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A NEW MITE SPECIES OF THE GENUS *PSORERGATES* TYRRELL (ACARI: PROSTIGMATA: PSORERGATIDAE) PARASITIC ON THE TREE SHREW *TUPAIA GLIS* FROM MALAYSIA AND SINGAPORE, WITH NOTES ON PATHOLOGY

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ABSTRACT. - A new species of psorergatid mite, *Psorergates fritzi,* from Malaysia and Singapore is described from the tree shrew *Tupaia glis*. The species is closest to *P. tupáiae* from Borneo but can be separated by its leg, aedeagus and dorsal shield structures. Notes on the histopathology of the species on *Tupaia glis* are also provided.

INTRODUCTION

Giesen *et al.* (1982) described three new species of mites of the family Psorergatidae from Malaysian small mammals. During a second five-week collecting trip in Peninsular Malaysia made by F. S. Lukoschus in 1982, one of the tree shrews, *Tupaia glis* collected in a disturbed rainforest in Fraser's Hill, Pahang, was found to be heavily infested with mites. The mites were of the genus *Psorergates* Tyrrell, 1883 and represented a new species very closely related to *P. tupaiae* Giesen & Lukoschus, 1982 found on *Tupaia dorsalis* in Sabah (Borneo). Additional material of adults and nymphs of the new species were recovered from a specimen of *Tupaia glis* from Bukit Timah Forest Reserve in Singapore in 1985. To date, 70 species of mites of the family Psorergatidae are known. All stages are obligate parasites of a number of host orders, all of which are characterised by strongly reduced chaetotaxy. It appears that *Psorergates* species from Tupaiidae are most closely related to species from sciurid hosts.

In this paper, the new species of *Psorergates* is described and illustrated in detail based on material collected in Peninsular Malaysia. Observations on histopathology are also provided. All measurements are in micrometers (μm).

Specimens are deposited in the British Museum (Natural History) (BMNH), London; Museum of Zoology, University of Michigan (MZUM), Ann Arbor; Acarology Laboratory, Columbus (ALC), U. S. A.; United States National Museum of Natural History (USNM), Smithsonian Institution, Washington D. C.; Rijksmuseum van Natuurlijke Historie (RMNH), Leiden; Zoologisches Institut und Zoologisches Museum (ZIM), Hamburg; Zoological Reference Collection (ZRC), Department of Zoology, National University of Singapore; and the personal collections of the authors.

TAXONOMY

FAMILY PSORERGATIDAE

GENUS *PSORERGATES* TYRRELL, 1883

Psorergates fritzi, new species

(Figs. 1-9)

Material. - Holotype female (BMNH) ex *Tupaia glis* (Scandentia: Tupaiidae), disturbed primary rainforest, Fraser's Hill, Pahang, Peninsular Malaysia, 1200 m asl, coll. F. S. Lukoschus & M. Nadchatram, 8.x.1982.

Allotype - male (BMNH) ex *Tupaia glis*, same data as holotype.

Paratypes - 10♂, 10♀(MZUM, ALC, USNM, RMNH, ZIM, ZRC, authors' collections) ex *Tupaia glis*, same data as holotype.

Others - 27 adults and nymphs (ZRC) ex *Tupaia glis*, Bukit Timah Forest Reserve, Singapore, coll. M. Nadchatram, 4.ix.1985.

Description. - *Female* - body length (holotype, Fig. 1), including gnathosoma 129, width 112; measurements of paratypes with mean, minimum range given in Table 1; ventral idiosome with smooth cuticle, one pair of ventral setae *(v)* between epimera III; epimera I recurved laterally, II-IV straight and directed ventro-medially; epimera in holotype and some paratypes weakly sclerotised, in others strongly sclerotised; epimera and trochanters subcutaneously connected by strong sclerotisations; two adanal lobes between legs IV; anterior portion of genital opening partly covered by sickle-shaped fold. *Legs* - 5-segmented, evenly spaced along podosoma; each trochanter with ventral acute spur directed ventro-medially, seta inserted at base of this spur, small area of sclerotisation opposite femoral spur; basal two third of trochanter weakly sclerotised in holotype and some paratypes, in other paratypes, proximal portion of trochanter heavily sclerotised; femora I-IV with much reduced, spine-like, proximal, ventro-posterior blunt seta; distal seta normally developed, long, tapering; triangular basal spurs of femora I-IV as prominent as trochanter spurs; genua I-IV with one short, almost blunt ventrolateral seta; tibia I-IV with single ventral spine; only closely related *P. tupaiae* and other *Psorergates* species parasitic on sciurid hosts bear a tibial spine on leg IV; median seta on dorsal surface of tibiae I-IV; tarsi with two apical claws and bilobed empodium *(em)*; larger part situated ventrally, smaller part dorsally between claws; ventrally a strong cone-shaped spine present, two subequal seta *(da, dp)* observed dorso-laterally; dorso-posterior seta lacking on leg IV; tarsi I, II with two solenidia *(so)*, smaller posterior solenidion enveloped by skinfold (Fig. 2).

