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SOME NOTES ON MORPHOLOGY
OF MITES OF THE GENUS PYGMEPHORUS
(ACARI : HETEROSTIGMATA)

by Hieronim DASTYCH * and Gisela RACK *

ABSTRACT: Selected, predominantly external structures of mites of the genus Pygmeophorus (Acari: Heterostigmata) have been examined through light-and scanning electron microscopy. Gnathosomal complex, stigmata, solenidia, some propodosomal setae, the claw’s counterpart on tibiotarsus I, and the internal thickening of the tibiotarsus were investigated and for most of them the first SEM micrographs are presented. The taxonomic importance of the structures and possible homologies are discussed.


INTRODUCTION

The genus Pygmeophorus Kramer, 1877 (Acari : Heterostigmata, Pygmeophoridae) represents phoretic mites associated with small mammals. Present studies on North American members of the genus revealed significant intraspecific variability of some structures used as taxonomic characters (DASTYCH et al. 1991, 1992). This variability and also insufficient descriptions of the structures have resulted in numerous synonyms within Pygmeophorus (op. cit.).

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As some of the characters are hardly discernible in light microscopy, they have been either neglected or variously interpreted by previous authors. This is particularly valid for the gnathosomal complex of these mites.

It is only recently that a sound basis for systematic and phylogenetic studies of Heterostigmata has been founded by Lindquist (1977, 1986). That author accentuated (1986) the need for examination of minute and underestimated structures with the scanning microscope (SEM) as a source of additional information about possible homologies. Morphological data on the family Pygmephoridae have been acquired by SEM. There are only two SEM micrographs known, depicting a male genital shield in Petalomium Cross, 1965 and a fragment of tibiotarsus of Pygmephorus (Ebermann & Rack 1982, Smiley & Whitaker 1984, respectively). In the sister-group of Pygmephoridae, i.e. the family Scutacaridae, SEM studies have been initiated by Ebermann (1979, 1980a, 1980b, 1982a, 1982b, 1991) and have already accumulated a considerable amount of information on morphology and, indirectly, on the biology of these mites.

In this paper those Pygmephorus structures which are either poorly defined or barely discernible in a light microscope are mainly analysed. The structures are the gnathosomal complex (the least studied tagma of heterostigmatic mites), some propodosomal setae, the leg solenidia, the claw's counterpart on tibiotarsus I, and the internal thickening within the tibiotarsus. Their descriptions are given below.

**Materials and Methods**

The paper is based on 26 species of Pygmephorus represented by 638 specimens (females) mounted on microslides in chloral gum (Berlese’s, Hoyer’s or Swan’s medium). The individuals originate from the Holarctic (see e.g. Rack 1975, Dastych et al. 1991, 1992). The majority of the material is deposited in the Zoologisches Museum, Universität Hamburg, some specimens were loaned from other institutions (see “Acknowledgements”). The following taxa were examined: *P. arcuatus* Dastych & Rack, 1991; *designatus* Mahunka, 1973; *erlangensis* Krczal, 1959; *forcipatus* Willmann, 1952; *hastatus* Mahunka, 1973; *horridus* Mahunka, 1973; *idei* Smiley & Whitaker, 1979; *iglehartiae* Smiley & Whitaker, 1984; *islanicus* Sellick, 1940; *kunadai* Sasa, 1961; *mahunkai* Smiley & Whitaker, 1979; *microti* Krczal, 1959; *mongolicus* Mahunka, 1967; *moreohorridus* Mahunka, 1975; *plurispinosus* Mahunka, 1975; *rackae* Smiley & Whitaker, 1979; *scalopi* Mahunka, 1973; *sicarius* Mahunka, 1969; *soricis* Krczal, 1959; *spickai* Mahunka, 1974; *spinosus* Kramer, 1877; *stammeri* Krczal, 1959; *tristosus* Dastych & Rack, 1991; *urotchii* Rack, 1975; *whartoni* Smiley & Whitaker and whartikeri Mahunka, 1973. The observations were carried out using phase- and interference contrast microscopy. Setal notation and terminology of structures follow Lindquist (1977, 1986), unless otherwise indicated.

