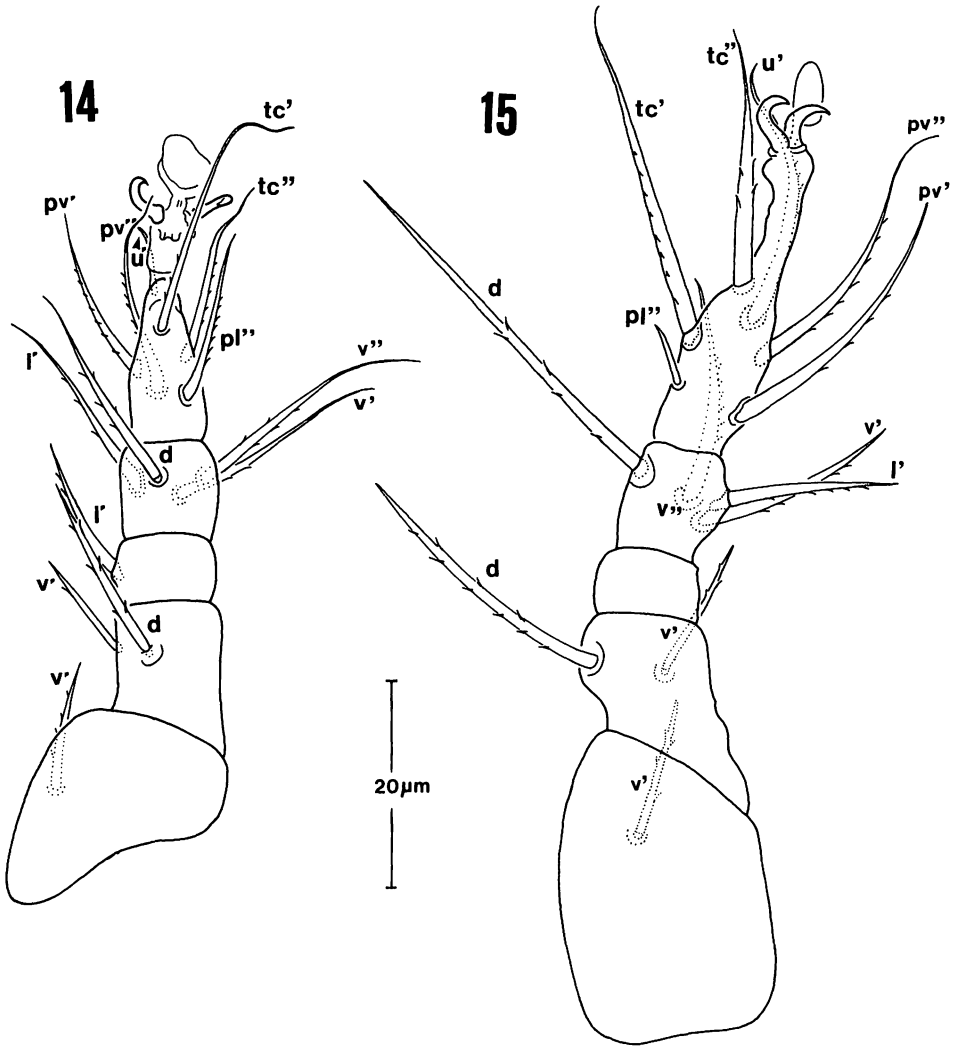


Figs. 12-13. *Spatulaphorus camerikae* sp. n.: 12- leg I; 13- leg II.

cuticle and near the bases of setae c_p , d , f and h_1 distinct, gland(?) like structures with their (?) pores discharging onto the cuticular surface. A pair of such pores also on segment C and D , two pairs on segment EF . Pores were not seen on segment H . However, they may be covered by the telescopic part of segment EF . Medially on dorsum three pairs of segmental apodemes for muscle insertion. Distances between setae e and f relatively large (Fig. 1).

Lengths of dorsal idiosomal setae as follow: setae $v_1 = 20(19-23; \bar{x} = 21.2)$, $v_2 = 13(11-15; \bar{x} = 13.3)$, $sc_1 = 15(15-18; \bar{x} = 15.4)$, $sc_2 = 40(37-46; \bar{x} = 42.0)$, $c_1 = 24(20-29; \bar{x} = 25.0)$, $c_2 = 39(37-42; \bar{x} = 39.4)$, $d = 28(25-30; \bar{x} = 24.9)$, $e = 17(15-21; \bar{x} = 17.9)$, $f = 26(24-31; \bar{x} = 27.7)$, $h_1 = 26(24-31; \bar{x} = 27.4)$, $h_2 = 15(13-18; \bar{x} = 15.9)$. Distances between the setae: $v_1 = (13-18; \bar{x} = 15.6)$, $v_2 = 30(28-32; \bar{x} = 29.7)$, $sc_1 = 39(37-41; \bar{x} = 38.5)$, $sc_2 = 34(33-37; 34.9)$, $c_1 = 34(27-36; \bar{x} = 33.8)$, $c_2 = 80(71-85; \bar{x} = 79.9)$, $d = 46(39-46; \bar{x} = 44.8)$, $e = 61(51-68; \bar{x} = 60.1)$, $f = 37(31-39; \bar{x} = 35.7)$, $h_1 = 17(15-19; \bar{x} = 17.3)$, $h_2 = 52(50-56; \bar{x} = 51.6)$.

Idiosomal venter (Fig. 2): Apodemes (ap) 3 and posterior part of apodemes 5 weakly sclerotized, other apodemes well developed and formed as in Fig. 2. The apodemes 5 and poststernal apodeme, shaped as an inverted "Y". Setae $1c$, $4b$ and ps_3 more or less barbed, the remaining setae smooth. Setae ps_1 and ps_2 thin, long and with slightly flattened lateral edges which are hardly discernible in light microscopy, but



Figs. 14-15. *Spatulaphorus camerikae* sp. n.: 14- leg III; 15- leg I.

well recognizable in SEM (Fig. 18). Other idiosomal setae (except *1c*) short and more or less needle-like. Setae *2b* reduced (absent). Setae *ps*₃ distinctly displaced on ventral side, i.e. they are not located on the posterior edge of idiosoma as are the setae *ps*₁ and *ps*₂ (Fig. 2).

Lengths of ventral idiosomal setae as follow: *1a* = 10(10-12; \bar{x} = 10.6), *1b* = 9(8-10; \bar{x} = 9.1), *1c* = 16(13-17; \bar{x} = 16.1), *2a* = 11(9-12; \bar{x} = 11), *2c* = 11(9-11; \bar{x} = 11.0), *3a* = 11(9 -11; \bar{x} = 10.3), *3b* = 10(9-11; \bar{x} = 9.6), *3c* = 12(11-12; \bar{x} = 12.1), *4a* = 10(9-11; \bar{x} = 10.3), *4b* = 14(13-15; \bar{x} = 14.6), *4c* = 11(9-13; \bar{x} = 11.5), *ps*₁ = 15 (13-17; \bar{x} = 13.3), *ps*₂ = 15(13-17; \bar{x} = 15.2), *ps*₃ = 12(12-14; \bar{x} = 12). Distance between the setae: *1a* = 15 (12-18; \bar{x} = 15.3), *1b* = 18(13-18; \bar{x} = 15.7), *1c* = 45(36-46; \bar{x} = 42.3), *2a* = 22(19-25; \bar{x} = 23), *2c* = 44(36-50; \bar{x} = 44.0), *3a* = 14(14-21; \bar{x} = 16.9), *3b* = 23(19-28; \bar{x} = 24.2), *3c* = 55(54-59; \bar{x} = 54.1), *4a* = 14 (10-17; \bar{x} = 14.2), *4b* = 20(17-22; \bar{x} = 18.5), *4c* = 53(50-57; \bar{x} = 52.6). Distance between caudal setae *ps*₁ = 1.1, between *ps*₁ and *ps*₂ = 1.1, between *ps*₂ and *ps*₃ = 13(12-14; \bar{x} = 13.4).

Legs (Figs. 12-15): The length of legs increases posteriorly. The first pair of legs distinctly wider than legs II to IV. Tibiotarsus I (*TiTa*) with well formed claw which is smooth in light microscopy and delicately ribbed in SEM (Figs. 12 and 19, 20). A distinct counterpart (= subunguinal seta *s*) located opposite to the claw base. Claws on legs II to IV relatively small, of similar size, smooth and simple, i.e. without thickened bases. Empodia moderately sized and smooth. Empodial stalks short.