Dorsum - (Fig. 4) with sclerotised shield as long as wide, punctate; lateral weak parts of dorsum striated as figured; 3 pairs of lateral setae *(ls)* at shield border, pair of minute antero-median *(am)* setae anteriorly. *Gnathosoma* - gnathosomal base dorsally with pair of bisegmented gnathosomal *(gs)* setae (Fig. 5); similar to those described for *P. tupaiae*; ventrally with two minute subgnathosomal *(sg)* setae and pharyngeal bulb *(ph.b)* within; palps 2-segmented; palpal tibia with pair of strong, relatively short, truncate palpo-tibial setae dorsally, small seta close to these setae; with weakly sclerotised spur apically; ventrally situated palpal tarsus bears 3 ventro-medially directed spines of which 2 are bifid (Fig. 3); between palps are chelicerae with sclerotised dentations (Fig. 6).

Male. - (allotype, Fig. 7) length 109, width 102; measurements of paratypes given in

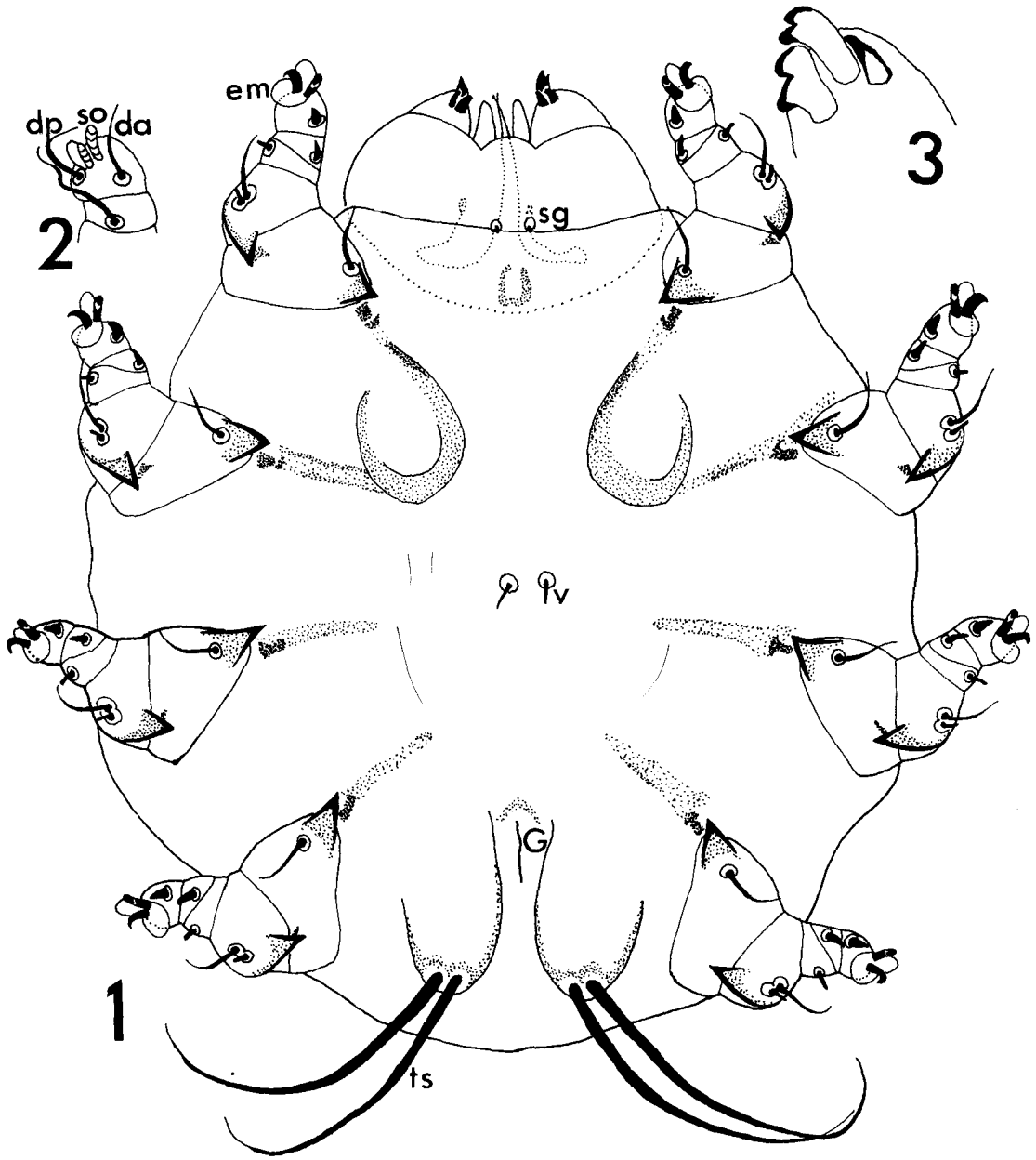
Table 1; male similar to female holotype; the allotype described here is one of the more strongly sclerotised specimens displaying extra spots of sclerotised material near ends of epimera ventrally (Fig. 8). *Dorsum* - with sclerotised, striated shield, with weak lateral margins; aedeagus opening *(eo)* situated at antero-median part of dorsum, position of opening located as figured, anteriorly bordered by distinct margin; antero-median setae anterolateral of aedeagus opening, somewhat posterior of *am* setae; genital setae *(gs)* close-set; aedeagus *(e)* and cone-shaped aedeagus sheath as figured (Fig. 9).

