Bull. Inst. r. Sci. nat. Belg. Bull. K. Belg. Inst. Nat. Wet.	Bruxelles Brussel	31-VIII-1982
54	ENTOMOLOGIE	10

THE LIFE-CYCLE OF *COSMOGLYPHUS INAEQUALIS* FAIN & CACERES, 1973, WITH COMMENTS ON THE SYSTEMATIC POSITION OF THE GENUS (*)

RESULTS OF THE NAMAQUALAND — NAMIBIA EXPEDITION OF THE KING LEOPOLD III FOUNDATION FOR THE EXPLORATION AND PROTECTION OF NATURE (1980)

BY

H. A. P. M. LOMBERT, F. S. LUKOSCHUS,
Department of Aquatic Ecology, Catholic University Nijmegen, Netherlands

B. M. OCONNOR,
Museum of Zoology, The University of Michigan, Ann Arbor, Michigan 48109, U.S.A.

(With 27 figures in the text)

ABSTRACT

Descriptions are given of all stages in the life-cycle of *Cosmoglyphus inaequalis* FAIN & CACERES, 1973, a species previously known only from the deutonymphal (hypopial) instar. This species, originally collected from several mammal species in Angola, was recovered from the nest of *Trinervitermes trinervoides* in South Africa.

INTRODUCTION

During a stay in South Africa by one of us (FSL), our attention was called by Mrs. MARTINDALE of the Institute for Medical Research in Johannesburg to the heavy infestation of laboratory cultures of the termite, *Trinervitermes trinervoides* (Sjöstedt) (Isoptera : Termitidae : Nasutiter-

(*) This study was funded in part with the aid of grant R 87 - 111 by the Netherlands Foundation for the Advancement of Pure Research (Z. W. O.).

mitinae) by deutonymphs of an acarid mite. These termites were maintained as food for spider cultures and exhibited massive infestation by these acarid deutonymphs, especially in the head region. We suspected that the entire life-cycle of this mite should be present in the natural nests of this termite and that the large numbers of mites in the laboratory cultures resulted from conditions more favorable to mite development. Examination of material, collected from a freshly obtained nest of *T. trinervoides* using a Berlese funnel apparatus, yielded the entire life-cycle of this mite, namely larva, protonymph, deutonymph (hypopus), tritonymph, adult female (gravid and non gravid) and homeomorphic male. On the basis of the deutonymphal morphology, this mite was identified as *Cosmoglyphus inaequalis* FAIN & CACERES, 1973. As the entire life-cycle of a *Cosmoglyphus* species has never been described, we present descriptions of all ontogenetic stages. To shorten descriptions, only a few of the measurements are repeated in the written description (see tables I-II). All measurements are in micrometers.

DESCRIPTION OF THE LIFE-STAGES OF *COSMOGLYPHUS INAEQUALIS* FAIN & CACERES, 1973

E g g . — Eggs within females without shell sculpture; length 89-94 μm, width 54-60 μm.

L a r v a (Figs. 1-5). — Egg-shaped body with very pale and thin cuticle. Length including gnathosoma 290 μm, width 165 μm. Only one other specimen in collection measuring respectively 233 μm and 124 μm.

Venter (Fig. 1). Gnathosoma as in all other stages, except hypopus, with subcapitulum tapering slightly anteriorly. Palp placed more or less laterally. Basal podomere with one dorsal and one ventral seta, apical podomere with one dorsal seta, a very short apical solenidion and a knob-like apical eupathid. Subcapitulum with two pairs of setae, the ventral subcapitulars and the dorsal palpal supracoxals. Chelicerae chelate with well developed teeth on both digits. Podocephalic canal visible on lateral region of propodosoma. Grandjean's organ (G. o) elongate, unbarbed, projecting from apex of podocephalic canal. Idiosoma ovoid. When mounted, legs I and II more lateral than legs III, the region in between being somewhat more heavily sclerotized than rest of body. Epimerae I contacting each other in plane of symmetry forming Y-shaped figure. Epimerae II and III free. Epimerae II with short lateral extension, the posterior apodeme of coxal field I. Posterior apodemes of coxal fields II straight, with separate, medial elements in sejugal region. Between epimerae I and II a pair of Claparède's organs (Cl. o) and coxal setae (*cx I*). Coxal region III with one pair of setae (*cx III*). Claparède's organs with transparent terminal bulb (total length 25 μm). Genital region and setation completely absent. Anal region subterminal, flanked posteriorly by setae *l 4*, and laterally by cupules *i h*.