Leg I (Figs. 12, 16, 19, 20, 21): Setal formula for each joint: *Tr*(1), *Fe*(4), *Ge*(2), *TiTa*(18 + 4 solenidia: $\omega_1, \omega_2, \phi_1, \phi_2$). Tibiotarsus slightly elongated, not wider than the genu. Claw sickle-shaped, distinct (Figs. 12, 19, 20). Counterpart relatively long and with distinctly widened base (Figs. 12, 19, 20). Seta *FeId* elongated and characteristic spatula-shaped, with a tiny asymmetrical tooth on its distal edge (Figs. 5, 6, 12, 21). Setae *pv''* and *u'* with distal parts slightly expanded and blunt-tipped. The endings more transparent than the rest of the seta, thus poorly visible in a transmitted light (Fig. 12; see also Fig. 19). Tarsal eupathidia (*p', p'', tc', tc'', ft', ft''*) and tibial eupathidium *k'* smooth. Other tibiotarsal setae more or less barbed, except setae *FeI l'* which are short, smooth and slightly bent at their tip. Genual setae *GeI v'* and *GeI v''* lacking. Solenidia ω_1 and ϕ of same size and thicker and longer than solenidia ω_2 and ϕ_2 . The length of the solenidia in a paratype 260 μm long: ω_1 and $\phi = 7 \mu\text{m}$, ω_2 and $\phi_2 = 6 \mu\text{m}$. Internal tibiotarsal thickening poorly formed.

Leg II (Figs. 13, 16): Setal formula: *Tr*(1), *Fe*(3), *Ge*(1), *Ti*(4), *Ta*(6 + solenidion ω). Unguinal seta *u''* absent. All setae, except seta *u'* barbed. Primiventral setae *pv'* and *pv''* blunt-tipped, their distal units more transparent than the proximal ones (Fig. 13). Tarsal solenidion ω well formed, tibial solenidion ϕ lacking.

Leg III (Fig. 14). Setal formula: *Tr*(1), *Fe*(2), *Ge*(1), *Ti*(4), *Ta*(6). Unguinal seta *u''* absent. All setae (except seta *u'*) more or less barbed. Primiventral seta *pv''* and tectal seta *tc''* with distal tips slightly blunted and membranous, compared with other tarsal setae. This character, hardly discernible, however, when the tips are seen laterally. Tarsal and tibial solenidion absent.

Leg IV (Fig. 15). Setal formula: *Tr*(1), *Fe*(2), *Ge*(0), *Ti*(4), *Fe*(6). Unguinal seta *u''* absent. All setae barbed, except *TaIV pl''*, shaped as a small, smooth spine. Tarsal and tibial solenidion absent.

Males and immatures unknown.

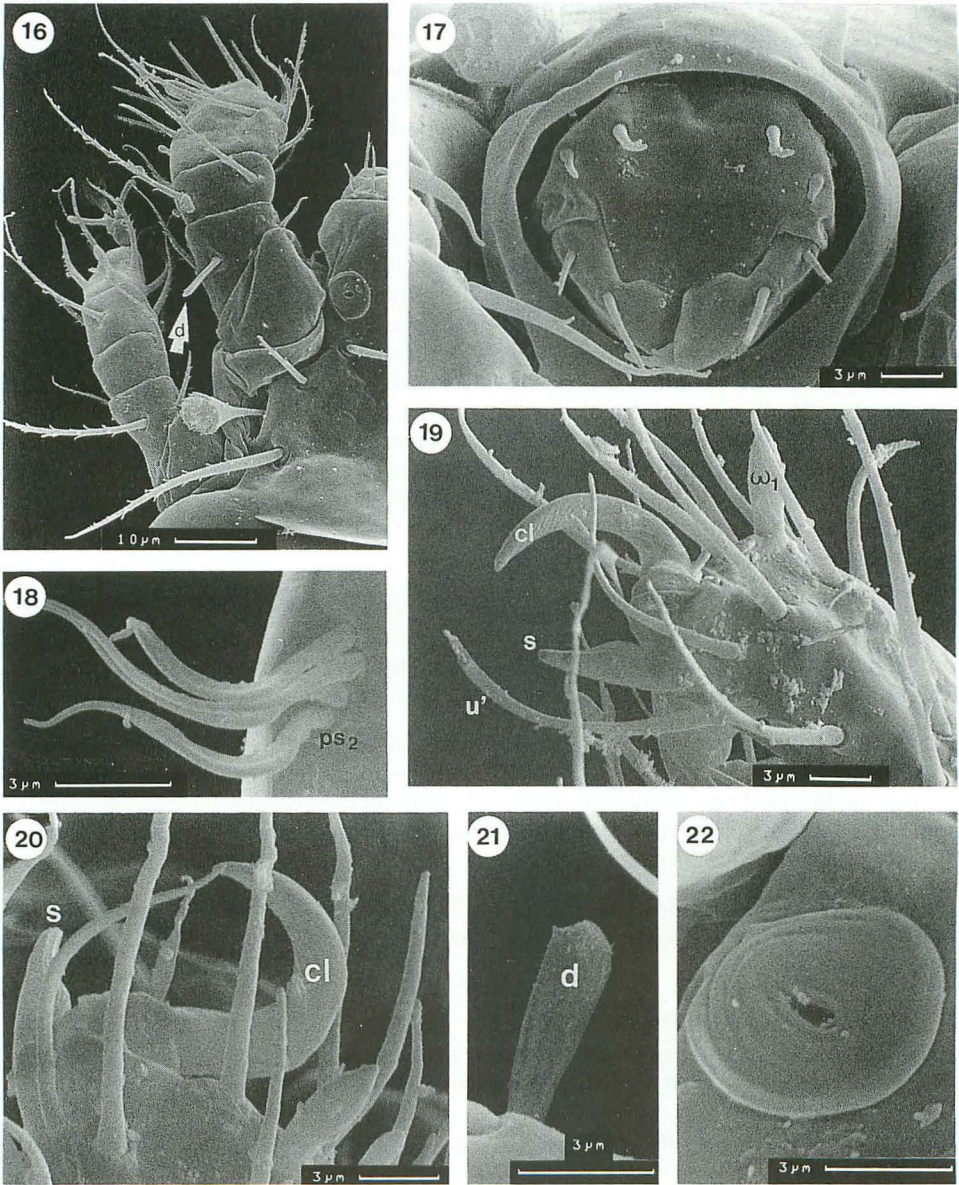
Etymology: The species is named in honour of Sister KARIN CAMERIK, MSc. (Zoological Department, The Witwatersrand University, Johannesburg, South Africa), who collected the material.

Remarks: Taxonomic differences between *S. camerikae* sp. n. and two other new species of *Spatulaphorus* gen. n. are discussed at the descriptions of the remaining taxa. The differences are also summarized in the identification key provided for the genus (see "Discussion").

Spatulaphorus langi sp. n.
(Figs. 23-28)

Holotype: Female, 185 μm long, 98 μm wide, ZMH No. A108/86; 18 September 1967, coll. J. D. LANG..

Type locality: Southern Vietnam, Lai Khe (about 50 km NE of Ho Chi Minh City: see Lang 1978). From elytra of *Catharsius* sp. (male) (Scarabaeidae).



Figs. 16-22. *Spatulaphorus camerikae* sp. n.: 16- fragment of prodorsal shield and the legs I and II; 17- gnathosoma, dorso-frontal view; 18- caudal setae ps_1 and ps_2 , ventral view; 19, 20- fragment of tibiotarsus; 21- seta *Fel d*; 22- peritreme with stigma.

Diagnosis: Median sized species with moderately long dorsal idiosomal and relatively short ventral setae. Hysterosomal setae h_2 about 1/3 of the length of setae h_1 . Distance between setae e and f small (Fig. 23). Ventral setae $2c$ about 50% of the length of setae $2a$. Caudal setae ps_3 located on the posterior edge of idiosoma and distinctly longer than the setae ps_1 and ps_2 . Tibiotarsal claw and its counterpart well formed. Tarsal setae *TaII tc'* and *TaIII pv'* as short, thick spines. Several tarsal setae (*TiTa pv'*, pv'' , u' , *TaII pv'*,

pv'', *TaIII pv''*, *tc''*) apically expanded, flattened and blunt-tipped. The endings more transparent in a transmitted light than the remaining part of the seta.