TABLE 1

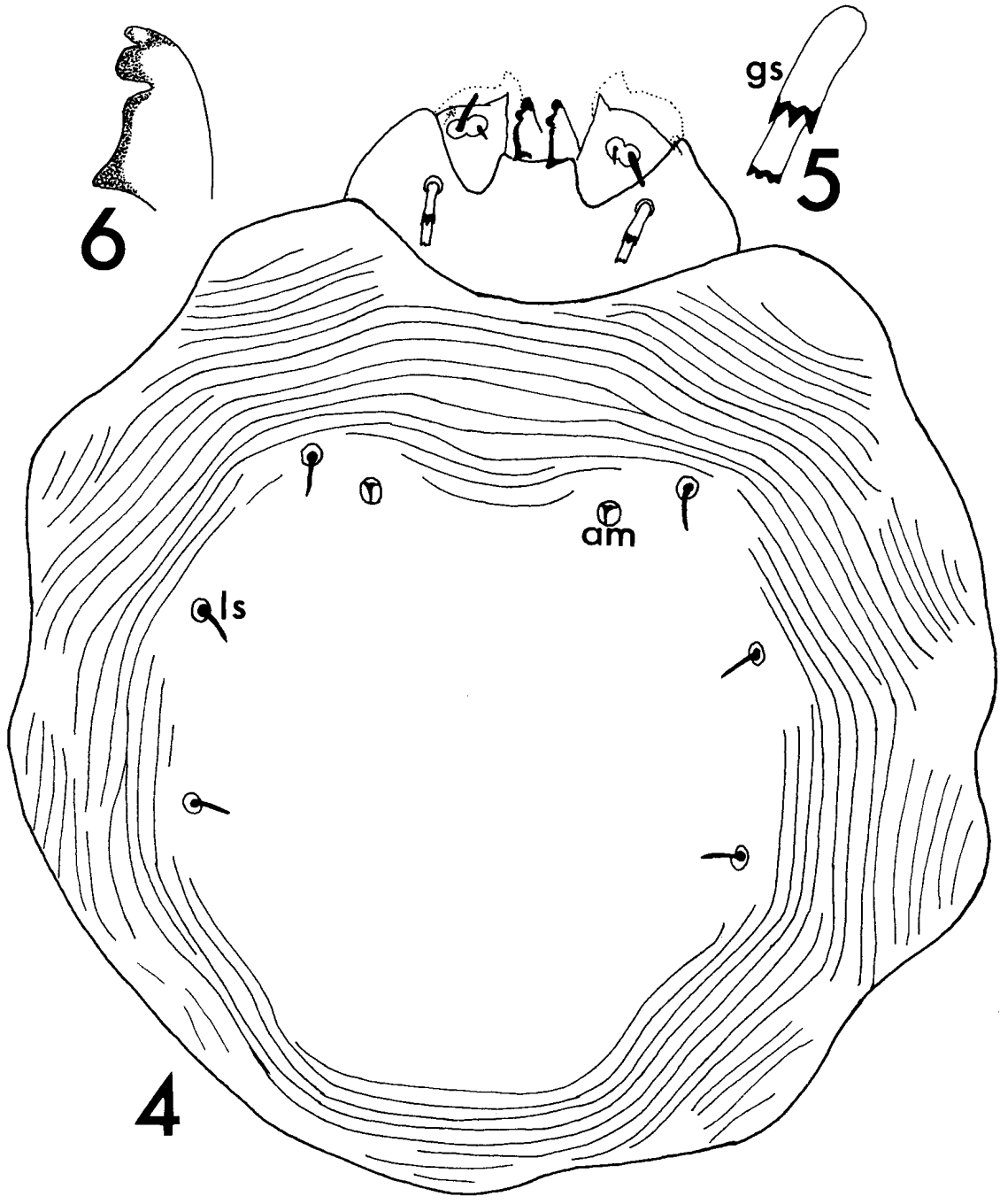
Measurements of *Psorergates fritzi*, new species and *P. tupaiae* Giesen & Lukoschus, 1982. All measurements in micrometers.

