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A redescription of *Pterygosoma aegyptiaca* Mostafa (Acari: Prostigmata: Pterygosomatidae), a little known ectoparasitic mite of spiny-tailed lizards (Squamata: Agamidae), with new morphological data for the Pterygosomatidae

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Abstract

The female of *Pterygosoma aegyptiaca* Mostafa, 1974 (Acariformes: Prostigmata: Pterygosomatidae) is redescribed. This species, previously known only from its type locality (Egypt) and type host (*Uromastyx* sp.), is newly recorded from Sudan and from the ocellated spinytail, *Uromastyx ocellata* Lichtenstein. An unstriated area of idiosomal cuticle is proposed as a prodorsal shield, a character not previously attributed to the genus. Two pairs of idiosomal lyrifissures, *ip* and *ih*, are identified in *Pterygosoma* Peters, 1849, for the first time, as is a distal microseta (κ) on leg genu I. A dorsal structure observed near the base of the leg tarsi is considered to be a lyrifissure (= proprioceptor) and is newly recorded in the Pterygosomatidae. In the light of these new morphological observations and of character states described recently by other authors, amendments to the diagnosis and definition of adult *Pterygosoma* are proposed. Questions are raised about the conspecificity of presumed syntypes of *P. persicum* Hirst, 1917, and of specimens of *P. tuberculata* Jack, 1962a, identified by its author. The number of idiosomal lyrifissures present in *Geckobiella diolii* (Baker, 1998) (new combination for *Hirstiella diolii* by Paredes-León *et al.* (2012)) is corrected from four to two.

Key words: Reptilia; Uromastycinae; eyed dabb lizard; scale mite; slit organ; cupule

Introduction

Mites infesting a captive ocellated spinytail (Squamata: Agamidae: *Uromastyx ocellata*) were submitted to the Natural History Museum, London (NHM) for identification. All belonged to the genus *Pterygosoma* (Prostigmata: Pterygosomatidae), members of which are blood-feeding ectoparasites of Afrotropical, Asian, Neotropical, North African and Oriental lizards. They are adapted to living under the scales of their hosts, hence their common name of scale mites. The submitted specimens closely matched the original description of *P. aegyptiaca*, a species known only from its type locality in Egypt and its type host *Uromastyx* sp. (Mostafa 1974), and one that was omitted from the most recently published inventory of *Pterygosoma* (Bertrand *et al.* 2000). *Pterygosoma aegyptiaca* is unique in that it is the only member of the genus that has been recorded from lizards of the agamid subfamily Uromastycinae. The majority of the others (57 species and 10 subspecies) occur on members of the subfamily Agaminae (Mostafa 1974, Bertrand *et al.* 2000, Bertrand & Modry 2004, Bochkov *et al.* 2009, Fajfer 2013a, b, Fajfer & González-Acuña 2013, Fajfer & Melnikov 2014, Fajfer 2016, Fajfer *et al.* 2016). The remainder are one species from the Draconinae (Jack 1962a) and respectively three and seven from the squamate families Gerrhosauridae (Lawrence 1935) and Liolaemidae (de la Cruz *et al.* 2004, Fajfer & González-Acuña 2013, Fajfer 2014). Lawrence (1959) proposed his new subgenus *Gerrhosaurobia* for the species he described from gerrhosaurids, the remaining members of the genus being accommodated in the nominotypical subgenus.

Apart from its species identity, no data could be obtained for the host of the submitted sample of *P. aegyptiaca* and so more examples were collected from *U. ocellata* deposited in the NHM's reptile collection. Certain character states shared by mites from both sources differed from those described by Mostafa (1974), but unfortunately type material could not be located for comparison. Nevertheless, these differences were judged to be explainable and insufficient to warrant proposing a new species name. Consequently, a redescription of *P. aegyptiaca*, with an updated geographical and host range, is presented here.

Materials and methods

Six specimens of alcohol-preserved *U. ocellata* deposited in the reptile collection of the NHM were searched for mites. Before examination under a dissecting microscope, each lizard was placed on several layers of paper towelling in order to draw off excess preservative (80% industrial methylated spirit, IMS). Mites were found on two hosts and removed using a fine paintbrush or mounted needle and stored in 80% IMS. Each specimen was then prepared for compound microscopy by mounting in 60% lactic acid on a flat glass slide, covering with an 18 mm diameter coverslip and warming on a hotplate (*ca.* 70°C) until cleared. Three mites were then dismembered (by pressing down on the coverslip) so that the various body parts could be more easily orientated for observation. Specimens were examined, measured and drawn using a Zeiss Axioskop 2 plus compound microscope with Differential Interference Contrast optics (DIC), a stage calibrated eyepiece graticule and a *camera lucida*. Photomicrographs were taken through an Olympus SZ11 stereo microscope fitted with a Nikon Coolpix 995 digital camera (Fig. 19), an Axioskop with a Canon EOS450D (Figs. 28–30) and an Olympus BX63 (Figs. 20–27, 31). After the morphological study had been completed, specimens were permanently mounted in Hoyer's medium.

Measurements are given in micrometres (μm) as the mean followed by the range or as a range only. The setae were often broken and/or too curved to measure accurately and therefore their lengths are not definitive.

If a term is followed by another in parentheses, the latter is that used by the author whose work is being discussed. The equivalent term is given at first mention only.

Notations used for setae of the ano-genital area and subcapitulum follow those of Grandjean (1944), while those for palpal and coxal setae follow Grandjean (1946) and Grandjean (1934) respectively. The leg setae are notated according to the system devised for acariform mites by Grandjean (1940) and applied to other prostigmatid families such as the Tuckerellidae (Quiroz-Gonzalez & Baker 1984), Tarsonemidae (Lindquist 1986) and Eupodidae (Baker 1990). This system was chosen over that of Grandjean (1944) which has been used for *Pterygosoma* and other pterygosomatids by some authors, *e.g.*, Bochkov and OConnor (2006), Paredes-León *et al.* (2012), Fajfer (2013a) and Quiroz-Gutiérrez *et al.* (2015). This preference is because the application of a single nomenclatorial system to the Acariformes will simplify the comparison of setae on homologous palp- and podomeres within the superorder.

Family Pterygosomatidae Oudemans, 1910

Pterygosoma Peters, 1849

Type species: *Pterygosoma agamae* Peters, 1849, 87, by monotypy.

Diagnosis (amended)

Pterygosoma can be distinguished from all other genera in the family by the following combination of character states: idiosoma usually clearly wider than long, sometimes subcircular; idiodorsal chaetotaxy usually hypertrichous, sometimes hypotrichous, setae often forming paired anterolateral clusters; lateral margins of hypostome parallel along whole length; coxal setae smooth and fine; solenidion of tarsus I much shorter than associated fastigial seta.

Definition (amended)

Adult: idiosoma usually clearly wider than long, occasionally as wide as long or slightly longer than wide, never inverted pear-shaped; dorsum with or without weakly defined prodorsal shield; eyes present or absent; idiodorsal chaetotaxy usually hypertrichous with most setae concentrated in 1 or 2 pairs of dense anterolateral clusters, sometimes clusters absent and/or pairs few in number, but setae never more or less evenly distributed over whole surface or forming transverse segmental rows; 0, 1 (*ip*) or 2 (*ip*, *ih*) pairs idiosomal lyrifissures present, each comprised of circular region with small central pore and short, longitudinal fissure in overlying cuticle; female ano-genital area usually mostly dorsal, sometimes mostly or wholly ventral; male ano-genital opening dorsal, aedeagus directed anteriorly or posteriorly; hypostome with lateral margins parallel along whole length, never expanded apically; cheliceral shaft with swollen basal and slender distal part, movable digit with or without basal tooth; palp with variously developed thumb-claw complex, palp tarsus with or without solenidion ω ; combined leg coxae I–II and III–IV located ventrally along anterolateral idiosomal margins; coxal setae smooth and fine, never ornamented or greatly thickened; a distal, slightly anterolateral microseta (κ) present on genu I of at least some species; tarsi I and II each with one solenidion, usually closely associated with much longer fastigial seta.