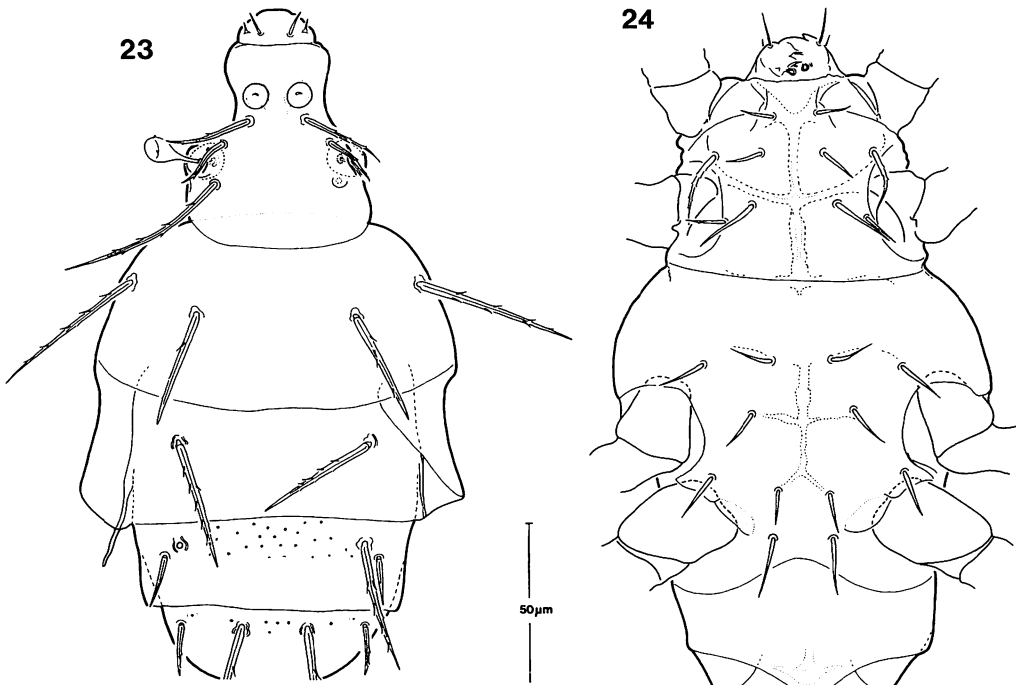
Description of adult female: Idiosoma finely punctuated, dorsum of segments *EF* and *H* with small, roundish cavities about 1 μm in diameter (Fig. 23).

Gnathosoma (Figs. 23, 24): Tagma shaped as in *S. camerikae* sp. n. Dorsum with one pair of cheliceral setae (*ch*₁) and a pair of short, blunt-tipped supracoxal setae (*pp*). Femoral setae 3 μm in length, genual setae 10 μm . Setigenous accessory structure formed similarly as that in *S. camerikae* sp. n. Other structures indiscernible due to orthognathous position of the gnathosomal capsule.

Idiosomal dorsum (Fig. 23): Prodorsal shield with round peritremes. All idiosomal setae more or less barbed, except setae *e*. Length formula for prodorsal setae: $sc_2 > v_1 > v_2$. Cupules *ih* just discernible, other cupules invisible. Seta *f* located anteriomedially of seta *e*, distance between them small.

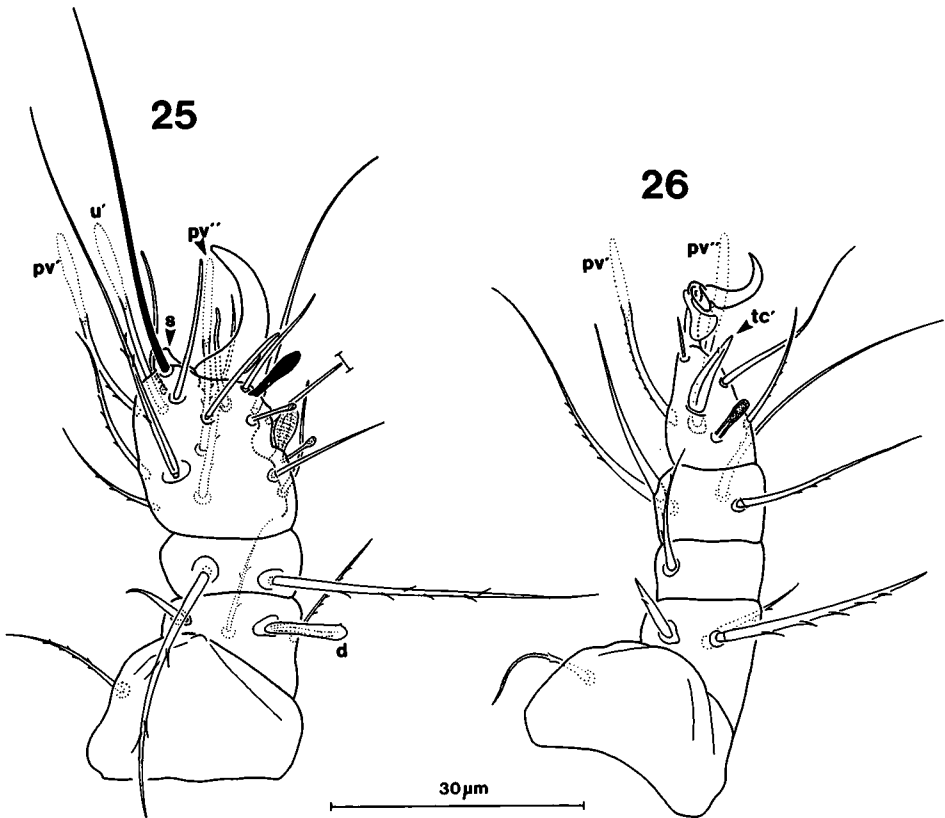
Lengths of dorsal idiosomal setae as follow: $v_1 = 24$, $v_2 = 15$, $sc_1 = 17$, $sc_2 = 53$, $c_1 = 33$, $c_2 = 47$, $d = 37$, $e = 13$, $f = 36$, $h_1 = 32$, $h_2 = 12$. Distances between the setae: $v_1 = 17$, $v_2 = 30$, $sc_1 = 41$, $sc_2 = 35$, $c_1 = 45$, $c_2 = 78$, $d = 52$, $e = 59$, $f = 51$, $h_1 = 19$, $h_2 = 50$.

Idiosomal venter (Fig. 24): Sejugal apodeme and apodeme 3 to 5 poorly sclerotized, apodemes 3 almost indiscernible. The apodemes 5 and poststernal apodeme inversely Y-shaped. Setae *1c* and *ps*₃ barbed, other setae smooth. Seta *2c* about 50% shorter than *2a*. Caudal setae *ps*₁ and *ps*₂ needle-like, distance between the setae *ps*₁ distinctly greater than between *ps*₁ and *ps*₂.



Figs. 23-24. *Spatulaphorus langi* sp. n.: 23- dorsal view of female; 24- ventral view of female

Lengths of ventral idiosomal setae as follow: $1a = 10$, $1b = 11$, $1c = 22$, $2a = 19$, $2c = 11$, $3a = 12$, $3b = 13$, $3c = 13$, $4a = 12$, $4b = 17$, $4c = 14$, $ps_1 = 9$, $ps_2 = 10$, $ps_3 = 15$. Distance between the setae: $1a = 12$, $1b = 18$, $1c = 45$, $2a = 24$, $2c = 40$, $3a = 15$, $3b = 28$, $3c = 52$, $4a = 14$, $4b = 18$, $4c = 51$. Distance between caudal setae $ps_1 = 4$, ps_1 and $ps_2 = 1$, $ps_2 - ps_3 = 10$.



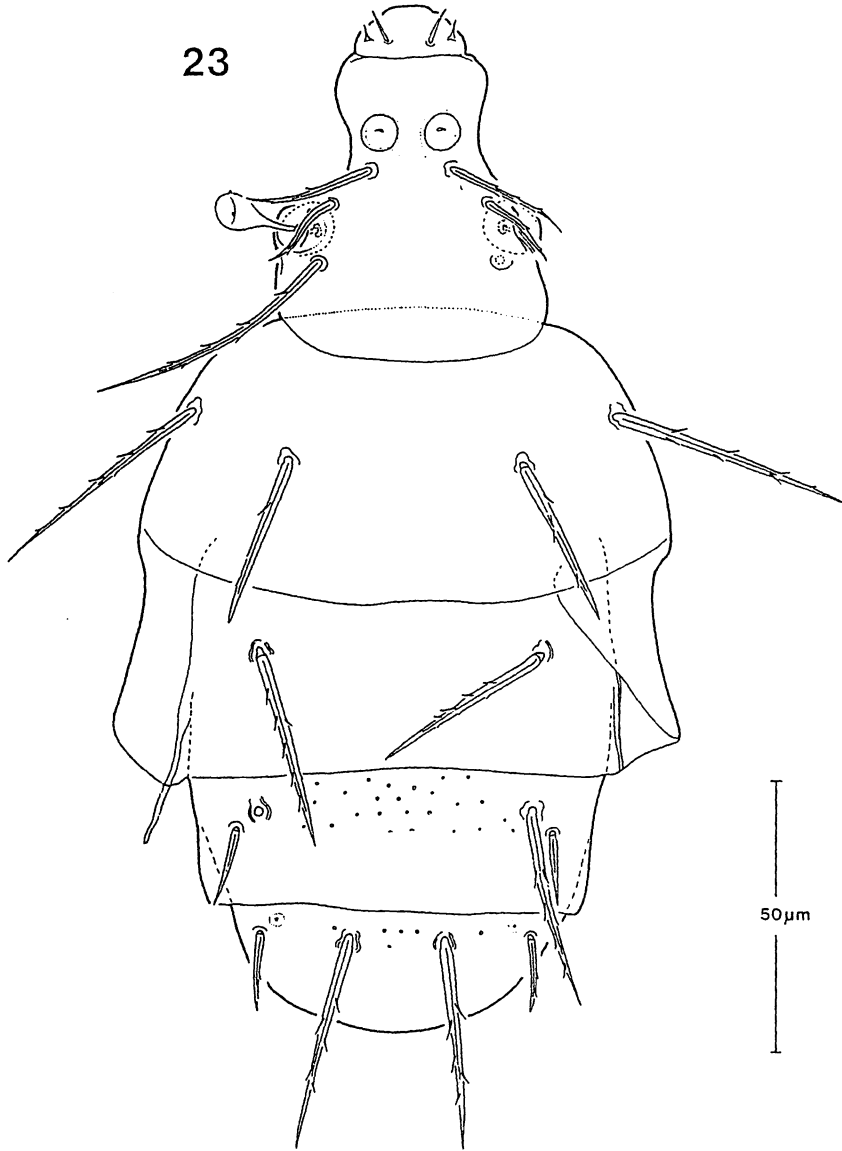
Figs. 25-26. *Spatulaphorus langi* sp. n.: 25- leg I; 26- leg II.