	P. fritzi females			*P. tupaia* females		*P. fritzi* males			*P. tupaia* males	
	Holo-type	X	min-max (N = 10)	X	min-max (N = 10)	Allo-type	X	min-max (N = 10)	X	min-max (N = 9)
Body length	129	121	(101-129)	126	(122-137)	109	110	(97-122)	114	(106-122)
Body width	112	108	(102-112)	108	(103-122)	102	99	(90-109)	99	(91-106)
Shield length	71	73	(71- 76)	81	(78- 84)	72	74	(71- 77)	75	(69- 80)
Shield width	70	74	(70- 77)	76	(74- 81)	65	69	(65- 74)	72	(69- 74)
Length setae:										
terminal	50	53	(49- 59)	52	(38- 56)	70	64	(60- 70)	53	(41- 60)
trochanter	9	7	(6- 9)	8	(6- 10)	8	7	(6- 8)	9	(8- 10)
femora I-III (distal)	8	8	(7- 10)	9	(8- 11)	9	8	(7- 10)	10	(9- 12)
femora IV (distal)	7	7	(6- 8)	9	(7- 10)	7	7	(6- 8)	9	(8- 9)
genua I-III	3	3	-	3	-	2	2	(2- 3)	3	-
genua IV	3	3	-	3	-	2	2	(2- 3)	3	-
tibia	13	12	(8- 15)	n.o.	-	12	12	(10- 16)	n.o.	-
tarsus da	8	8	(6- 10)	10	(9- 10)	7	8	(7- 9)	10	(9- 10)
tarsus dp	10	8	(6- 10)	10	(9- 10)	8	8	(7- 9)	10	(9- 11)
lateral shield	6	6	(5- 7)	5	(4- 5)	5	5	(5- 6)	5	-
palpal tibial post.	6	6	(5- 7)	4	(4- 5)	6	5	(4- 6)	5	(3- 6)
gnathosomal	9	8	(7- 9)	5	-	6	7	(6- 7)	5	(4- 6)
ventral	4	4	(4- 5)	4	(3- 4)	4	4	(3- 4)	4	-
Distance between:										
ventral setae	5	7	(5- 10)	11	(10- 12)	8	8	(6- 9)	11	(9- 12)
am setae	28	29	(28- 34)	28	(27- 29)	24	24	(23- 25)	26	(25- 28)
genital setae	-	-	-	-	-	14	14	(13- 15)	14	-
Length penis	-	-	-	-	-	24	25	(20- 28)	37	(36- 39)
Length penis sheath	-	-	-	-	-	18	18	(15- 21)	25	(24- 28)