Remarks

A prodorsal shield (= scutum) is conventionally regarded as absent in *Pterygosoma* (e.g., Zumpt 1961, Bertrand *et al.* 2013). The dorsal unstriated area in *P. aegyptiaca* is proposed as a prodorsal shield because its shape is consistent in all specimens and the boundary seems no less defined than in species acknowledged to have such a shield, e.g., *Geckobiella trombidiformis* Berlese. Despite manoeuvring idiosomal cuticle of the dismembered specimens into different positions, the unstriated areas retained the same shape and appearance, and so were apparently not the result of adhering debris or cerotegument (Fig. 22). The creases in the shield were possibly made during or accentuated by the mounting process. Their number appears to be related to the age of the specimen or the time spent in preservative as there were fewer in the mites originally submitted to the NHM. Of the other species examined during the present study (Table 1), creased and unstriated cuticle could only be seen as clearly as in *P. aegyptiaca* in one *P. persicum* (Fig. 28). Such areas were suspected in some *P. inermis* Trägårdh, 1905, and *P. sinaita* Jack, 1961, and in other *P. persicum*, but the specimens were not sufficiently cleared to be certain.

The structures identified as idiosomal lyrifissures in *P. aegyptiaca* are the first to be recorded in *Pterygosoma* and have the same form as those seen in other pterygosomatids (see **Discussion**). A cursory survey of the genus (Table 1) found *ip* and *ih* in similar positions in one female *P. tuberculata* (Fig. 30), and *ip* in three female *P. adramitana* Jack, 1961, two *P. sinaita*, four *P. inermis* and three *P. persicum* (Fig. 29). The lyrifissures of *P. aegyptiaca* could be obscured by slight changes in idiosomal orientation and so the failure to discern them in particular individuals and species is not seen as conclusive proof of their absence. In two species, however, the conspecificity of the material examined is questionable. Hirst's and Jack's specimens of *P. persicum* were collected at different times from the same host species and province of Iran. In both samples, the idiodorsum of mites with and without lyrifissures has respectively two and five to seven pairs of setae in the inner anterolateral cluster. Also, the former specimens have about 10

pairs of long posteromarginal idiosomal setae confined to the lateral areas and similarly long posterior mid-dorsals and pseudanal setae ps_1 (Figs. 28, 29). By contrast, the latter have about 20 pairs of long setae usually distributed along most of the posterior margin and markedly shorter posterior mid-dorsals and ps_1 , as in figure 17 of Hirst (1926). Jack (1962b) noticed the variation too as he highlighted the length difference between the posterior mid-dorsals. The *P. tuberculata* with idiosomal lyrifissures has posteromarginal (peripheral) and pseudanal (genital) setae that are, as Jack (1962a) described, apically flattened and expanded (Fig. 30). Those apparently lacking lyrifissures have setae that taper to a point. Also, the two pairs of minute ventral spines described by Jack (1962a) (Fig. 30) could not be discerned in these specimens. In contrast to the *P. persicum* material, specimens with and without lyrifissures were collected from different hosts and localities, respectively India, *ex Laudakia tuberculata* (Gray)) and South Tibet, *ex Paralaudakia himalayana* (Steindachner) (Jack 1962a, b).

TABLE 1. Pterygosomatid material (adults) examined for presence of idiosomal lyrifissures (pair seen when notation in brackets, only one when not).

Species	NHM slide no./details	No. of specimens	Lyrifissures seen
<i>Pterygosoma adramitana</i>	1966.2.22.775–779(1–3) ¹	3 ♀	(ip)
<i>P. agamae</i>	1926.XII.31.71–74 ²	5 ♀	–
<i>P. inermis</i>	1926.XII.31.80–82, 82A ²	4 ♀	(ip)
	1926.XII.31.83 ²	2 ♀	–
<i>P. melanum</i>	1926.XII.31.84, 85 ²	2 ♀	–
<i>P. neumanni</i>	1926.XII.31.75 ²	1 ♀	–
<i>P. persicum</i>	1926.XII.31.87 ^{2,3}	1 ♀	(ip)
	1926.XII.31.86, 88, 89 ⁴	3 ♀	–
	1966.2.22.851–860(1, 2) ⁵	2 ♀	(ip)
	1966.2.22.851–860(3) ⁵	1 ♀	–
<i>P. sinaita</i>	1966.2.22.303–309(1, 2) ⁵	2 ♀	ip
	1966.2.22.303–309(3) ⁵	1 ♀	–
	1966.2.22.303–309 ⁵	2 ♂	–
<i>P. tenuisetis</i>	1966.2.22.680–4(part) ⁵	1 ♀	–
<i>P. tuberculata</i>	1966.2.22.258–260(1, 2) ⁵	2 ♀	–
	1966.2.22.263(1) ⁵	1 ♀	(ip), (ih)
<i>Geckobiella pyriformis</i>	1964.4.1.1 ⁶	5 ♀	(ip), (ih)
<i>G. nr texana</i>	<i>ex</i> granite spiny lizard (<i>Sceloporus orcutti</i> Stejneger) ⁷	1 ♂, 1 ♀	(ip), (ih)
<i>G. trombidiformis</i>	1920.10.29.1 ¹	1 ♀	(ip), (ih)

¹ syntype/s; ² S. Hirst determination; ³ probably one of the specimens described by Jack (1962b, p. 288); ⁴ presumed syntype figured by Hirst (1926, p. 198); ⁵ K.M. Jack determination; ⁶ paratypes; ⁷ A.S. Baker determination.

The distal structure on genu I designated microseta κ was seen in all *P. aegyptiaca* collected (Figs. 9, 27). Three genual setae were present and so there was no confusion with an empty setal socket. A microseta was also identified in the same position in examples of the other species examined (Table 1). Because the microseta is so small, its form needs to be confirmed at higher magnifications than were available in this study, *e.g.*, by scanning electron microscopy. *Pterygosoma* now joins *Bertrandiella* Paredes-León, Klompen & Pérez, *Geckobia* Mégnin and *Geckobiella* Hirst *sensu* Paredes-León *et al.* (2012) as a possessor of a genual I microseta (Baker 1998, Paredes-León *et al.* 2012, Quiroz-Gutiérrez *et al.* 2015). Definitive data could not be found for the other genera in the family (*Bharatoliaphilus* Prasad, *Callopiestiella* Silva-de la Fuente *et al.*, *Cyclurobia* de la Cruz, *Ixodiderma* Lawrence, *Pimeliaphilus* Trägårdh, *Scaphothrix* Lawrence, *Tequisistlana* Hoffmann & Sanchez and *Zonurobia* Lawrence). If a microseta is confirmed in these taxa, its presence will become a character state that, assuming homology can be established, is plesiomorphic for the family.

Redescription

Pterygosoma aegyptiaca Mostafa

(Figs. 1–27)

Pterygosoma aegyptiaca Mostafa, 1974, 96.

Diagnosis

The female differs from that of all other *Pterygosoma* species by the form of the pseudanal setae: each comprises a short stalk bearing a longitudinally striated, flattened ovate part which narrows to a dentate apex. It is also unique in having setal complements of 1-1-1-0 on leg trochanters I–IV, in combination with 3-1-1-1 on the femora and genua.