Legs (Figs. 25-28): The length of the legs increases posteriorly. Claws II to IV, empodia and empodial stalks similarly shaped to those of *S. camerikae* sp. n. Setal formula for each leg as in the latter species.

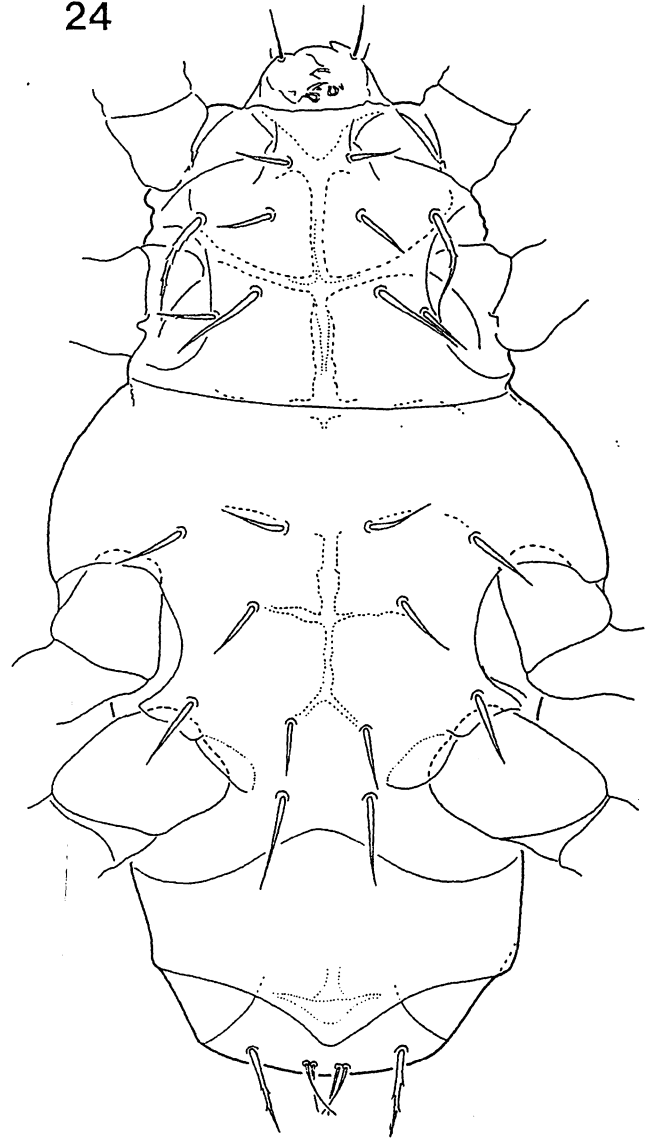
Leg I (Fig. 25): Tibiotarsus relatively short and with distinct smooth claw, as seen in transmitted light. Counterpart moderately sized and with wide base. Seta *Fel d* spatulate. Primiventral setae pv' , pv'' and unguinal seta u' apically expanded, flattened, blunt-tipped and in transmitted light more transparent than the basal parts of the setae (Fig. 25). Tarsal eupathidia and tibial eupathidium k'' smooth, other setae on tibiotarsus more or less barbed. Seta *Fel l'* short, smooth and slightly bent at the tip. The remaining setae on trochanter, femur and genu more or less barbed. Solenidia ω_1 and ϕ_1 (about 8 μ m long) thicker and longer than solenidia ω_2 and ϕ_2 (Fig. 25). The latter club-shaped and about 6 μ m long. Genual setae *Gel v'* and v'' absent. Internal tibiotarsal thickening poorly formed.

Leg II (Fig. 26): Unguinal seta u'' absent. All setae (with the exception of seta u') more or less barbed. Seta *TalI tc'* a short, thick spine with a tiny barb. Primiventral

23

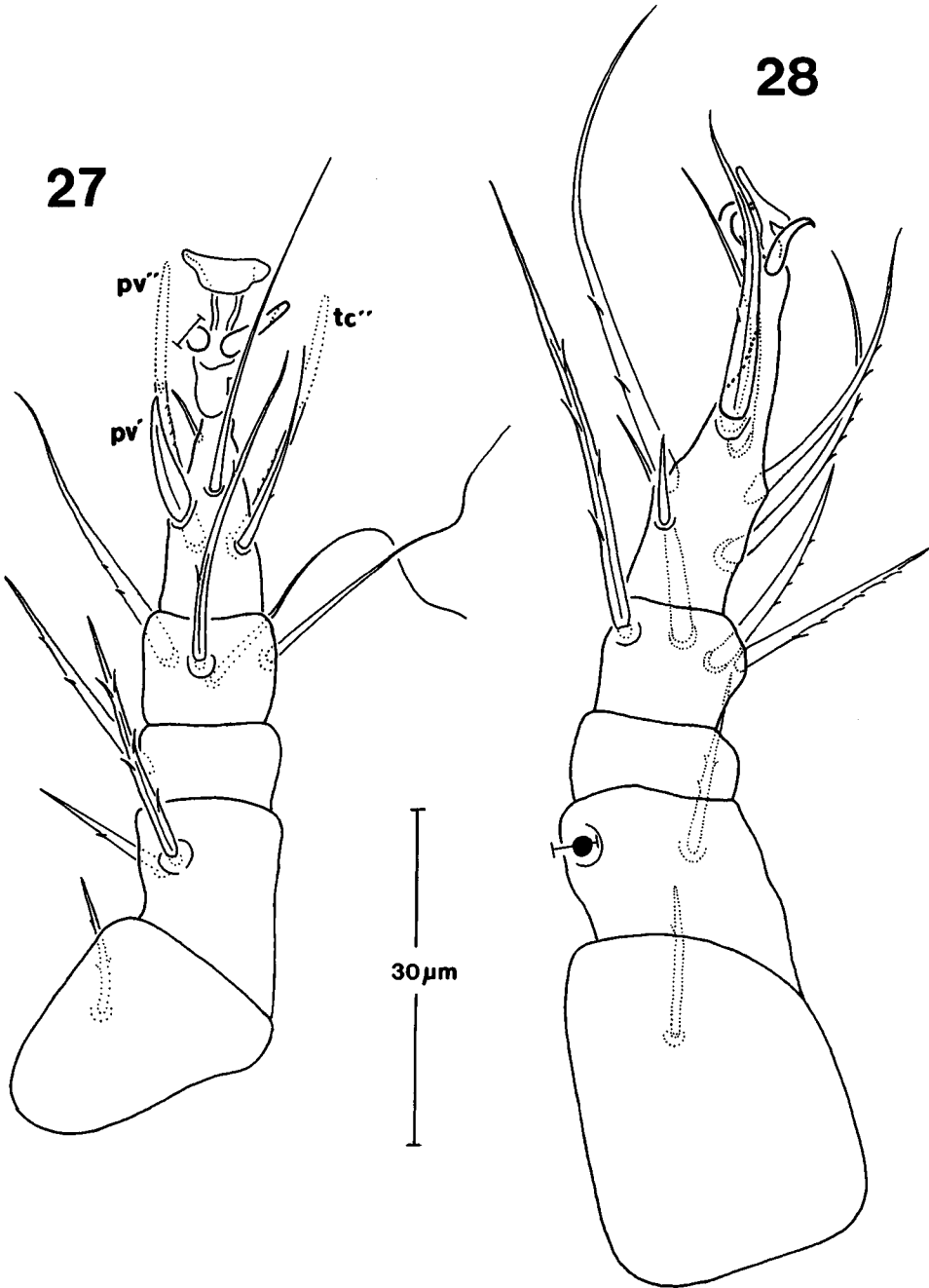


24



50 μ m

setae *Tail* pv' and pv'' blunt-tipped, slightly expanded apically, flattened and their distal parts more transparent than the proximal ones (Fig. 26). Tarsal solenidion ω well formed, tibial solenidion ϕ absent.