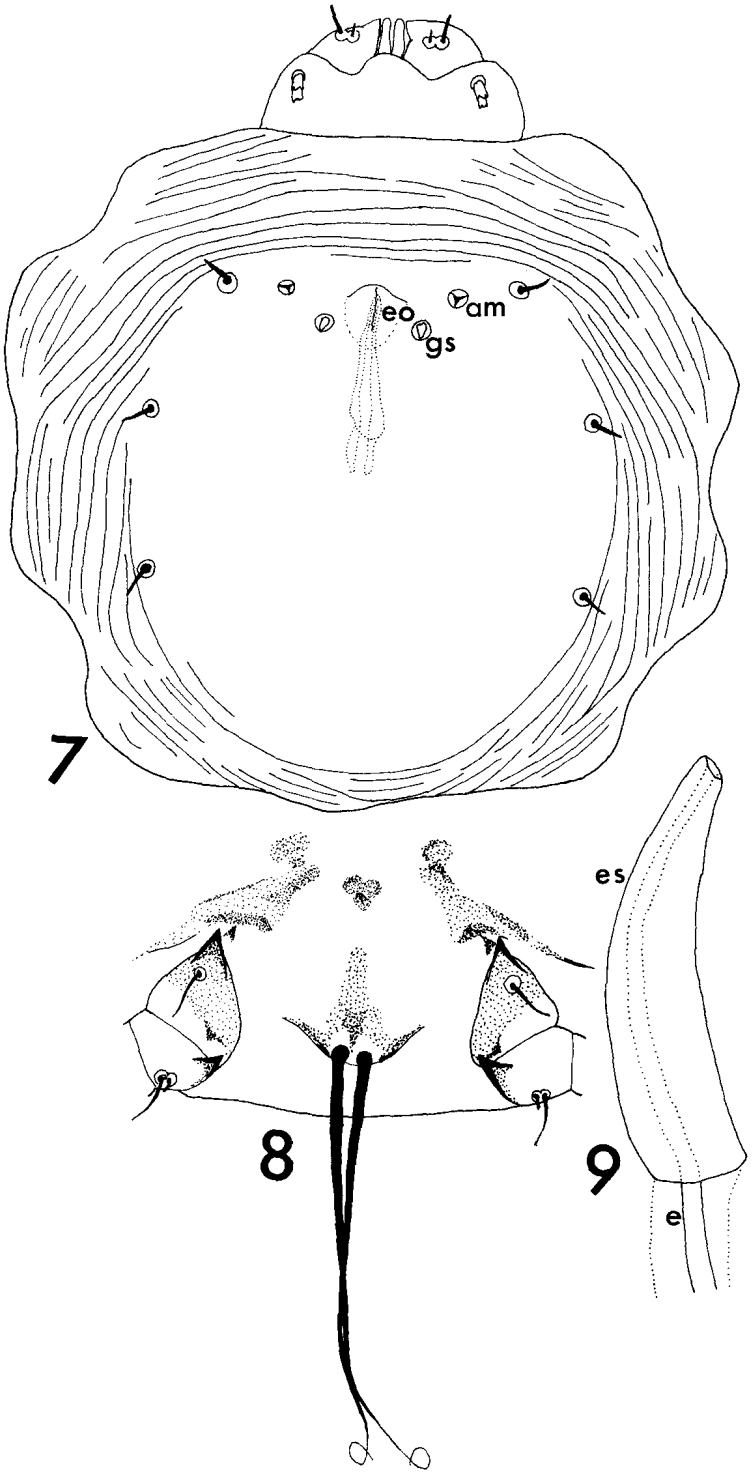
Etymology. - The new species is affectionately dedicated to the memory of the late Dr. Fritz S. Lukoschus (Catholic University of Nijmegan, The Netherlands) in recognition of his enormous contribution for the promotion of modern acarology. An indefatigable worker and dedicated scientist, Fritz Lukoschus travelled extensively to the remote corners of the world in pursuit of acarological knowledge and its advancement. He is credited with the discovery of new host biotopes and the retrival of numerous "specialised" mite parasites new to science. During his lifetime, he authored over 200 publications and



Figs. 1-3. *Psorergates fritzi*, new species. Female holotype. 1, venter – *(v)* ventral setae; *(G)* genital slit; *(ts)* terminal seta; *(sg)* subgnathosomal setae; *(em)* empodium; 2, tibia and tarsus leg I, dorsal *(dp)* dorso-posterior seta; *(da)* dorso-anterior seta; *(so)* solenidia; 3, palp tarsus with three spines



Figs. 4-6. *Psorergates fritzi*, new species. Female holotype. 4, dorsum – (*ls*) lateral seta; *(am)* antero-median seta; 5, gnathosomal seta (*gs*); 6, chelicera



Figs. 7-9. *Psorergates fritzi*, new species. 7, dorsum of male allotype – (*eo*) aedeagus opening; (*am*) antero-median seta; (*gs*) genital seta; 8, posterior part of venter male allotype; 9, male paratype, aedeagus (*e*) and aedeagus sheath (*es*)

trained numerous students, some of whom are now distinguished acarologists. With the demise of Fritz Lukoschus on 23 August 1987 at the age of 68 years, the world of acarology has lost another distinguished scientist.