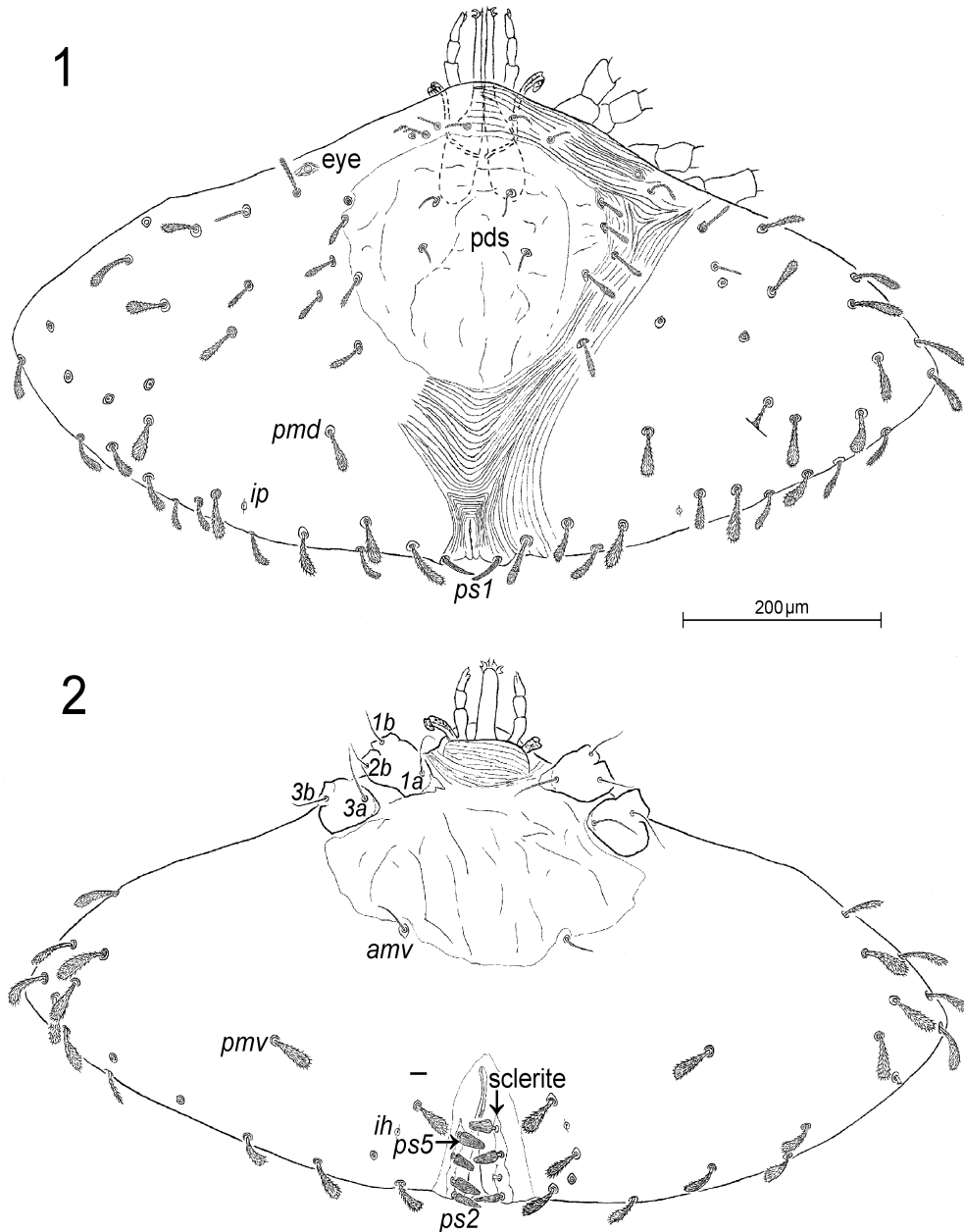
Female (12 specimens examined)

Idiosoma – dorsum (Figs. 1, 20–22). Maximum width (between lateral angles) 904(760–1080), median length 449(400–520), width 2.04(1.72–2.22) times length. Cuticle clearly striated apart from across creased, roughly oval prodorsal shield posterior to anteriormost setae, median length of shield 213(195–225), greatest width 275(263–285). One pair lensed eyes located near anterior margin posterior to where legs III–IV emerge, diameter 8–9. Setae: 28–37 + 29–36 present (excluding those of ano-genital area), none forming clusters, unpaired ones variously positioned; 2 pairs medially on prodorsal shield, weakly spinose, simple, taper to fine point, often broken and appear blunt, no specimen with all 4 setae intact, but measurements of apparently unbroken ones indicate pairs subequal, *ca.* 35–43 long; 2 weakly spinose, simple pairs on striated cuticle anterior to prodorsal shield (4 + 2 setae in 1 specimen), inner slightly longer than outer pair, 33(31–36) versus 28(23–33); remaining setae 30–60 long; *ca.* 9 spinose, simple to weakly subclavate pairs (all appear simple in lateral view) in areas flanking prodorsal shield, 1 pair usually inserted in small indentations in anterolateral margins of shield (absent in 2 specimens) and 2 on or slightly outside lateral margins; remaining setae spinose, clavate (simple when viewed laterally, subclavate at an angle); only posterior pair (*pmd*) of mid-dorsals identifiable, 45(38–50) long; *ca.* 8–13 + 9–12 setae along or near posterior margin. Lyrifissures *ip* submarginal, posterior or posterolateral to *pmd* setae; smaller in diameter than setal sockets (form as in Fig. 26).

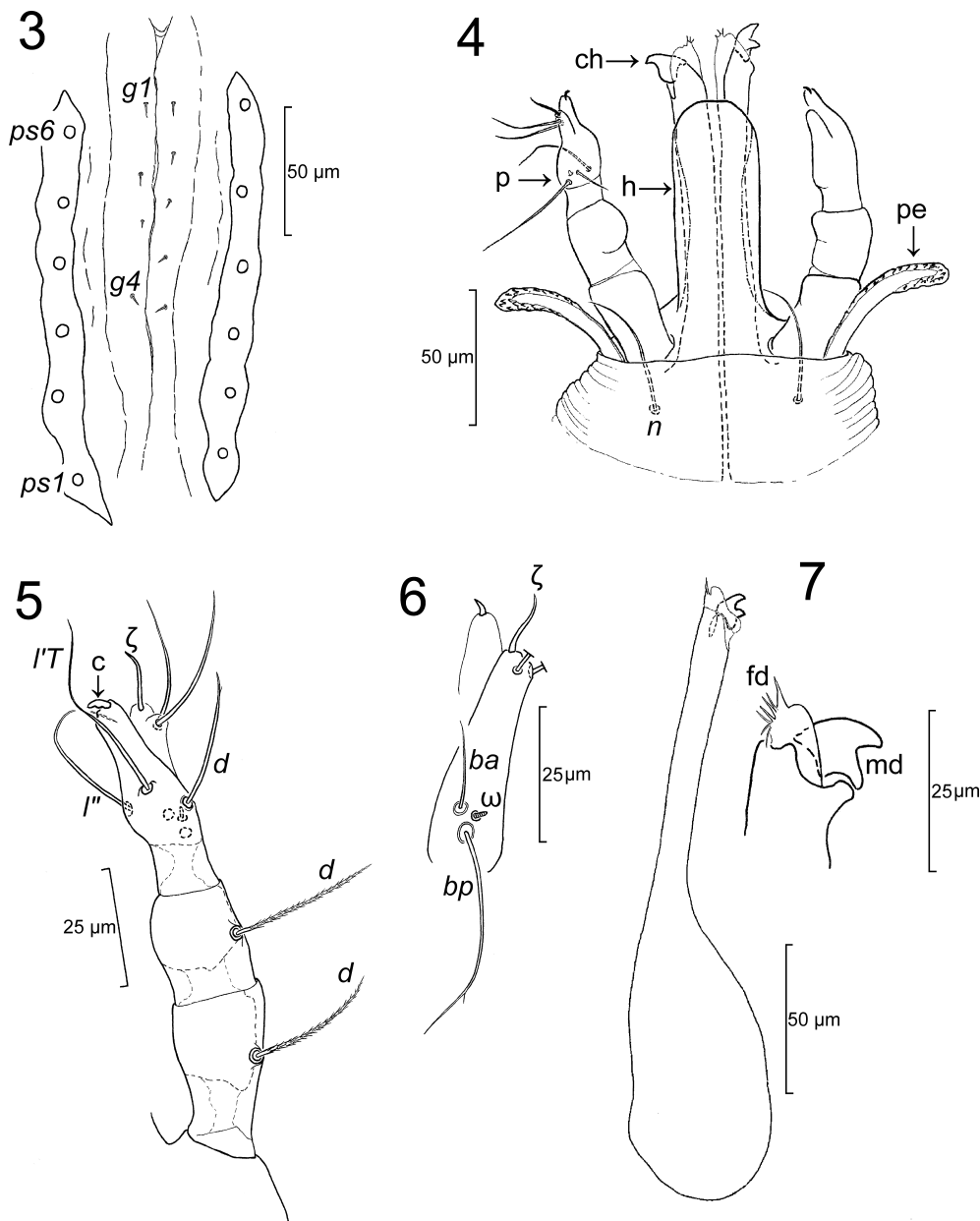
Idiosoma – venter (excluding ano-genital area) (Fig. 2, 23, 26). Cuticle striated apart from across creased area (as for prodorsal shield) between leg coxae which reaches just posterior to anterior mid-ventral setae (*amv*) and to lateral limits of coxae IV. Coxae I–II and III–IV in close proximity to each other on either side of body; setal complement (I–IV) 2-1-2-0, setae inserted within coxal fields, all smooth, filiform, *1a* and *3a* slightly the thickest and longest, 54(50–58) and 57(53–63) respectively, *1b* 48(43–54), *2b* 40(38–53), *3b* 46(38–53). Two pairs mid-ventral setae, *amv* inserted slightly outside margin of unstriated cuticle, weakly spinose, filiform, 44(35–50) long, posterior pair (*pmv*) posterolateral to *amv*, spinose, clavate, 41(37–45) long. Remaining 12–16 + 13–16 setae spinose, subclavate or clavate, 38–55 long, unpaired setae variously positioned, *ca.* 6–9 + 8–10 on or near posterior margin, 3 clavate pairs flank ano-genital area (3 + 4 setae in 1 specimen), lyrifissures *ih* sited between anterior 2 pairs, same form as *ip*.