The specimens for SEM observations originate either from the collection of mites preserved in ethanol and kept in the Zoologisches Museum, Hamburg [*P. spinosus* : ex *Talpa europaea* (Linnaeus, 1758), Germany, Bremen, 8 May 1899, coll. S. Poppe, 5 females (see S. Poppe & Oudemans 1906) or were recovered from some microslides [*P. whartieri* : ex *Blarina brevicauda* (Say, 1823), U.S.A., Iowa, Webster Co., Lehigh, 30 Sep 1979, coll. N. Wilson (6 females)]. In the latter case, from each of the selected microslides a protective seal (varnish) was carefully scraped off and the microslides were placed for 24 hour in a Petri dish with distilled water. After the mounting medium (the Swan’s) had fully dissolved, the cover glass was cautiously removed under a dissecting microscope and the mites were transferred by micropipette into 70 % ethanol for 6 hours. Afterwards all specimens were dehydrated in graded ethanol, critical-point-dried, arranged on double-sided sticky tape and coated with gold. Micrographs were made using the scanning electron microscope CamScan S4.

Abbreviation used in illustrations (Figs. 1-20) are as follow: *a* = artifact, *b2* and *c2* = propodosomal ventral setae, *ch1* and *ch2* = cheliceral setae, *cl* = claw, *cs* = cylindrical structure, *d* = tibial setae, *fe* = femoral setae, *FG* = palpal femorogenu, *ge* = genual setae, *l* = tibia seta, *ms* = modified tibiotarsal seta,
RESULTS AND DISCUSSION

GNATHOSOMA (Figs. 2-6)

Gnathosomal capsule is formed by fused cheliceral bases integrated with the infracapitulum (see Lindquist 1986). The capsule is protected by the camerostome, is more or less quadrangular and has a wide roundish incision on its ventral proximal edge. A short dorsomedian apodeme is always present in all investigated taxa. In the majority of species there are two pairs of cheliceral setae (Fig. 2: $ch_1, ch_2$) inserted dorsally on the capsule. The setae have variable length and barbation. However, in four taxa ($P. spinosus, P. plurispinosus, P. urotrichi$ and $P. soricis$) only one pair of such setae is present and another is totally reduced, i.e. is lacking. The first three taxa are provided with the setae $ch_1$ (Figs. 5, 6), while in $P. soricis$ only the setae $ch_2$ occur. The number of cheliceral setae is a good taxonomic character and allows to discern with
certainly the variable and confusing *P. spinosus* from similar species, e.g. *P. whitakeri, P. scalopi* : (see DASTYCH et al. 1991, 1992).

A pair of palpcoxal setae *pp* is inserted laterad, anteriolateral or anteriad (rarely) of the setae *ch*, (Fig. 2 : *pp*). The setae are palpal in origin and occur in all taxa examined. In the literature they are also termed "supracoxal setae e" (e.g. LINDQUIST 1986 : see also his Fig. 201, where they are designated as "pp"). However, this terminology is rather confusing, as a pair of hysterosomal setae dorsally on segment *EF* is also termed "setae e". The setae *pp* are relatively short, rod-like, blunt-tipped and their slightly thickened bases are prolonged in a hardly discernible, thin canal within the cuticle. The canal indicates sensory function of these setae. A pair of subcapitular setae is inserted on the ventral side of the capsule in all taxa studied (Fig. 3 : *su*).