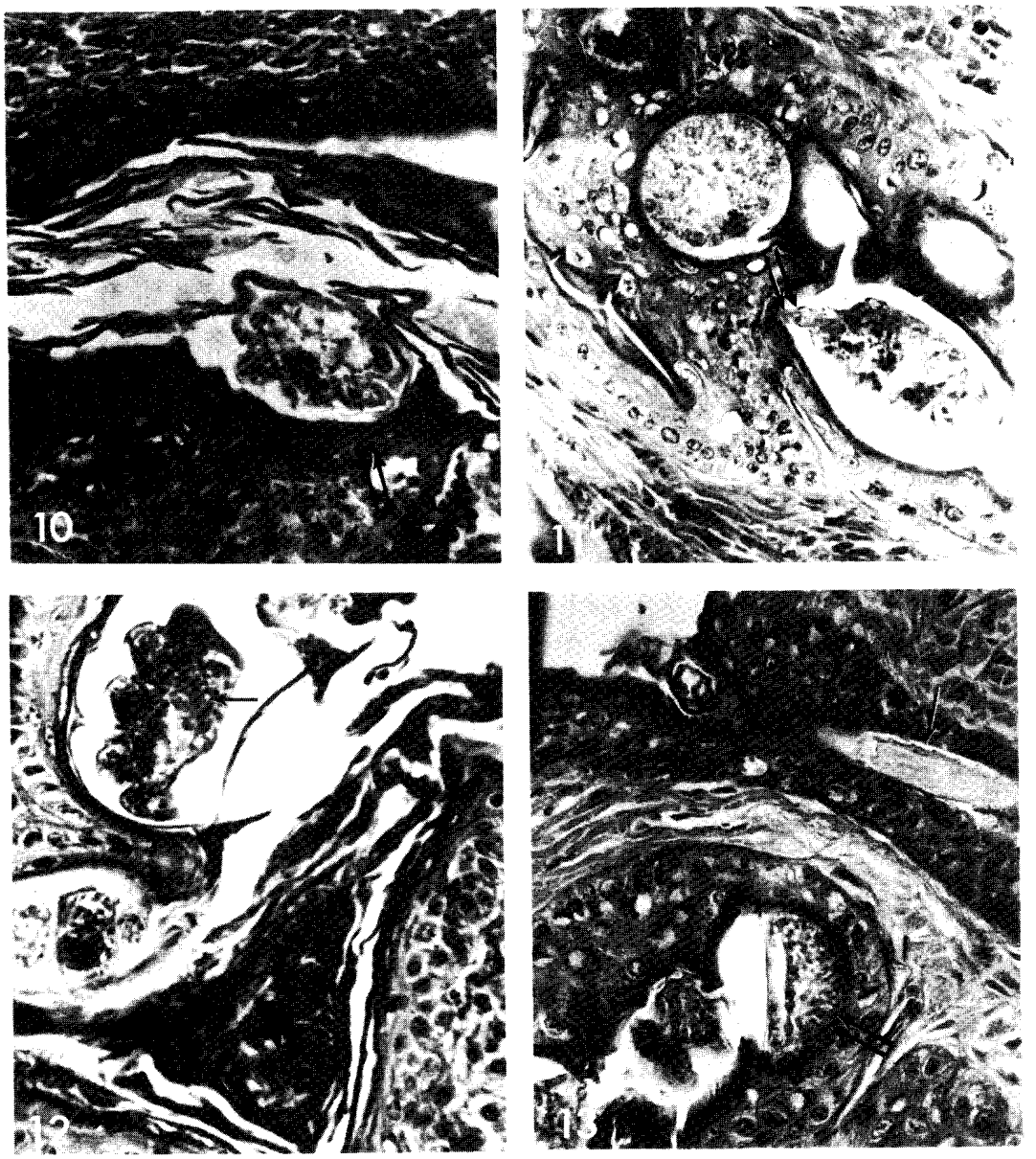
Remarks. - *Psorergates fritzi*, new species, is closest to *P. tupaiae* Giesen & Lukoschus, 1982. It is easily distinguished from all other species by the combination of a very short, spine-like proximal seta on all the femorae and the presence of a tibial spine on leg IV. From *P. tupaiae*, it can further be distinguished by the smaller dorsal shield in females and the shorter aedeagus and aedeagus sheath in males.