Ano-genital area (Figs. 2, 3, 24, 25). Folds bordering opening weakly developed. All pseudanal setae comprise short stalk bearing longitudinally striated, flattened ovate part which narrows to dentate apex, 41(34–48) long; 6 specimens with 6 pairs, 3 with 5, 2 with 6 + 5 setae, 1 with 7 + 8; each longitudinal row inserted in sclerite on fold, sockets of respective pairs slightly staggered so that setae interleave; usually *ps*₁ or *ps*_{1 & 2} dorsal, *ps*₂ or *ps*₃ terminal and remainder ventral. Genital setae smooth, fine, minute, 5–6 long, number difficult to confirm because view obscured by creases

in soft cuticle bordering opening, but at least 4 pairs observed (4 + 5 setae in 1 specimen); g_1 inserted approximately between ps_6 , g_2 and g_3 on either side of ps_5 , and g_4 between ps_4 & 3 .



FIGURES 1–2. *Pterygosoma aegyptiaca* Mostafa, female. 1, Idiosoma, dorsal view; 2, Idiosoma, ventral view. *amv* = anterior mid-ventral seta, *ih/ip* = lyrifissure, *pds* = prodorsal shield, *pmd* = posterior mid-dorsal seta, *pmv* = posterior mid-ventral seta, *ps* = pseudanal seta.



FIGURES 3–7. *Pterygosoma aegyptiaca* Mostafa, female. 3, ano-genital area, *g* = genital seta, *ps* = pseudanal seta; 4, gnathosoma, ventral view, *ch* = chelicera, *h* = hypostome, *p* = palp, *pe* = peritreme; 5, palp, paraxial view; 6, palp tarsus, ventral view; 7, chelicera, lateral view, with detail of digits, *fd* = fixed digit, *md* = movable digit.

Gnathosoma (Figs. 2, 4–7). Located under ventral, transversely striated fold. Subcapitulum: hypostome with smooth, flattened apex, 98(88–109) long; 1 pair smooth filiform setae (*n*) inserted posterior to palp bases, 48(43–53) long. Palps: extend to between tips of hypostome and chelicerae; thumb-claw complex well-developed; setal complement (femur–tarsus, solenidion in brackets) 1-1-3-5(ω), all setae simple; femur and genu with weakly spinose dorsal seta *d*, that of femur usually

slightly shorter (29–34 versus 32–36); tibia terminates in small curved claw, *ca.* 5 long, setae (*d*, *l'**T*, *l''*) smooth, although single subterminal spine seen on *d* in 2 specimens, *l'T* and *l''* extend past tip of tibia by about half their lengths, *d* reaches or only slightly surpasses it; tarsus terminates in 2 small lobes, distal bears curved eupathid (ζ), 15–17 long, and proximal 2 smooth, subequal setae, *ca.* 28–33 long, basal group of ventral setae comprises short blunt antiaxial solenidion ω , *ca.* 4–7 long, paraxial smooth *ba* slightly anterolateral to ω , 15–19 long, and posterior smooth *bp* (occasionally with subterminal spine) at least 2.5 times length of *ba*. Chelicerae: total length 207(201–222), slender distal section of shaft 1.02–1.2 times longer than swollen base; robust movable digit with antiaxially curved terminal and basal teeth, total length 11–14; fixed digit membranous, pointed paraxially, sometimes denticles proximal to base of point evident, denticles revealed as 5–6 times when chelicera rotated. Emergent part of each peritreme reaches to about distal limit of palp genu.

Legs (Figs. 8–18, 27). Pair IV slightly the longest, lengths (from base of trochanter to tip of tarsus, excluding ambulacrum) I 247(215–280), II 226(200–263), III 241(225–270), IV 257(240–285); genua have 3 small processes near dorsodistal margin, posterolateral 2 closest together (Fig. 9); lyrifissure lies in slight dorsal depression at base of each tarsus, comprises transverse ridge with median pore (as in Fig. 31); ambulacra stalked with 2 robust claws each bearing 2 tenent hairs, that on inner surface the shorter (on a few claws, there appear to be 2 closely associated setae on one or both surfaces). Setal complements (I–IV, solenidia and microseta in brackets): trochanters 1-1-1-0, femora 3-1-1-1, genua 3(κ)-1-1-1, tibiae 5-3-3-3, tarsi 13(ω)-8(ω)-8-8. Lateral and ventral setae on trochanters, genua and tibiae simple, weakly spinose, dorsals usually more strongly spinose, simple or weakly subclavate, degree of expansion varies but generally increases from I–IV and tibia–femur. Trochanters I–III with anterolateral seta *l'*. Leg I (Figs. 8–11, 27): femur with dorsal seta *d*, *l'* and posteroventral *v''*, *d* usually weakly subclavate, sometimes simple; genu with simple *d* and pair of laterals (*l'*, *l''*), apparently spiniform microseta κ sited anterolateral to *d*, *ca.* 4 long; tibia with simple *d*, *l'*, *l''* and pair of ventrals (*v'*, *v''*); tarsus with slender, smooth fastigial seta (*ft''*) inserted just proximal to where podomere narrows, in lateral view often more upright than other setae, socket contiguous with that of much shorter blunt dorsodistal solenidion ω , 15–18 long, spinose prorals (*p'*, *p''*) present distal to *ft''*, comprise short slender stalk and oval head, tectals (*tc'*, *tc''*) and iterals (*it'*, *it''*) respectively dorsal and slightly dorsolateral to ambulacrum, all smooth blunt eupathids (ζ) and each inserted on tubercle, antilaterals (*a'*, *a''*) slightly proximal to iterals, unguinals (*u'*, *u''*) ventral to ambulacrum, both latter pairs smooth, pointed, curved distally, primiventrals (*pv'*, *pv''*) spinose, located in proximal half of podomere. Legs II (Figs. 12, 13): *d* of femur usually weakly subclavate, occasionally simple; *d* of genu simple; tibiae with simple *d*, *v'* and *v''*; tarsus differs from I by lacking tectals, iterals and *pv''*, ω is 6–8 long, its socket being close to but separate from that of weakly spinose *ft''*. Legs III–IV (Figs. 14–18): chaetotaxy as for II except *d* setae on femur–tibia typically weakly subclavate, occasionally simple, and tarsi with slightly more strongly spinose *ft''* and without solenidion.