Short palps with limited mobility are located laterally in the apical part of the capsule (Figs. 2-6). Palpal femur and genu are coalesced in a relatively wide and short joint called femorogenu (Figs. 2-4, 6 : FG). Its dorsum is strongly sclerotized and its distal part distinctly widened (Figs. 2, 6). A pair of setae is inserted on each femorogenual dorsa, *i.e.* a femoral and genual seta, respectively (Figs. 2, 5 : *fe, ge*). The genual setae are distinctly longer. No boundary could be discerned on the ventral side between the femorogenu and a subsequent fused joint, *i.e.* palpal tibiotarsus. Each tibiotarsus is provided ventrally with five structures. Proximally, there is a tibial solenidion and so-called setigenous accessory structure (LINDQUIST 1986, DASTYCH & RACK 1991). Both are closely located to each other (Figs. 3, 4, : *so, se*, respectively). The solenidion is hollowed, striated and located laterally on the joint. Its striation is visible only by light microscopy. External surface of the solenidion is completely smooth, as is that on leg solenidia (comp. Figs. 4 and 10). The setigenous accessory structure is short, cylindrically shaped, dome-tipped and with relatively thick wall. It is not striated and is inserted medially in relation to the solenidion. The size of both structures varies slightly from species to species. Usually the solenidion is longer than the setigenous structure, but the latter one mostly has a larger diameter.

The palpal tibiotarsi terminate with a small and short claw-like structure. The claws are blunt-tipped, with relatively wide base, slightly bent medially at their apex and oriented horizontally (Figs. 2-4 : *cl*). Medially at the base of each claw there is a small elongated cylindrical capsule with a thin internal rod (Figs. 3-4 : *cs*). The rod is about 1/5-1/4 longer than the capsule and protrudes slightly outside this structure. Only this protruding part of the rod is visible in SEM, but the whole rod is discernible in a light microscope (see DASTYCH & RACK 1991 : Figs. 3, 4). This distinct structure, termed here "palpal tibiotarsal capsule", may have a sensory function. As far as is known, its presence has not been mentioned in the literature. Similarly formed palpal tibiotarsal capsules were also found in selected species of some other pygmephorid genera, *i.e.* Siteroptes Amerling, 1861, Mahunkania Rack, 1972, Pseudopygmephorus Cross, 1965 and Bakerdania Sasa, 1961. Probably a homologous structure occurs also in a not yet described species of Athyreacaridae, kindly loaned by Dr. LINQUIST. The genus belongs to the recently described new family of heterostigmatic mites, *i.e.* Athyreacaridae (see LINDQUIST et al. 1990). The fifth structure observed on palpal tibiotarsus in *Pygmephorus* is represented by a vestige of any tarsal seta (?) located at the median edge of each claw (Fig. 4 : undescribed arrow).

**Stigmata** (Fig. 7)

A pair of external openings of the respiratory system, termed stigmata, occur in *Pygmephorus* only in females. Usually these openings are located dorsally in the anterior area of the propodosomal shield. Sometimes they are placed at the shield edge (Fig. 7 *st*) or, rarely, even slightly under the edge, *i.e.* on lateral side of the body. The location of stigmata is relatively constant and specific, thus representing a good taxonomic character. Usually, but not quite correctly, termed as stigmata are structures, *i.e.* strongly sclerotized cavities, which lead into the tracheal trunks. The shape of the cavities is also specifically constant. Dorsally these structures are covered with a weakly sclerotized membrane, trans-
parent in light microscopy. The membrane has a small, slit-like opening in its middle (Fig. 7: st), through which the respiratory system makes contact with the external surroundings. Similarly shaped and usually barely discernible openings in some other pygmephorid genera have been also observed. As far as is known here, this structure has been illustrated with SEM in heterostigmatic

Figs. 5-8: Pygmephorus spinosus Kramer (Figs. 5-6), gnathosoma: 5. - Ventral view, 6. - Lateral view; Pygmephorus whitakeri Mahunka (Figs. 7-8): 7. - Edge of propodosomal shield, dorsal view; 8. - Edge of propodosomal venter. (Scale lines: Figs. 5, 7 = 10 μm, Figs. 6, 8 = 3 μm.)
mites only in the families Heterocheylidae by Lindquist & Kethley (1975 : Figs. 7, 8) and Athyreacaridae by Lindquist et al. (1990 : Figs. 8, 9).