Figs. 27-28. *Spatulaphorus langi* sp. n.: 27- leg III; 28- leg IV

.Leg III (Fig. 27): Unguinal seta u'' absent. Tarsal seta pv' a short and thick spine. Setae $TaIII\ pv''$ and $TaIII\ tc''$ blunt-tipped and with transparent tips. Tarsal and tibial solenidia absent. Seta $TaIII\ u'$, $TaIII\ tc'$, $TaIII\ pv'$ and $TiIII\ v'$ smooth, other setae more or less barbed.

Leg IV (Fig 28): Unguinal setae u'' absent. All setae more or less barbed, except seta $TaIV\ pl''$ which is a short, smooth spine.

Males and immatures unknown.

Etymology: The species is named in honour of its collector, Mr. J. D. LANG.

Remarks: *Spatulaphorus langi* sp. n. closely resembles *S. camerikae* sp. n. but can be readily separated from the latter through its short, thick, spine-like tarsal setae $TaII\ tc'$ and $TaIII\ pv'$, longer hysterosomal setae h_1 , ventral setae $2a$ and shorter caudal setae ps_1 and ps_2 . Other taxonomic differences are included in the identification key.

The only specimen known is slightly damaged. Some of its setae have been lost and the embedding medium is partly deteriorated. The lost structures on the right leg I were drawn from the undamaged left leg and marked in black (Fig. 25). Interestingly, LANG (1978) had not included this form in his list of mites associated with insects in Vietnam, in spite of the listing of other Heterostigmata, i.e. podapolipids, scutacarids and tarsonemids.

Spatulaphorus foliatus sp. n.
(Figs. 29-47)

Holotype: Female, 154 μm long, 84 μm wide, ZMH No. A29/92.

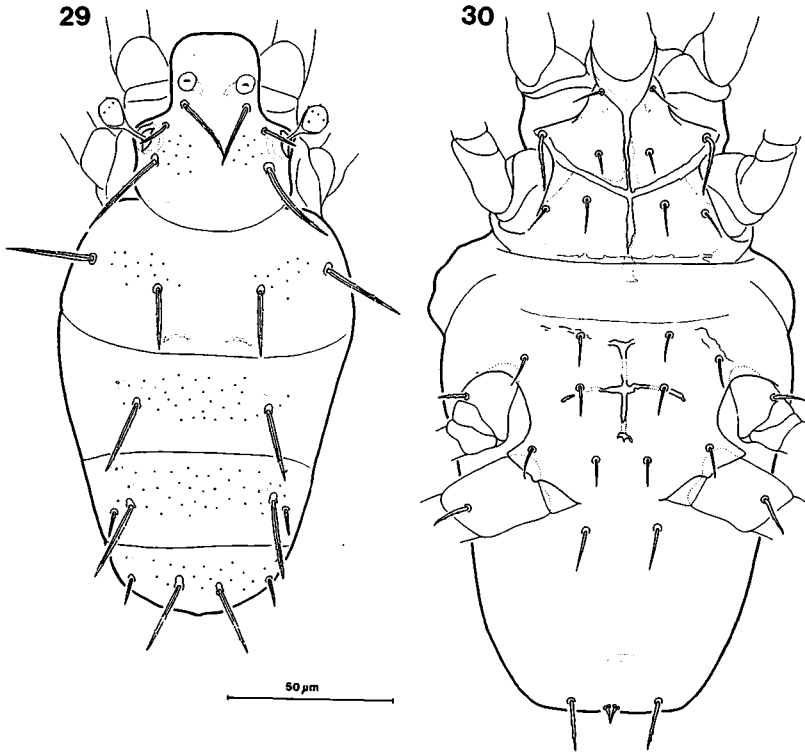
Type locality: Botswana, Mahalapye. On a specimen of *Onitis* sp. (Scarabaeidae, Coprinae), 26 January 1977, coll. K. CAMERIK.

Paratypes: 42 females, data for locality as for the holotype. - 40 paratypes in ZMH No. A29/92, one paratype in NMNH, and one in CNC.

Diagnosis: Small sized species. Dorsal idiosomal setae moderately long, ventral setae short. Hysterosomal setae e and h_2 smooth, other hysterosomal setae more or less barbed. Tibiotarsus elongated and with small simple claw and without counterpart (subunguinal seta s is tiny and hardly discernible). Tarsal setae $TaII\ tc'$ and $TaIII\ pv'$ shaped as a short, thick and slightly barbed spine. Several tarsal setae ($TiTa\ pv'$, pv'' , u' , $TaII\ pv'$, pv'' , $TaIII\ pv''$, tc') distinctly expanded at their tips, blunt-tipped and more or less transparent in a transmitted light.

Description of adult female: Body length 152-205 μm ($x=173.3$), width 72-110 μm ($x=89.8$). Idiosoma finely punctuated, its dorsal side with sparsely distributed small and roundish cavities of about 1 μm diameter (Fig. 29).

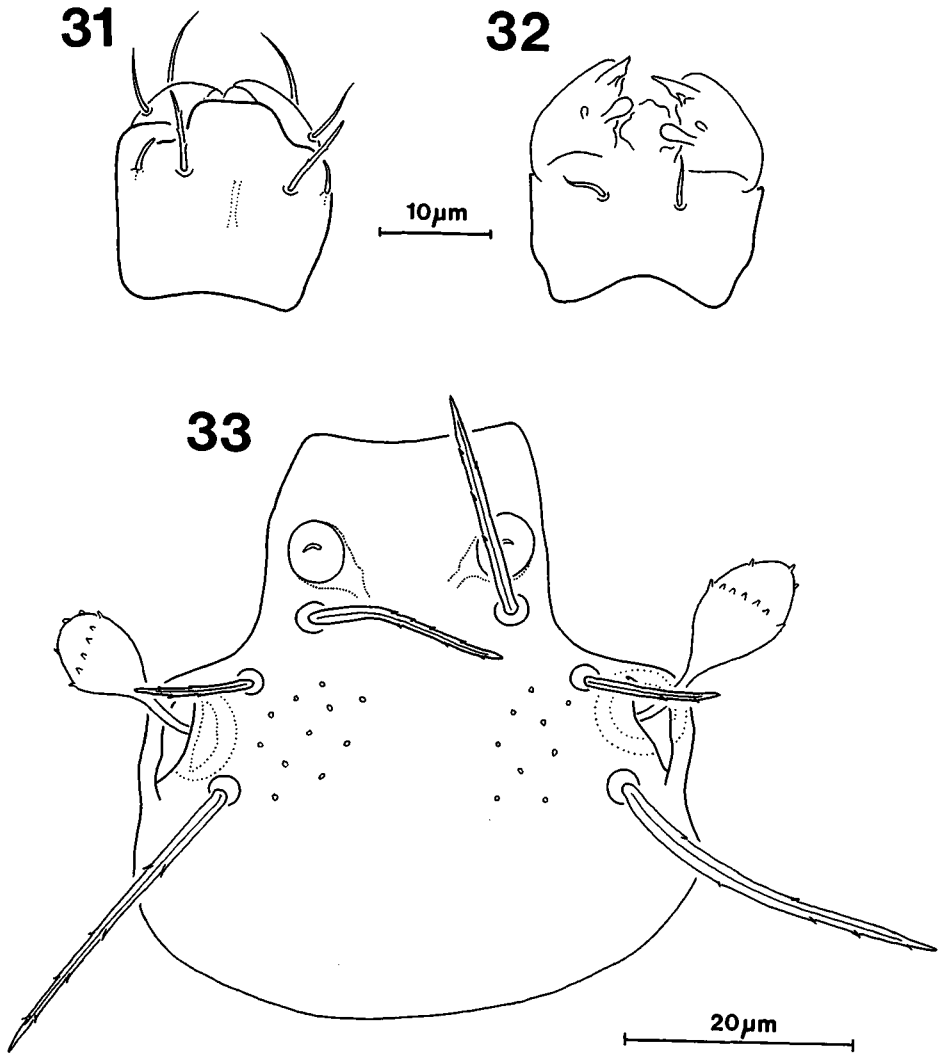
Gnathosoma (Figs. 31, 32): Shaped as in the type species. A small dorsomedian apodeme present. Dorsum with one pair of cheliceral setae (ch_1) which are either smooth or with 1-3 small barbs. A pair of short, blunt-tipped supracoxal setae (pp) located laterally of the setae ch_1 (Fig. 31). A pair of smooth and short subcapitular setae on gnathosomal venter. Palpi terminated with small, claw-like structures, palpal tibiotarsal capsule (ptc) tiny and hardly discernible. Genual setae longer than femoral ones. Setigenous accessory structure (sas) club-like, a neighbouring tiny palpal solenidium corn-shaped and almost invisible under the light microscope (Fig. 32). Length of gnathosomal structures in a paratype 178 μm : $sas=2.5$, palpal solenidium= about 1, $ptc=1.5$ μm . Pharyngeal pumps shaped similarly to those in *S. camerikae* sp. n.