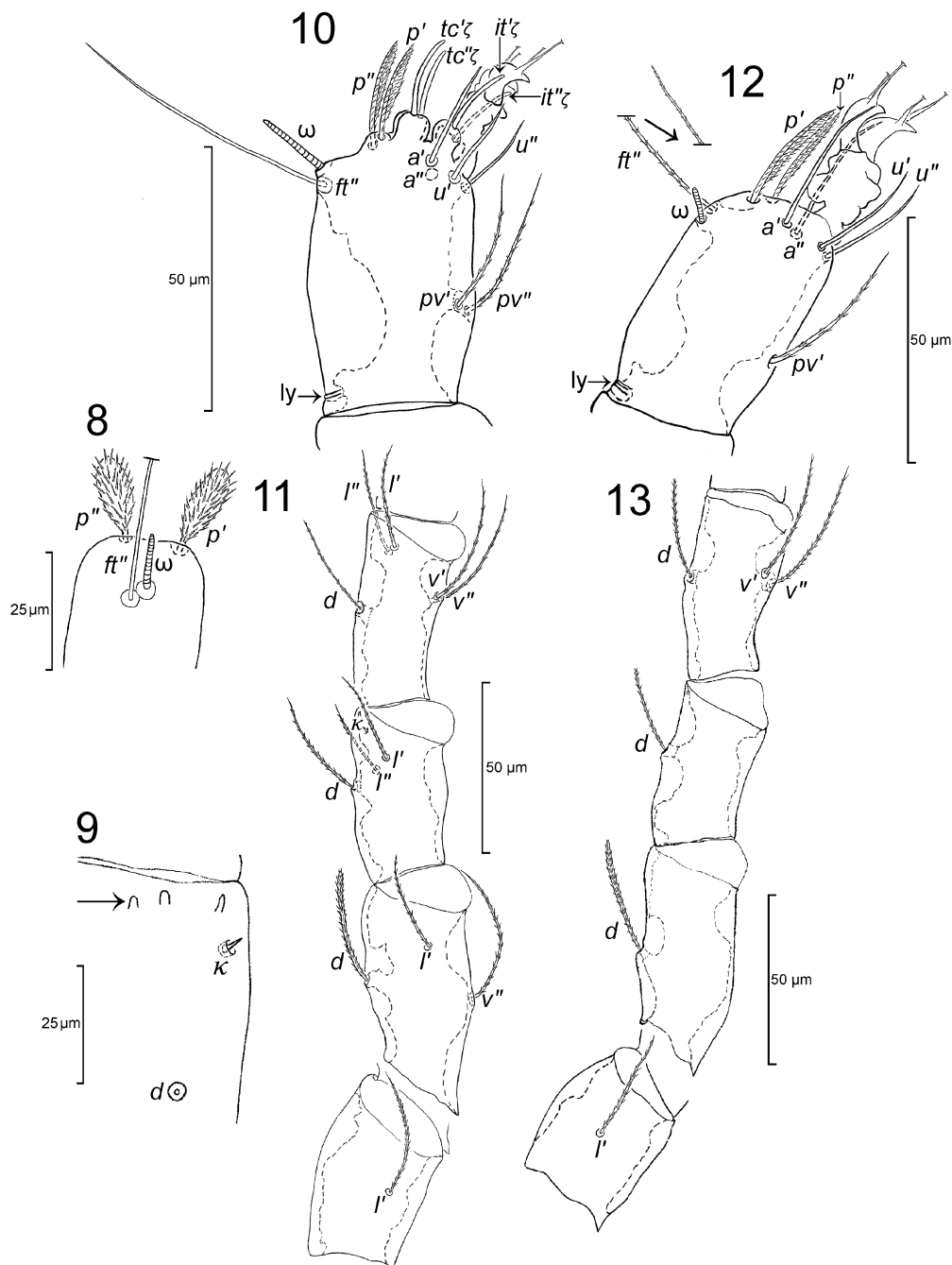
Male. Unknown.

Pre-adult stages. Two specimens contain 2–4 subcircular eggs, 170–215 x 175–243; larva and nymphs unknown.

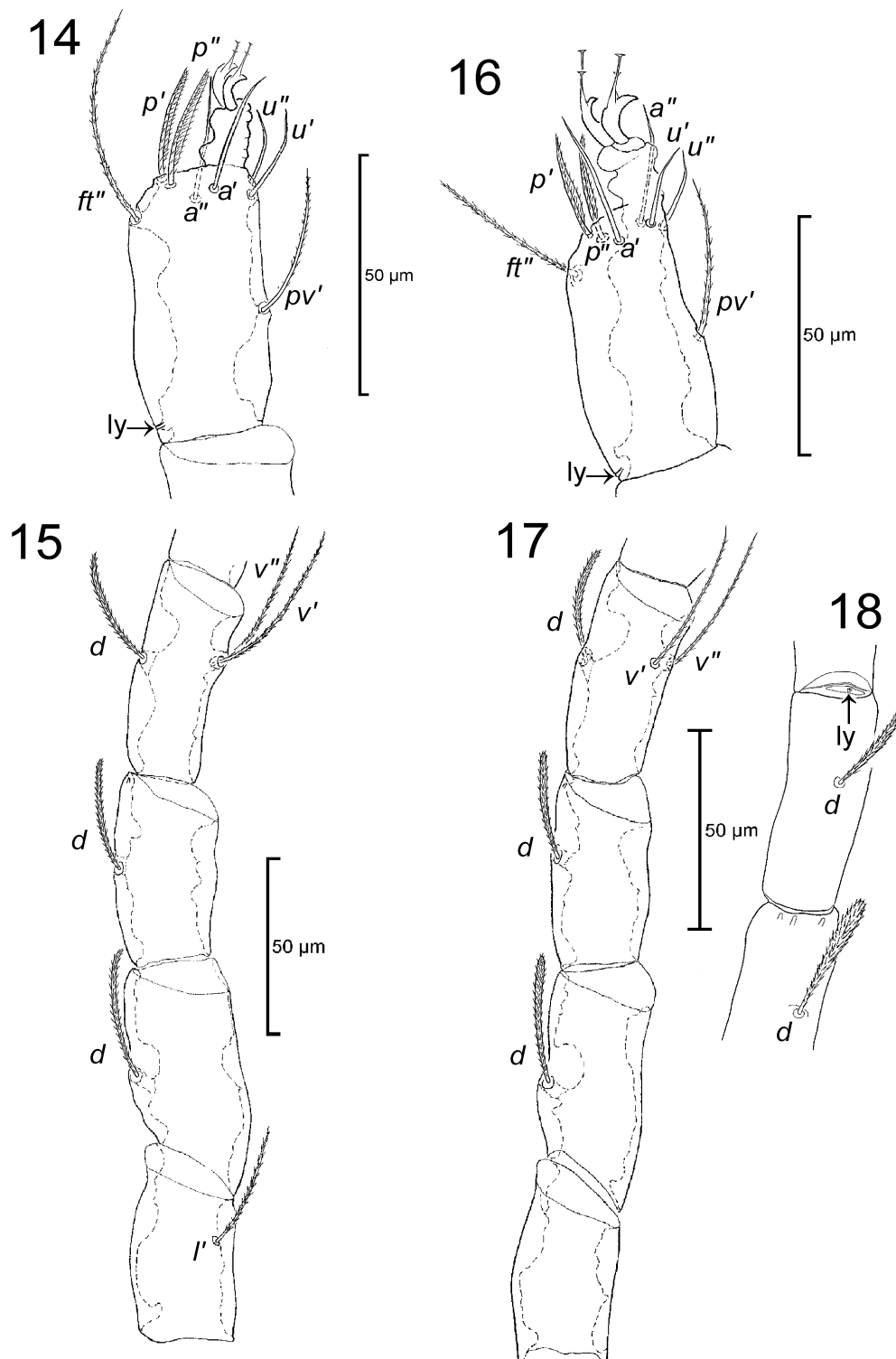
Material examined

Pterygosoma aegyptiaca. Three females: Sudan, Northern State, Wadi Halfa, *ex Uromastyx ocellatus* Lichtenstein (Reptilia: Agamidae), host donated by Dr J. Anderson, no date given, NHM 1897.10.28.200–201; under scales on underside of body at base of tail, coll. A.S. Baker, 11.ii.2016. Eight females: Sudan, Red Sea State, near Sinkat, *ex U. ocellatus*, host coll. P.W. Lowe, 28.iii.1914,