**Propodosomal setae lc** (Figs. 8, 9)

Setae lc are inserted ventrally on the edge of propodosoma and have a specific shape and size. They are more or less flattened above their bases, and also usually in their middle and distal parts (Figs. 8, 9 : lc). The setal edges are more strongly sclerotized than their middle and are more or less barbed. Mostly between the edges occurs a thin, hardly discernible transparent membrane. This membrane gives an impression of bifurcation of the seta (see Dastych & Rack 1991 : Fig. 2) and is termed here as a “pseudobifurcated” seta. Depending on the position of the setae in a slide preparation, the degree of pseudobifurcation can be different even in the same specimen. The pseudobifurcation can be considered as an evolutive step towards true setal separation (bifurcation) which in Pygmephorus was found only in one species, i.e. P. spiekai.

**Leg solenidia** (Figs. 10, 13)

Solenidia on legs, similarly to those on palps, are hollow, striated and more or less elongated. Their external surface is also smooth. Tibiotarsus I is provided with four such structures (Fig. 13), specifically inserted, shaped and sized. Two solenidia are inserted on legs II : the tarsal solenidion (s) is much longer than the tibial one (g) and it is usually located on a small tubercle (Fig. 10 : so2). The tibial solenidion is reduced in size and appears to be embedded in the cuticle. Its anterior club-shaped unit is placed in a small cavity (Figs. 10 : so1) which leads to a short canal within the cuticle. On legs III and IV only vestiges of tibial solenida (g) are retained. They are reduced to a tiny pore located close to setae TIII d and TIV d, respectively, which leads also to a short and thin canal within the cuticle.

**Tibiotarsal counterpart** (Figs. 11, 12, 14-17, 20)

A large striated claw on tibiotarsus I in Pygmephorus (Figs. 1, 12, 14, 15, 20 : cl) is accompanied by a strongly sclerotized structure inserted on the side opposite to the claw base (Figs. 11, 12, 14-17, 20 : ns). The structure, which supports the claw in its function, is termed here “counterpart” and is specifically shaped and sized. The claw and the counterpart constitute a bristle-grasping apparatus (“tongs”) used by these mites for phoresy.

The counterpart in Pygmephorus can be relatively large and thorn-like, often with a lateral accessory tooth (P. idei, mongolicus, sicarius, stammeri, designatus, islandicus, horridus, forcipatus, arcuatus) or small, to some degree scale-like and then usually striated (P. whitakeri, spinosus (Figs. 11, 12, 14-16), soriciis, moreohorridus, spickai, urotriehi, rackae, scalopi, hastatus). In other species examined, the structure is shaped intermediate between the above two. The counterpart has been variously defined in the literature (“zapfenförmiger Fortsatz” : Krammer 1877, “Chitindorn”, “Chitinlöffler” Sellnick 1940, “Gegenglieder” : Willmann 1953, “Chitinzapfen” : Krčzal 1959, “Gegenstück” : Rack 1975). Recently it was designated as a “modified seta” by Smiley & Whitaker (1979, 1984). Kaliszewski & Rack (1985) called the structure “modified subunguinal seta s” and, as a result of such a homologization, they assumed the reduction (absence) of one of the two unguinal setae on each tibiotarsus, i.e. the seta u”. If this is accepted, then the counterpart must have arisen independently at least twice in heterostigmatic mites. An example of different origin of the structure is provided by the genus Athyreacarus of the family Athyreacaridae (see Lindquist et al. 1990), an early derivative of Heterostigmata. There the counterpart is composed of two, partly separated units which were homologized with unguinal “normal” setae u’ and u” (op. cit. : Fig. 11). Consequently, the “normal” setiform seta inserted below the bases of two unguinals u’ and u” was designated by the latter authors as the subunguinal seta s.