Figs. 29-30. *Spatulaphorus foliatus* sp. n.: 29- dorsal view of female; 30- ventral view of female.

Idiosomal dorsum (Fig. 29): Peritremes almost round and covered with dome-shaped membrane when seen in light microscopy but flattened when seen in SEM (Figs. 29, 33 and 41, 42). The membrane medially with a small slit. Sensilla (sc_1) with several minute teeth. Prodorsal setae more or less barbed, their length formula: $sc_2 > v_1 > v_2$. Other dorsal setae also barbed, with the exception of setae e and h_2 which are smooth spines. Cupules ia , im and ih well discernible, with a pair of gland(?) like structures under the cuticle on segments D , EF and H , located at the bases of setae d , f and h_1 . A pair of distinct apodemes medially on segment C (Fig. 29). Distance between setae e and f relatively small.

Length of dorsal idiosomal setae as follows: $v_1 = 20(17-23; \bar{x} = 19.3)$, $v_2 = 10(9-11; \bar{x} = 10.1)$, $sc_1 = 14(13-17; \bar{x} = 15.1)$, $sc_2 = 29(27-36; \bar{x} = 30.5)$, $c_1 = 23(19-28; \bar{x} = 24.2)$, $c_2 = 26(23-36; \bar{x} = 28.3)$, $d = 25(21-30; \bar{x} = 26.2)$, $e = 9(7-13; \bar{x} = 8)$, $f = 25(21-29; \bar{x} = 25.6)$, $h_1 = 22(19-27; \bar{x} = 23.0)$, $h_2 = 7(6-10; \bar{x} = 7.7)$. Distance between the setae: $v_1 = 19(17-21; \bar{x} = 19.5)$, $v_2 = 31(26-35; \bar{x} = 30.2)$, $sc_1 = 36(28-42; \bar{x} = 33.7)$, $sc_2 = 37(36-44; \bar{x} = 38.2)$, $c_1 = 31(28-40; \bar{x} = 33.2)$, $c_2 = 68(63-84; \bar{x} = 75.2)$, $d = 42(36-57; \bar{x} = 46.6)$, $e = 53(44-72; \bar{x} = 59.2)$, $f = 45(38-63; \bar{x} = 49.7)$, $h_1 = 13(9-15; \bar{x} = 13.6)$, $h_2 = 41(38-53; \bar{x} = 45.9)$.

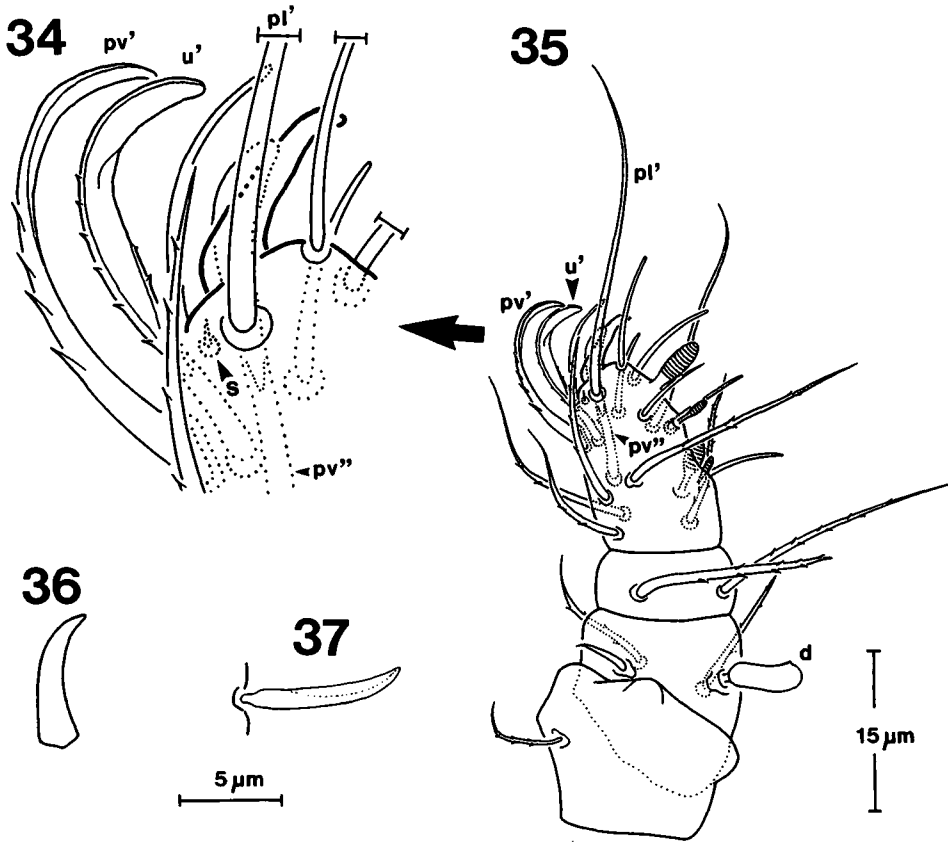


Figs. 31-33. *Spatulaphorus foliatus* sp. n.: 31- gnathosoma, dorsal view; 32- gnathosoma, ventral view; 33- prodorsal shield.

Idiosomal venter (Fig. 30): Sejugal apodeme and apodemes 3 and 5 weakly sclerotized, the apodemes 5 greatly reduced (Fig. 30). Setae *1c* and *ps*₃ barbed, other setae short, smooth and needle-like. Setae *2b* absent. Caudal setae *ps*₁ and *ps*₂ short and thin, with setae *ps*₃ located very close to posterior edge of opisthosoma.

Lengths of ventral idiosomal setae as follow: *1a* = 7(6-9; \bar{x} = 7.4), *1b* = 7(5-7; \bar{x} = 6.0), *1c* = 1(11-18; \bar{x} = 13.5), *2a* = 9(7-10; \bar{x} = 8.7), *2c* = 8(7-9; \bar{x} = 7.7), *3a* = 9(8-10; \bar{x} = 8.3), *3b* = 9(6-9; \bar{x} = 7.6), *3c* = 8(7-10; \bar{x} = 8.1), *4a* = 7(7-9; \bar{x} = 7.6), *4b* = 11(8-12; \bar{x} = 10.5), *4c* = 8(6-12; \bar{x} = 8.0), *ps*₁ = 6(4-7; \bar{x} = 5.1), *ps*₂ = 6(4-7; \bar{x} = 5.1), *ps*₃ = 12(10-13; \bar{x} = 11.5). Distances between the setae: *1a* = 11(11-13; \bar{x} = 12.3), *1b* = 13(12-15; \bar{x} = 13.5), *1c* = 39(37-44; \bar{x} = 41.0), *2a* = 18(17-23; \bar{x} = 19.8), *2c* = 40(36-45; \bar{x} = 40.6), *3a* = 22(19-23; \bar{x} = 21.8), *3b* = 21(21-25; \bar{x} = 22.5), *3c* = 50(43-55; \bar{x} = 49.8), *4a* = 12(12-15; \bar{x} = 13.7), *4b* = 17(14-18; \bar{x} = 16.7), *4c* = 43(41-51; \bar{x} = 43.4). Distance between *ps*₁ = 1.5(1-2; \bar{x} = 1.4), *ps*₁-*ps*₂ = 1(1; \bar{x} = 1), *ps*₂-*ps*₃ = 8(8-12; \bar{x} = 8.6).

Legs (Figs. 34, 35, 38-40, 41): The length of the legs increases posteriorly. Width of first pair of legs almost equal to that of legs II and III. Tibiotarsus with a small, simple and weak claw and without a counterpart. Claws on legs II to IV relatively small, similar in size, smooth and simple, i.e. without thickened bases. Empodia relatively large and smooth, empodial stalks short. Setal formula for each leg as in *S. camerikae* sp. n.



Figs. 34-37. *Spatulaphorus foliatus* sp. n.: 34- part of tibiotarsus; 35- leg I; 36- claw I; 37- seta *Fel d*, lateral view.