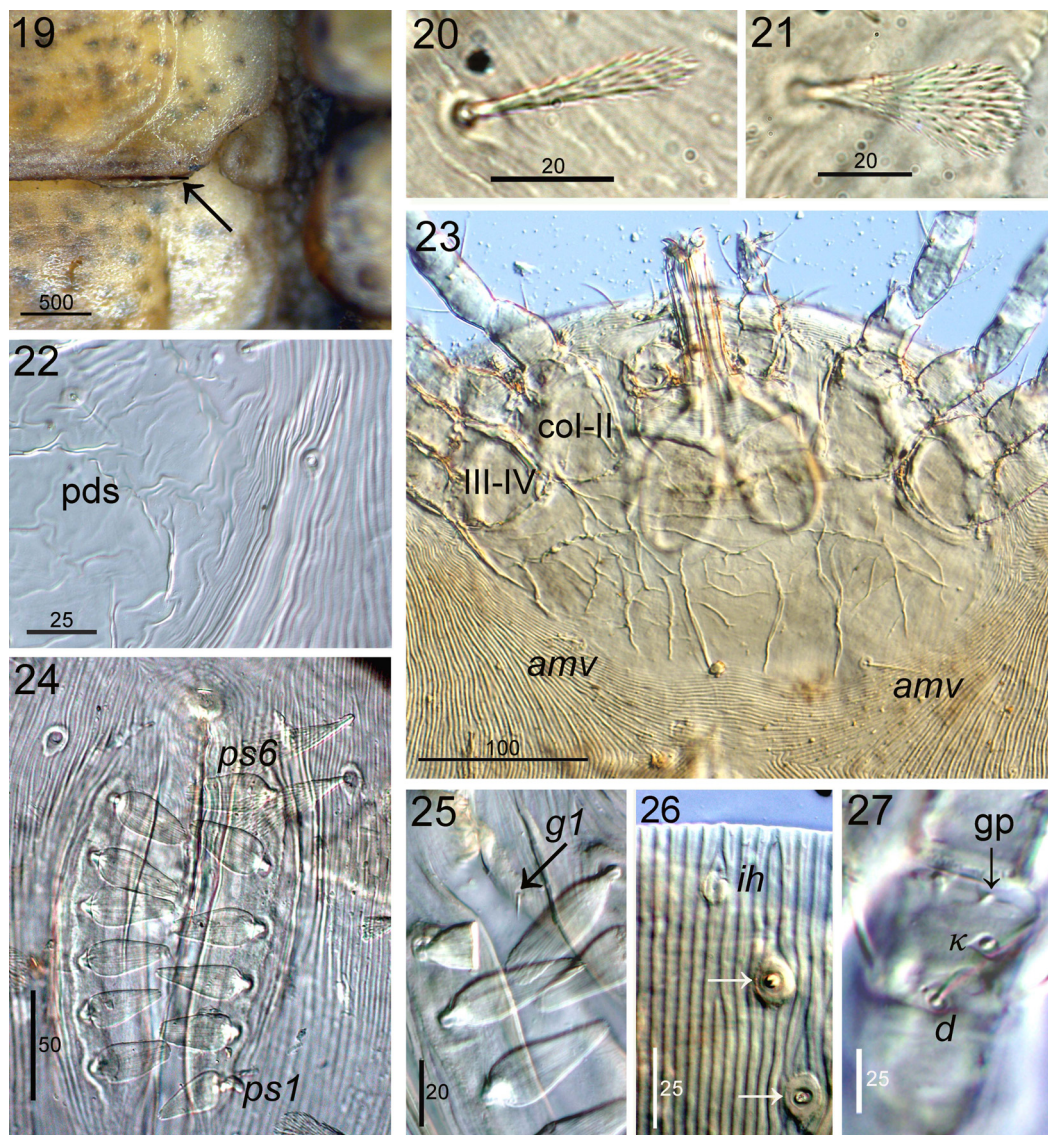
NHM 1914.5.14.13; on dorsal or ventral surface between whorls of tail scales (4), between ventral scales of tail whorls (3) (Fig. 19) and under scale on side of body near hind leg (1), coll. A.S. Baker, 12.ii.2016. All mites deposited in the Arachnida & Myriapoda collection of the Natural History Museum, London, BMNH(E)2017-168.



FIGURES 8–13. *Pterygosoma aegyptiaca* Mostafa, female. 8–11, leg I: 8, tarsus, dorsodistal part; 9, genu, dorsodistal part, process arrowed; 10, tarsus, anterolateral view; 11, trochanter–tibia, anterolateral view. 12–13, leg II, anterolateral view: 12, tarsus; 13, trochanter–tibia. ly = tarsal lyrifissure.



FIGURES 14–18. *Pterygosoma aegyptiaca* Mostafa, female. 14–15, leg III, anterolateral view: 14, tarsus; 15, trochanter–tibia. 16–18, leg IV: 16, tarsus, anterolateral view; 17, trochanter–tibia, anterolateral view; 18, distal genu–basal tarsus, dorsal view. ly = tarsal lyrifissure.



FIGURES 19–27. *Pterygosoma aegyptiaca* Mostafa, female. 19, specimen (arrowed) *in situ* between scales of tail whorl; 20, weakly subclavate seta flanking prodorsal shield; 21, clavate submarginal idiodorsal seta; 22, prodorsal shield (pds) and bordering striated cuticle; 23, intercoxal region, *amv* = anterior mid-ventral seta, *co* = coxa; 24, ano-genital area, *ps* = pseudanal seta; 25, anterior ano-genital area, *g* = genital seta; 26, ventral lyrifissure *ih*, empty setal sockets arrowed; 27, leg genu I, dorsal view, *gp* = genual process. Scale bars in μm .

Distribution

Egypt, Sudan (new record). Potentially occurs throughout the range of the host genus or species. Members of *Uromastyx* Merrem have been found in all North African countries bordering the Sahara Desert, and in Northeast Africa and most of the Middle East (Wilms *et al.* 2009). *Uromastyx ocellata* has been recorded in Djibouti, Egypt, Ethiopia, Eritrea, Somalia and Sudan (Wilms *et al.* 2009).

Justification for the species determination

The Sudanese specimens were first suspected to be conspecifics of those Mostafa (1974) described as *P. aegyptiaca* because they shared the unusual form of pseudanal setae, absence of

clustered anterolateral idiodorsal setae and lack of setae on leg trochanter IV. Subsequently, they were found to also have the same idiosomal dimensions, shape and length of most idiosomal setae, palpal form and chaetotaxy, blunt hypostome, cheliceral proportions, chaetotaxy of most podomeres and distinctly spinose (plumose) dorsal leg femoral setae. There were some differences, but unfortunately type material could not be located for comparison. The holotype was to have been deposited in the Rocky Mountain Laboratory (RML), Montana, USA, and the only paratype retained by the author (Mostafa 1974). The RML's Acari collection was donated to the US National Museum of Natural History (Smithsonian Institution) in 1983 and the ticks subsequently transferred to Georgia Southern University, USA. The holotype could not be located in either institution. It is possible that Mostafa retained all type material because paratypes of the species described in the same paper as *P. aegyptiaca* were destined for the NHM, but never deposited there. The location of Professor Mostafa's collection is currently unknown.

The species determination of the Sudanese specimens is regarded as valid because the discrepancies between their morphology and that described for *P. aegyptiaca* can be explained as follows (original description first):

1) No description of unstriated areas of prodorsal and intercoxal cuticle. Mostafa (1974) did not make any comment about ornamentation and so may not have thought it remarkable.

2) Anterior pair of prodorsal shield setae (mid-dorsal D_1) much shorter than posterior pair. Because these setae are evidently prone to breaking and Mostafa had only two specimens to examine, it is possible he did not have the opportunity to measure intact setae, which are probably subequal.

3) Setae flanking prodorsal shield cylindrical. These setae are usually weakly subclavate, the expansion being indiscernible in lateral view or so slight that it is not obvious at low power.

4) Three pairs palmate pseudanal (genital) setae and obvious pair of genital spines. Although described as palmate, *i.e.*, comprising lobes radiating from a common point, Mostafa illustrated the pseudanals with the form seen in the Sudanese material. Examination of a dismembered specimen confirmed the presence of more than three pairs of pseudanals and at least four of genitals. The terminal pseudanals usually lie so that they are seen side-on, giving the appearance of spiniform setae. Mostafa's pair of genital spines was undoubtedly one of the pseudanals, probably ps_3 . Dorsal pairs can be difficult to discern when specimens are viewed ventral side uppermost, which might explain Mostafa's low count. The genital setae are minute, cryptic and easily overlooked, and only first seen in the present study in a dismembered specimen.