Interestingly, the relatively uniform counterpart in the genus Pygmephorus as observed in light microscopy, seems to be composed of two coalesce-
ed units when studied in SEM. It was found, that the structure was “double” in *P. spinosus* (Figs. 12, 15, 16) and, to some degree, also in *P. whitakeri* when examined by SEM (Fig. 14). The character of such a formation of the counterpart is unknown, it should therefore be examined in other species of the genus. Based on this “duality” it can not be excluded that the structure has the same origin as that in *Athyreacarus*, i.e. that it has arisen from unguinal setae *u’* and *u”*, now fused in a single, more or less uniform structure. Such a fusion would then be an apomorph character. Subsequently, the setiform and barbed seta inserted close to the counterpart and considered as unguinal setae *u’* (Kaliszewski & Rack 1985 : Fig. 3) would then represent the subunguinal seta *s*. The above homology remains an open question. It is noteworthy that similarly uniform counterpart in light microscopy occurs also in some other pygmeophorid genera, e.g. *Propygmephorus* Cross, 1974, *Elatoma* Mahunka, 1969 and *Pygmephorellus* sensu Cross, 1974.

**INTERNAL TIBIOTARSAL THICKENING (Figs. 17-21)**

Females of *Pygmephorus* have the tibia and tarsus of the first pair of legs fused into a single limb, termed tibiotarsus I. The border between these originally separated limbs is marked by an internal thickening on the tibiotarsal wall (Figs. 17-21 : arrows). The structure is located close to the base of solenidia *φ*. The thickening was already illustrated by Kramer (1877; see Fig. 21, arrow) and also reported or figured by Sellnick (1940), Willmann (1953), Rack (1975), Kaliszewski &
RACK (1985), DASTYCH & RACK (1991), DASTYCH et al. (1991, 1992). The structure, often cone-like and more or less similar in shape and size in the majority of species examined (e.g. Figs. 18-20), is in some taxa specifically shaped (P. stammeri) or may be absent (P. erlangensis, P. arcuatus). In P. stammeri it appeared as a roundish sclerotized "dot", separated from the wall limb (Fig. 17; see also DASTYCH et al., op. cit.). The function of the thickening is unknown. However, WILLMANN
(1953) suggests attachment of muscles to this structure. Such thickenings occur also in some other, above listed, members of pygmephorid genera provided with tibiotarsi, and may indicate convergence.

Recently SMILEY & WHITAKER (1984) describe an unknown structure on tibiotarsus I and termed it “spur-like seta”. The authors depicted the seta (Fig. 22, arrow), provided its SEM micrograph (op. cit. : Fig. 33) and suggested “that it may be used for grasping or it may be raptorial in function. It appears to be useful for generic identifi-
Figs. 21-22: Pygmeplhorus spinosus Kramer (Fig. 21), tibiotarsus I (arrow = internal tibiotarsal thickening); Pygmeplhorus rackae Smiley & Whitaker (Fig. 22), leg I with tibiotarsus (arrow = "spur-like seta") (Figs. 21 and 22, after Kramer (1877) and Smiley & Whitaker (1984), respectively. Both slightly altered).

cation..." (op. cit.: p. 59). The structure was recorded (and figured) by them in P. iglehartae, proctorae, utnarae (= scalopi), russellae, wilsoni, rackae and idei (op. cit.). However, present examination of the tibiotarsus I in all available Pygmeplhorus taxa, including some of those listed above (P. iglehartae, scalopi, idei) could not confirm the presence of the structure. It is the opinion here, that the authors misinterpreted the internal tibiotarsal thickening for the above "spur-like seta". Both structures are almost of the same size, similarly shaped and, as seen dorsally, occur almost or exactly in the same place on tibiotarsus I near solenidia ϕ (comp. Fig. 22 and 17-20). Nevertheless, the tibiotarsal thickening is located inside the tibiotarsus, not outside as assumed for a "spur-like seta". The incorrect assessment of the insertion of the structure seems to be a reason for that mistake. No such surface structure was found in 26 species of Pygmeplhorus, even using the highest power of interference contrast microscope. This is also valid for the SEM studies of P. whitakeri and P. spinosus.

Most probably, the meagre SEM micrograph of the "spur-like seta" provided by Smiley & Whitaker (1984: Fig. 33) does not contain an image of any seta but illustrates a hardly discernible minute artifact, if at all even that.

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