Leg I (Figs. 34, 35, 41, 43, 46, 47): Tibiotarsus elongated and slightly thinner than genu, tibiotarsal claw simple and only weakly bent (Figs. 34-36, 43, 46, 47). Subungual seta *s* minute, hardly discernible in light microscopy (Figs. 34, 35) and shaped as a short papilla with a sharp tip (Fig. 43). The seta thus not transformed into a counterpart (as in other taxa of *Spatulaphorus* gen. n.). Seta *Fel d* spatula-like, a tiny asymmetrical tooth on its distal edge (Figs. 35, 37, 44, 45). Primiventral setae *pv'* and *pv''* and unguinal seta *u'* apically distinctly expanded, their tips strongly flattened, foliose (Figs. 34, 35, 43, 46, 47). Apical parts of the setae poorly visible in a transmitted light. Tarsal eupathidia, tibial eupathidium *k''* and primilaterals *pl'* and *pl''* smooth, other tibiotarsal setae more or less barbed. Genual setae *Gel v'* and *Gel v''* absent. Solenidia ω_1 and ϕ similar in size and distinctly longer than solenidia ω_2 and ϕ . The solenidion ω_1 spindle-like, ϕ club-shaped. The length of solenidia in a paratype 170 μm : ω_1 and $\phi_1 = 6$, ω_2 and $\phi_2 = 3.5$ μm . Seta *Fel l'* short, smooth and spine-like, its tip slightly bent.

Other setae on trochanter, femur and tibia more or less barbed. Internal tibiotarsal thickening poorly developed.

Leg II (Fig. 38): Unguinal seta u' short and smooth, seta u'' absent. Seta $TaII\ tc''$ smooth, other setae more or less barbed. Primiventral setae pv' and pv'' blunt-tipped and with expanded, flattened distal parts. Tectal seta $TaII\ tc'$ a thick, short spine, seta $FeII\ l'$ a short spine. Tarsal solenidion ω well developed, tibial ϕ solenidion absent.

Leg III (Fig. 39): Unguinal seta u' short and needle-like, seta u'' absent. Setae $TaIII\ pv'$ and $TaIII\ tc''$ with distinctly expanded, flat and membranous distal parts. Setae $TrIII\ v'$, $FeIII\ v'$ and $TaIII\ pv'$ short spines, the latter are the thickest. The setae $TaIII\ v'$ and $TaIII\ u'$ smooth, other setae more or less barbed. Tarsal and tibial solenidion absent.

Leg IV (Fig. 40): Unguinal seta u' absent, seta $TaIV\ pl''$ shaped as a small, smooth spine. Other setae more or less barbed. Tarsal and tibial solenidion absent.

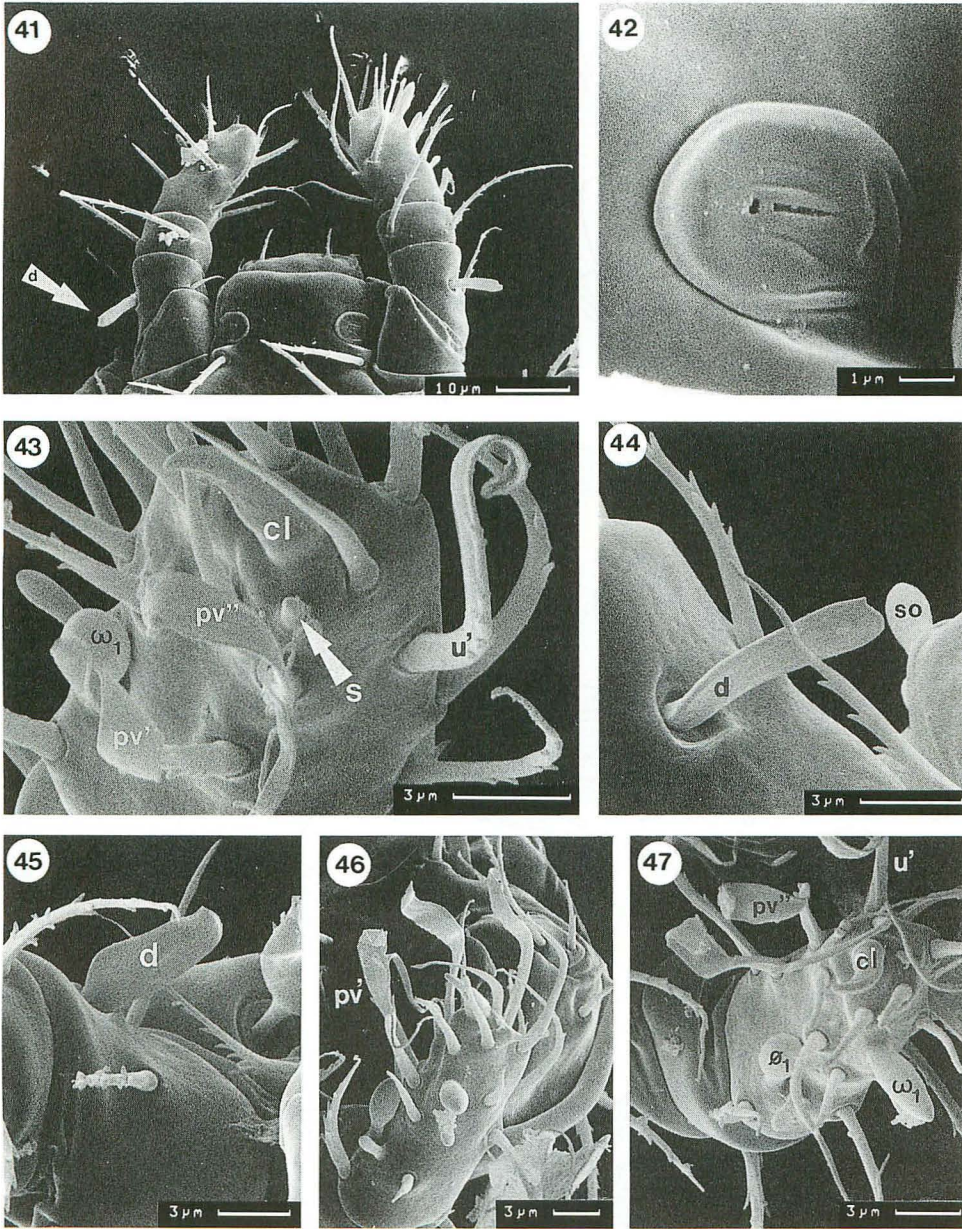
Males and immatures unknown.

Etymology: The specific name of this taxon [*foliatus* (Lat.)= leaved, leafy] is referring to several expanded, foliate setal endings on tarsi of legs I to III.