5) Palp genual (segment II) seta drawn smooth. The spinose ornamentation was evident when specimens were viewed at high magnification (x1000). Mostafa might not have thought it necessary to use such a high power for observations.

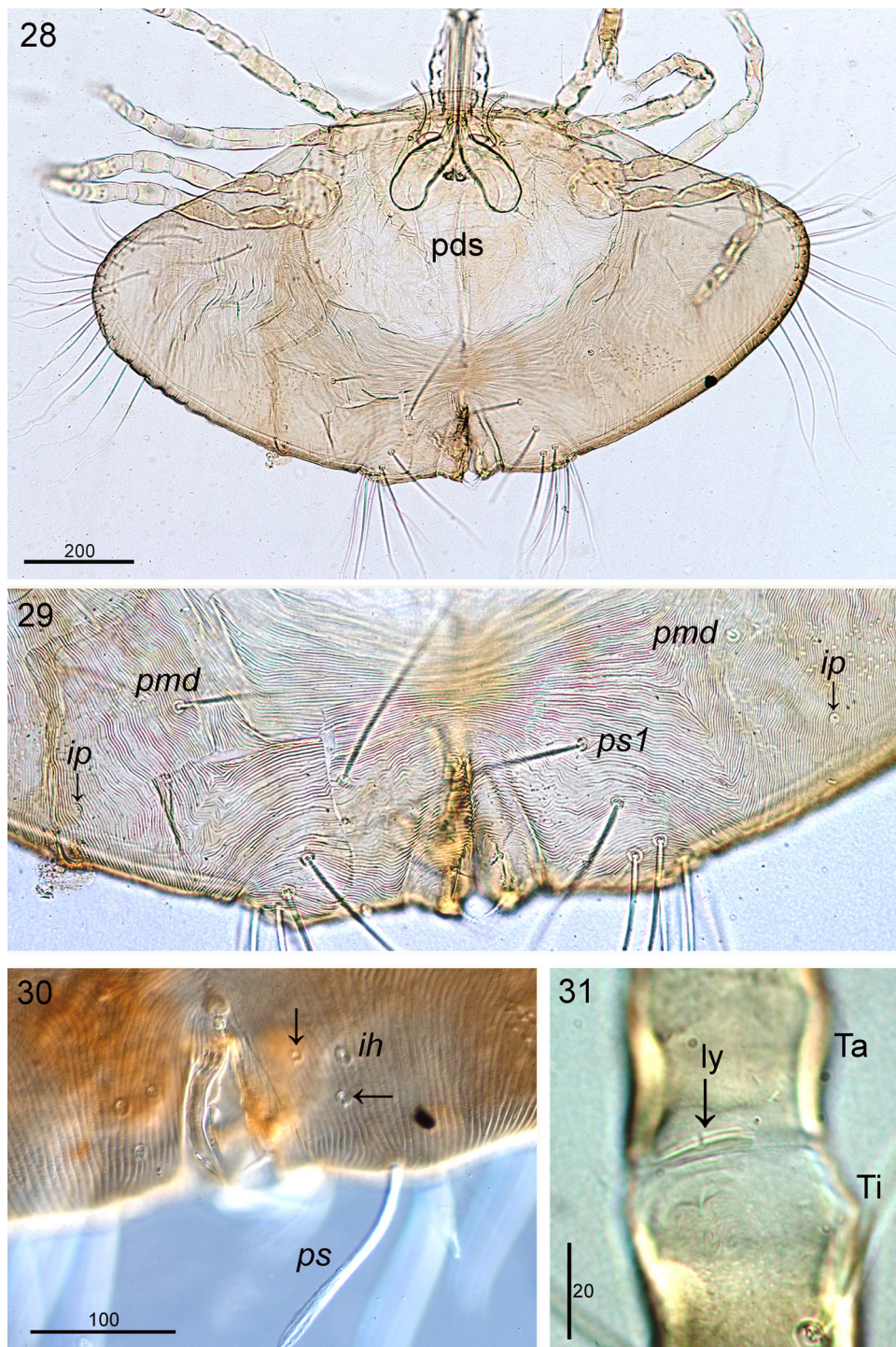
6) Ventral of two setae on proximal lobe of palp tarsus much longer than dorsal. When palps were rotated so that the setae could be seen from different angles, they appeared to be subequal.

7) Fixed cheliceral digit not illustrated or described with serrations or tines. The latter are not obvious at all angles and can be overlooked, especially in intact specimens.

8) Tibia IV has only two setae. According to Mostafa's figure 7, these were the pair of laterals, but he did not state whether this was the complement on both legs in both types. It is possible that he examined an aberrant specimen or that the dorsal setae had been lost and the empty sockets not discerned.

9) Tarsus I has two solenidia. The posterolateral fastigial seta (ft'') was wrongly identified as a solenidion (ω_2).

10) Tarsi III and IV have seven setae. In Mostafa's illustration, the anterolateral antilateral seta (a') is apparently absent. The antilaterals are slender and, hypothetically, he could not discern them amongst the other setae of the tarsal cluster.



FIGURES 28–31. 28–29, *Pterygosoma persicum* Hirst, female (NHM slide no. 1926.XII.31.87): 28, dorsal view, pds = prodorsal shield; 29, idiosoma, posterodorsal area, ip = dorsal lyrifissure, pmd = posterior mid-dorsal seta, ps = pseudanal seta. 30, *Pterygosoma tuberculata* Jack, female (NHM slide no. 1966.2.22.263(1)), ano-genital area, minute spines arrowed, ih = ventral lyrifissure, ps = pseudanal seta. 31, *Geckobiella* near *texana*, leg tarsus (Ta)–tibia (Ti) I, ly = tarsal lyrifissure. Scale bars in µm.

Taxonomic affinities of Pterygosoma aegyptiaca

Pterygosoma aegyptiaca does not show a particular morphological affinity to any of its congeners. Mostafa (1974) remarked that it was related in some features to the *melanum* species group (Jack 1962b), although did not specify which ones. As he himself pointed out though, members of the *melanum* group all have four pairs of rounded pseudanal setae, character states not possessed by *P. aegyptiaca*.

Jack (1962b) regarded the female ano-genital area as a source of valuable taxonomic characters and four of the five used to diagnosis his species groups for African *Pterygosoma* concerned the number, position and form of ano-genital setae. On this basis, *P. aegyptiaca* is closest to *P. sinaita* and *P. dhofarensis* Fajfer & Melnikov, 2014, which also have six pairs of pseudanal setae, at least half of them ventral, in combination with four pairs of spiniform genital setae. Both species differ most obviously from *P. aegyptiaca* in having the anterior idiodorsal setae arranged in two pairs of clusters (vs. no clusters), only two pairs of posteromarginal setae (vs. > 8 pairs), larger ano-genital folds, all or most pseudanal setae expanded distally (vs. narrowed distally), no setae on genua II–IV (vs. 1) and one seta on trochanter IV (vs. 0).

Although unusual within the genus, the lack of anterolateral clusters of idiodorsal setae is not unique to *P. aegyptiaca*. More or less evenly distributed setae that obscure those Jack (1962b) designated mid-dorsals also occur in females of the subgenus *Gerrhosaurobia* (Lawrence 1935), *P. gracilipalpis* Jack, 1962a, *P. livingstonei* Bertrand & Modry, 2004, and the *ligare* group of Fajfer and González-Acuña (2013). In all these taxa, however, the setae are more numerous than in *P. aegyptiaca* (> 50 vs. < 40 pairs), while none possesses the complement of six pairs of pseudanal and four of genital setae.

Fajfer and González-Acuña (2013) gave the presence of a palp tarsal solenidion as a diagnostic character state to distinguish their *ligare* species group from the remaining members of the subgenus *Pterygosoma*. *Pterygosoma aegyptiaca*, however, was recorded with this solenidion both by Mostafa (1974) and in the present study, but it does not qualify for inclusion in the *ligare* group. In addition to having far fewer idiodorsal setae, differences include the presence of only three setae on tibiae II–IV (vs. five) and tarsal complements of 13(ω)-8(ω)-8-8 (vs. 14(ω)-10(ω)-10-10).