Phylogenetic relationships of these two species and between the other *Psorergates* species are less clear. It is hypothesised that the species of *Psorergates* now parasitising the family Tupaiidae originated from species which parasitised the Sciuridae. Colonisation would be plausible since the ecology and habitat of the Sciuridae and Tupaiidae overlap to a great extent. Reconstructing the phylogeny of *Psorergates* and assuming no reversals of characters take place (this means abandoning the principle of parsimony in the phylogenetic analysis) results in a cladogram with a trichotomy of the genus, one branch of *Psorergates* species from the Tupaiidae, another from the Sciuridae, and the third branch with all the other species. This would not indicate any possible relationships of the Tupaiidae to other families of mammals because *a priori* assumptions are made (no reversals, full co-speciation of parasites and hosts) and the principle of parsimony is abandoned.

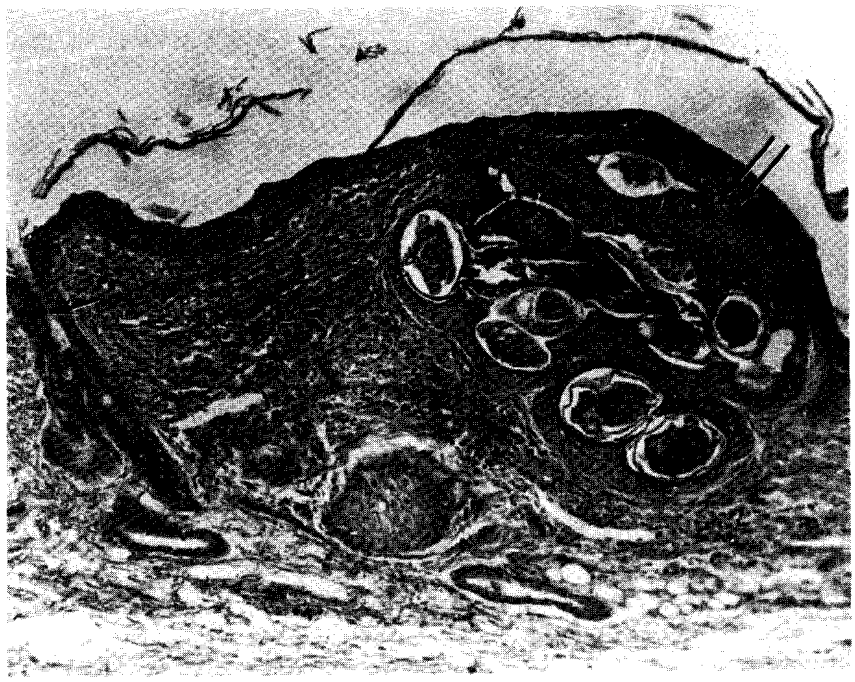
NOTES ON PATHOLOGY

Visuo-tactile inspection of the *Tupaia glis* integument of the ear revealed the following gross pathology due to *Psorergates fritzi* - small (ca. 1-3 mm), sparsely haired areas each with occasional rough keratinised microprominences (ca. 0.5 mm). An occasional whitish, hairless nodule (solid to palpation) about 0.5 to 1.0 mm in diameter, each of which has one to three minute keratinised surface prominences. Hair-reduced areas, keratinised prominences and nodules are much smaller, less prominent and less numerous than the gross pathology reported for *P. callipidis* in the integument of *Apodemus sylvaticus callipidis* by Lukoschus (1967).

Histological studies of hematoxylin-eosin stained, paraffin sections of whole skin disclosed the following - single adult mites are found either free in skin crypts or hair follicles, or in body-sized burrows in the surficial or follicular epidermis (Fig. 10). In the latter cases, they are covered dorsally with one or more layers of keratin, co-terminal with that of surrounding epidermis, and latero-ventrally (except for mouthparts) with one thin centrally punctured layer of keratin (Fig. 11). Leg claws apparently are, in part, responsible for the excessive thickening (Fig. 12). The epidermis is reduced in the area of the mouthparts, indicating cheliceral epidermal cell puncture and mite feeding, and some distortion, but no evidence of cellular infiltration appeared to be present at the margin of each pit. The latter may be due to physical rather than physiological stress. Sections through the micro-nodular prominences show that they are indeed due to mite pathogenesis (Fig. 14). Apparently in early invasion of the hair follicle by adults (as in Fig. 12), keratinisation is increased extensively until it plugs the follicular orifice. Trapped adults reproduce (egg in situ Fig. 13) and resulting immatures feed on and distend the follicular epithelium, adding to the plug of keratin. In the early stages of the prenodular lesion, the hair (in telogen stage) is apparently expelled and later an occasional adult is forced from