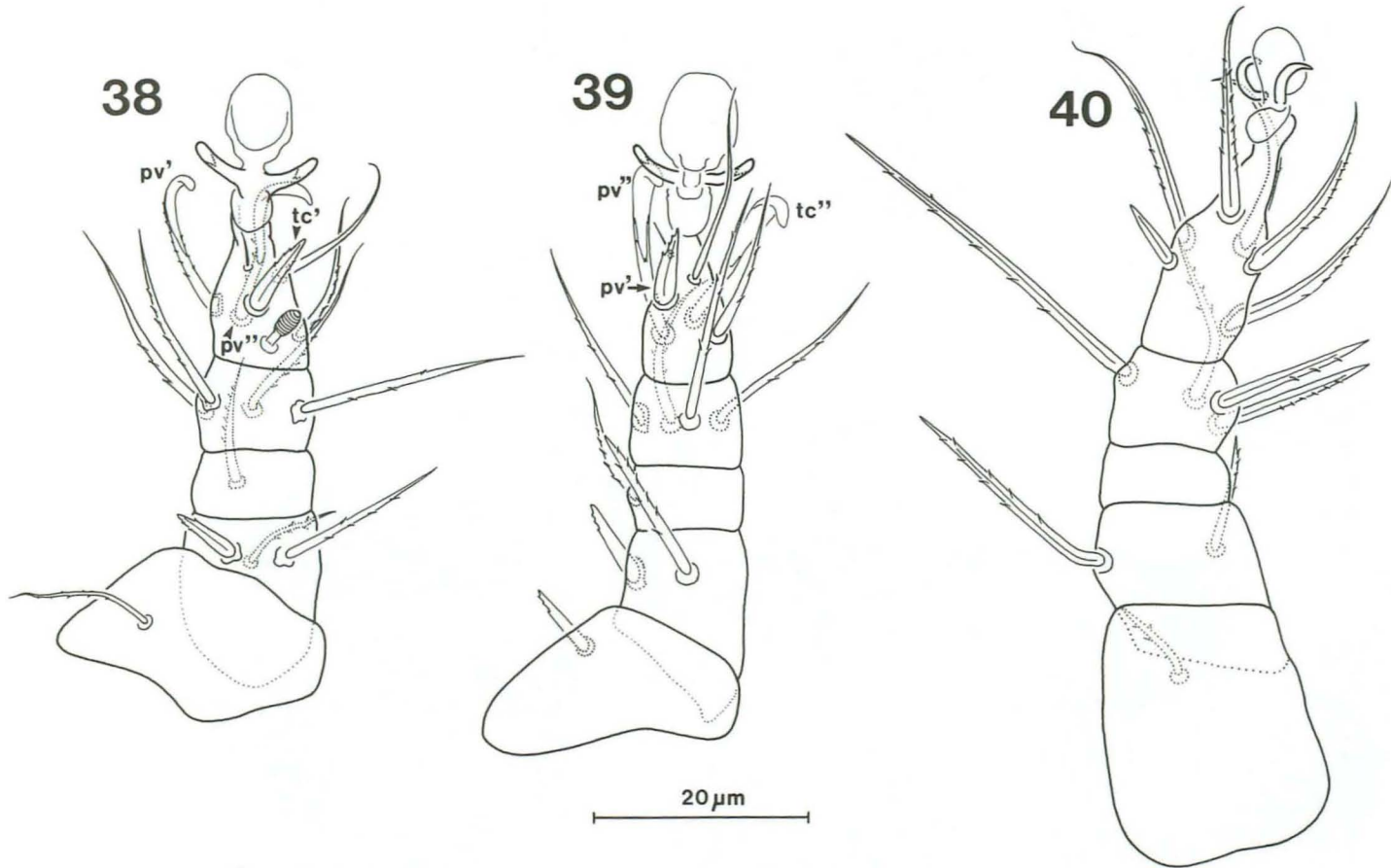
Remarks: *Spatulaphorus foliatus* sp. n. can be easily distinguished from two other species of the genus by the lack of counterpart on tibiotarsus and by its small, only slightly bent tibiotarsal claw. The highly modified subunguinal seta s which is formed as distinct counterpart in *S. camerikae* sp. n. and *S. langi* sp. n., forms in *S. foliatus* sp. n. a tiny hardly discernible spine. The latter species is also characterized in having the shortest caudal setae and highest degree of modification of several tarsal (chiefly primiventral) setae of the three species, in having shorter opisthosomal setae on dorsum and by almost fully suppressed ventral apodemes 5, compared to the other taxa.

Discussion

Spatulaphorus foliatus sp. n. represents most derived species within three new taxa as evidenced by the highest suppression of its apodemes 5, smooth hysterosomal setae e and h_2 , caudal setae ps_1 , ps_2 and modified, foliate tips of several tarsal setae, compared with the same structures in the remaining taxa. By the same token, *S. camerikae* sp. n. should be viewed as the most ancestral form. However, *S. foliatus* sp. n. is characterized by the lack of counterpart and presence of a simple, small tibiotarsal claw I. The interpretation whether these structures are derived or not is problematical. The claw is similar to that of relatively primitive, non-phoretic genus *Siteroptes* Amerling, 1861 (subfamily Siteroptinae sensu MAHUNKA, 1970). The modified subunguinal seta s , which forms large, wide counterpart in two other taxa, is reduced in *S. foliatus* sp. n. to a tiny vestigial structure. Such a formation of the tibiotarsal grasping apparatus in the latter species might represent either a plesiomorphy or a character reversal. Assuming that the homologisation of the counterpart with the seta s is correct (see DASTYCH & RACK 1993), the former possibility seems to be more probable. It suggests a slower evolution of the claw and suppression of primarily non-modified seta s by unknown selective pressure. Consequently, well formed tibiotarsal grasping apparatus in *S. camerikae* sp. n. and *S. langi* sp. n. is regarded here synapomorphic in relation to that in *S. foliatus* sp. n. The different formation of that apparatus within three new taxa may exemplify mosaic evolution, a phenomenon common in pygmephorid mites (CROSS 1974).



Figs. 41-47. *Spatulaphorus foliatus* sp. n.: 41- anterior part of body with prodorsal shield and legs I, dorsal view; 42- peritreme; 43- part of tibia-tarsus, ventro-lateral view; 44 and 45- seta *Fel d*; 46- tibia-tarsus, lateral view, 47- ventro-frontal view.



Figs. 38-40. *Spatulaphorus foliatus* sp. n.: 38- leg II; 39- leg III; 40- leg IV.

The function of the poorly formed tibiotarsal grasping apparatus of *S. foliatus* sp. n. seems to be supported by several modified (foliose) tarsal setae on legs I to III. These setae are less transformed in *S. camerikae* sp. n. and *S. langi* sp. n., i.e. in the taxa where the claw I and counterpart are well formed, which is consistent with the suggestion of their role in *S. foliatus* sp. n. The foliose, flattened and apically expanded setal endings are probably an adaptation to phoresy. They may help mites to adhere to smooth cuticle of a beetle carrier, supposedly by the surface adhesion. Such a function for convergently modified, similar tarsal setae has been described in phoretic hypopi of several genera of the Astigmata (e.g. OCONNOR 1982, FASHING 1991). This type of expanded setae, characteristic for *Spatulaphorus* gen. n., within Heterostigmata has been described in the scutacarid genus *Hauseripes* (see MAHUNKA & MAHUNKA-PAPP 1988). One can assume that these convergently similar structures serve all a similar attachment function as suggested for the new genus.

The presence of *Spatulaphorus* gen. n. at distant localities such as Botswana and Vietnam is indicative of a wide geographic range. It should be noted that closely related *S. camerikae* sp. n. and *S. langi* sp. n. from these far removed sites have been also found on the same scarab genus, viz. *Catharsius* HOPE, 1837. It may suggest any phoretic specificity of these mites and reflects also our still insufficient knowledge of the pygmephorid-insect associations. The third species, *S. foliatus* sp. n., is reported from another scarab genus, *Onitis* FABRICIUS, 1798 and the mite differs from the other taxa by poorly formed tibiotarsal grasping apparatus. This and some other differences exemplify two evolutionary lineages present within the new genus. In future it might be justified to erect two subgenera for these separate stocks.

The new genus is described on the basis of phoretic morphs only, i.e. those with tibiotarsi in legs I. The coalesced tibiotarsus was primarily separated in tibia and tarsus, thus it represents an apomorphy. It is difficult to say if "normal", non-phoretic morphs occur in *Spatulaphorus* gen. n., i.e. those with these joints separated. In the subfamily Pygmephorinae sensu MAHUNKA, 1970 such both forms are known only in a sole genus *Pediculaster* VITZTHUM, 1931. In the remaining genera, which form the majority of the subfamily, only morphs with tibiotarsus have been reported. However, the presence of tibiotarsus does not always reflect phoretic behaviour of the mites as many such taxa are reported only from soil, detritus or similar habitats. This additionally illustrates that knowledge of pygmephorid biology is highly incomplete.

Identification key for species of the genus *Spatulaphorus*

1. Tibiotarsus I with large, hook-like claw and a distinct counterpart opposite to the claw base (Figs. 10, 19, 25) 2
- Tibiotarsus I with a small, almost straight claw, and no counterpart (Figs. 35, 36, 43) *S. foliatus* sp.n.
2. Opisthosomal setae h_2 about 1/2 of length of setae h_1 , setae $2a$ and $2c$ of almost equal length; setae ps_1 and ps_2 longer than ps_3 . Tarsal setae $Tall\ tc'$ and $Tall\ pv'$ moderately long and setiform (Figs. 1, 2, 13, 14) *S. camerikae* sp. n.
- Setae h_2 about 1/3 of length of setae h_1 , setae $2c$ about 1/2 of length of setae $2a$; setae ps_1 and ps_2 shorter than ps_3 . Tarsal setae $Tall\ tc'$ and $Tall\ pv'$ short, thick and spine-like (Figs. 23, 24, 26 27) *S. langi* sp. n.

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Zusammenfassung

Drei neue phoretische Milbenarten aus der neuen Gattung *Spatulaphorus* gen. n. (Acari: Heterostigmata, Pygmephoridae) werden beschrieben. Sie wurden auf Mistkäfern (Scarabaeidae, Coprinae) in Botswana und Vietnam gefunden. *Spatulaphorus* gen. n. unterscheidet sich von allen bisher bekannten Gattungen der Familie Pygmephoridae durch die Spatel-ähnlichen Borsten "d" auf den Femuren des ersten Beinpaars. Die neue Gattung steht der Gattung *Pygmephorellus* am nächsten. Einige morphologische Anpassungen für Phoresie bei dieser Gattung werden diskutiert und ein Bestimmungsschlüssel für die neu beschriebenen Arten wird präsentiert.

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