The leg chaetotaxy (trochanter–tibia) of *P. aegyptiaca* does not fit into any of the groups identified by Jack (1964). It is closest in setal complements to group 1, but differs in having a dorsal rather than ventral seta on tibiae II–IV, two lateral setae on genu I instead of an anterolateral and ventral one and no setae on trochanter IV. The lack of setae on trochanter IV is rare in the genus. It occurs in Jack's group 3, comprising *P. annectans* Jack, 1962a and *P. annectans circularis* Jack, 1962a, but these taxa have femoral and genual complements of 3-1-1-2 and 2-0-0-1 respectively versus 3-1-1-1 for both in *P. aegyptiaca*. Bertrand *et al.* (2000) recorded their new species *P. gladiator* with either one or no seta on trochanter IV, but the genual setation is 2-1-1-0. The tarsal chaetotaxy of *P. aegyptiaca* matches Jack's group A, which differs from his group B by possessing a pair of primiventral (basal latero-ventral) setae on tarsus I rather than a single one (*mv*). Examples of group B (*P. adramitana*, *P. inermis* and *P. tuberculata*) examined during the present study (Table 1) possessed both primiventrals, indicating that these groups need to be reassessed.

Discussion

Although always clearly wider than long, the idiosoma of the *P. aegyptiaca* examined showed some variation in the acuteness of the lateral angles. They were particularly rounded in one specimen where the width was only 1.72 times the median length (750 x 435), versus a mean of 2.08 in the rest

of the sample. This specimen was found under a scale on the side of the host's body near to one of the back legs. The scales in this area were narrower than those under which other specimens were found and so the shape difference may represent an adaptation to the attachment site. The extent of engorgement and time since moulting are other suggestions for the variation.

Idiosomal lyrifissures are regarded as segmental structures, *ip* being located on segment F and *ih* on H (Grandjean 1939a). The associated transverse rows of setae are obscured in female *P. aegyptiaca* by the hypertrichous chaetome and the merging of the anal and genital areas. However, the position of putative *ih* would indicate that the setal pairs flanking the ano-genital area are *h* setae. This in turn would give support for the setae on the ano-genital folds being pseudanals. In *P. tuberculata*, the only other member of the genus in which *ih* was identified, these lyrifissures are slightly external to the anterior of the two pairs of minute ventral spines that Jack (1962a) speculated were reduced pseudanal setae (Fig. 30). Applying Grandjean's system, the minute spines would be *h* setae.

Four of the species found with idiosomal lyrifissures belong to the *inermis* species group of Jack (1962a, b), diagnosed primarily by the unique presence of two pairs of anterolateral setal clusters on the idiodorsum. On this basis, the fifth species, *P. persicum*, would also qualify for inclusion as all specimens in which the setae could be discerned had two pairs of clusters. Jack (1962b), however, thought it was not closely related to any of his species groups and that it formed a 'group' on its own. He did not give supporting data, but, in his key, separated it out first in the subgenus *Pterygosoma* due to the possession of five to nine pairs of long, slender pointed pseudanal setae (Jack 1962a).

As mentioned above, lyrifissure form in *P. aegyptiaca* resembles that of other pterygosomatids (Baker 1998, this study). Both pairs are recorded here for the first time in female *G. pyriformis* (Newell & Ryckman) (new combination for *H. pyriformis* by Paredes-León *et al.* (2012)) and *G. trombidiformis*, and in a female and male of *G. near texana* (Banks) (specimens examined given in Table 1). In their description of *G. pyriformis*, Newell and Ryckman (1964) illustrated the male with a pair of cuticular structures lateral to dorsal setae f_1 and one ventrolateral to h_2 (their figures 20, 22 & 24), but neither was mentioned in the text. Both look like the lyrifissures of the paratype females seen in the present study and so are regarded as *ip* and *ih* respectively. *Geckobiella diolii* was originally described with four pairs of lyrifissures (*ia*, *im*, *ip*, *ih*) (Baker 1998), but the present author could not confirm the presence of *ia* and *im* during a recent re-examination of specimens. Thus the diagnosis of pterygosomatids as having only *ip* and *ih* is evidently correct (Walter *et al.* 2009).

The dorsobasal structures on the leg tarsi of *P. aegyptiaca* have a similar appearance to those designated as lyrifissures in other members of the superorder Acariformes (Grandjean 1937, 1939b, 1942, 1943). They also conform to the statement of van der Hammen (1989) that the acariform (actinotrichid) tarsus 'generally presents one proximal, dorsal lyrifissure; other pedal lyrifissures are never present'. In addition to *P. aegyptiaca*, the present author has seen them in all pterygosomatid species examined during this study (Table 1), and they may well occur throughout the family. Podal lyrifissures of prostigmatids have rarely been mentioned in morphological accounts, with the result that their prevalence in the suborder is uncertain. Lyrifissures are considered to be proprioceptors (= stress receptors) that receive information about changes in tension within the exoskeleton and then facilitate an appropriate response. Leg lyrifissures are more common in parasitiform than acariform mites and the only ultrastructural data originate from the work of Hess and Vlimant (1984, 1986) on ticks. These authors suggest three functions: co-ordinating walking activity by analyzing strains in the tarsal cuticle caused by body weight; perceiving gravity, and detecting substrate or airborne vibrations. *Pterygosoma* mites need to be able to recognize and react quickly to changes in their habitat, for example, to scales shifting during host movement or grooming, and lyrifissures would equip them for this.

The function of the three dorsodistal processes on the leg genua of *P. aegyptiaca*, and also in the other species examined here (Table 1), is unknown. Van der Hammen (1989) described levator movements of the leg tarsi of *Anystis* sp. (Prostigmata: Anystidae) being restricted by small dorsal tibial protuberances that fit into corresponding cavities in the tarsi. The processes of *P. aegyptiaca* do not overlap the genual–tibial margins, while corresponding small cavities in the tibiae could not be discerned by light microscopy. They may, however, have a similar function to the protuberances of *Anystis* by acting as backstops to prevent over flexing of the tibiae.

The order of the dorsal tarsal setae in pterygosomatids differs from that described for acariform mites by Grandjean (1940). In the majority of members whose chaetotaxy has been described, the setae on tarsi I are notated, from proximal to distal, fastigial, tectal, proral and iteral, whereas Grandjean describes the iterals as being between the tectals and prorals. Setae identified as prorals in pterygosomatids are always the only expanded pair (*e.g.*, Bochkov *et al.* 2009, Paredes-León & Guzmán-Cornejo 2015). This is supported by the present author observing a pair of expanded dorsodistal setae on the tarsi of an undetermined pterygosomatid larva (*ex.* NHM Arachnida collection). According to the two setal orders just described, these setae can only be prorals or iterals, but, because iterals always appear postlarvally (Grandjean 1941), they must be prorals. Setal positions in *P. aegyptiaca* are different again in that there are no setae between the fastigial and expanded setae (Fig. 10). Accepting that the latter are prorals, it is hypothesized that the tectals have migrated distally and slightly laterally to them.

To date, Bertrand *et al.* (2000) are the only authors to have described leg trichobothria in pterygosomatids. One was identified in the *ft*" position on tarsi III and IV of *P. gladiator* Bertrand *et al.*, 2000, and in the *d* position on tibia IV of *Geckobia glebosum* Bertrand *et al.*, 2000, and *Ge. squameum* Bertrand *et al.*, 2000, and on tibiae I, II and IV of *Hirstiella* sp. (remarks by the authors plus data in Paredes-León *et al.* (2012) suggest the latter belongs to *Pimeliaphilus*). All are illustrated with the characteristic form of the seta being nearer to the perpendicular and inserted in a socket with a comparatively wider and deeper socket than the other tactile setae. In *P. aegyptiaca*, the relatively erect, smooth and slender *ft*" of tarsus I was suspected of being a trichobothrium, but its socket does not appear to be noticeably wide or deep and so its status is uncertain at present. A greater knowledge of the number and distribution of different setal types within *Pterygosoma* might contribute valuable data for determining taxonomic boundaries and relationships.

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