Figs. 10-13. Photomicrograph of paraffin prepared skin section of *Tupaia glis* showing an adult *Psorergates fritzi*, new species in an epidermal body-sized pit with investing keratin. Note reduction of epidermis ventral of the mite (arrow). HaE x 300; 11, Photomicrograph (as for Fig. 10) showing an adult *Psorergates fritzi*, new species within a lobule of the follicular epithelium with mouthparts (arrow) partially penetrating the keratinised layer. HaE x 300; 12, Photomicrograph (as for Fig. 10) of a section of the podosoma of an adult *Psorergates fritzi*, new species (arrow) in a heavily keratinised epithelial pit showing the rippled appearance of the ventral keratin layer which matches the leg pattern, thus indicative of abrasion. Moribund or dead mites (double arrows) are occasionally found trapped in the keratin plug. HaE x 300; 13, Photomicrograph (as for Fig. 10) of section showing an uninfested (arrow) follicle (with intact hair) and an adjacent heavily infested lobule with an ovum (double arrows) within a keratin-lined pit presumably excavated by a female mite. HaE x 300.



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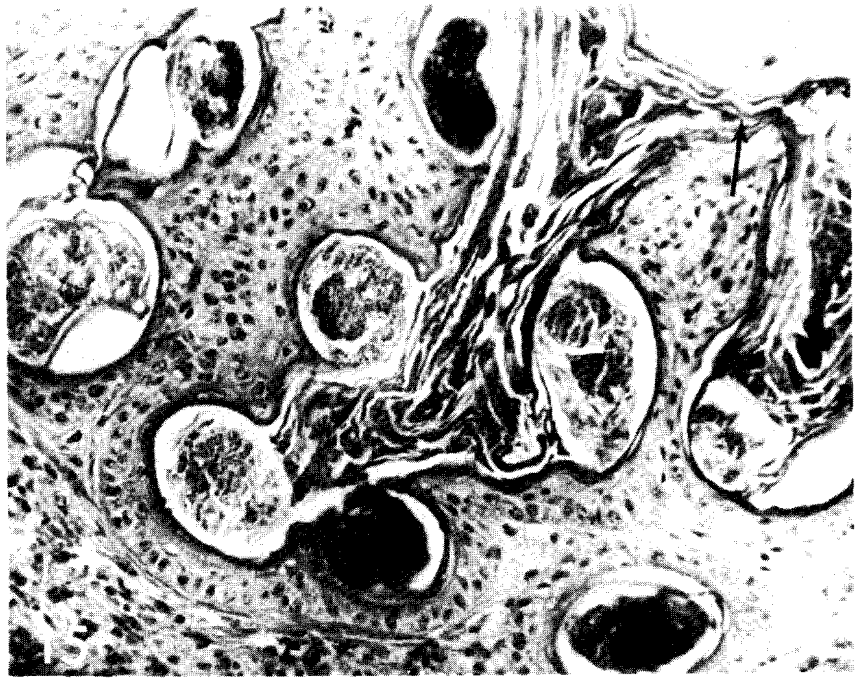

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Figs. 14-15. 14, Photomicrograph (as for Fig. 10) of a section through an uninfested hair follicle (arrow) and micronodule (double arrows). Hairs are not found in the keratin cores of small nodules. H&E x 125. 15, Photomicrograph (as for Fig. 10) of skin showing two adjacent heavily infested hair follicles and keratin plugs which have apparently become joined with a keratin bridge (arrow), possibly due to penetration of closely adjacent epithelial lobules by the mites. H&E x 250

the follicular orifice by the developing mass of keratin (Fig. 12). Also, (Fig. 15) adjacent infected follicles with similar keratin plugs are identical to the multiple keratinised microprominences found on the surface of the nodules. Successive generations of these trapped mites produce the nodules which histologically show a central (or several) dense, layered keratin cores with lobulation of the follicular epithelium (Fig. 15) due to activity of the successive generations of the adult and immature mites. These lobulations produce a solid nodule similar to those reported from *Antechinus stuartii* and produced by *Demodex antechini* (vide Nutting & Woolley, 1965), except that adjacent lobules in *Tupaia glis* have a very thin, weakly to non-vascularised dermis between lobules. Serial sections provide no evidence of mite invasion of sebaceous glands or perivascular infiltration of leucocytes in the dermis adjacent to the lesions. In comparison with the non-infested pilosebaceous complex (Fig. 14), however, the dermis adjacent to the nodular periphery does show some increase of histiocytes and polymorphonuclear leucocytes.

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