TABLE 1

Measurements of some idiosomal characters of life-stages of *Cosmoglyphus inaequalis* FAIN & CACERES, 1973. (μm)

	L	PrN	DN	TrN	♀	♂
length	290	384	276	562	818	566
width	165	187	211	345	502	312
length gnathosoma ...	48	58	28	91	128	91
width gnathosoma ...	35	40	12	66	100	66
length propod. shield ...	61	86	—	103	128	101
width propod. shield ...	49	nmb	—	86	116	76
l 1	7	27	28	46	61	59
l 2	20	29	24	50	76	91
l 3	25	38	22	58	98	147
l 4	35	30	23	55	96	182
l 5	—	34	20	70	203	221
d 1	40	30	31	46	47	56
d 2	47	51	28	59	98	108
d 3	33	51	24	77	184	227
d 4	33	48	23	69	162	277
d 5	—	41	20	79	159	270
sc e	32	33	23	112	282	216
sc i	5	22	33	42	93	88
s cx	13	20	nmb	29	37	29
v i	25	35	12	61	93	88
v e	8	7	36	11	10	20
cx I	10	14	—	29	40	50
cx III	9	9	9	20	32	37
cx IV	—	—	—	24	42	41
g a	—	9	12	16	28	30
g p	—	—	—	21	33	30
a 1	—	5	—	12	5	12
a 2	—	8	—	11	22	—
a 3	—	8	—	10	21	—
a 4	—	—	—	—	4	—
a 5	—	—	—	—	14	—
a 6	—	—	—	—	nmb	—
h	21	40	20	14	170	172
sh	8	10	20	76	35	34
Claparède's organ	25	—	—	—	—	—

— = absent; nmb = not measurable.

TABLE 2

Measurements of some leg characteristics of all life-stages of *Cosmoglyphus inaequalis* FAIN & CACERES, 1973. (μm)

	L	PrN	DN	TrN	♀	♂
length leg I	82	106	85	172	243	263
leg II	81	101	82	171	247	270
leg III	86	86	71	162	240	277
leg IV	—	93	81	179	270	265
ω 1 leg I	10	10	12	13	15	12
ω 2 leg I	—	5	4	7	7	9
ω 3 leg I	—	—	24	20	26	37
famulus	5	5	—	8	9	8
ω 1 leg II	10	11	18	16	25	16
φ I	61	72	54	99	118	108
φ II	46	61	40	82	nmb	100
φ III	34	43	16	nmb	nmb	100
φ IV	—	—	11	23	50	22
σ 1 leg I	13	13	9	31	30	31
σ 2 leg I	11	16	—	40	45	49
σ leg II	8	11	8	22	20	26
σ leg III	2	7	3	8	15	15
vF I	20	35	15	52	86	87
vF II	22	28	29	51	98	90
vF III	—	—	—	—	—	—
vF IV	—	—	22	18	37	44
pR I	—	—	25	18	35	43
pR II	—	—	nmb	14	40	39
sR III	—	—	24	17	34	52
sR IV	—	—	—	—	—	—

— = absent; nmb = not measurable.

Dorsum (Fig. 2). Sejugal furrow very faint. Propodosoma with a shield-like sclerite and two lateral podocephalic sclerites. *V i* setae at anterior border of propodosomal shield with very short spines. *V e* short, unbarbed, and inserted on lateral border of shield, at level of supracoxal setae. Supracoxals (*s cx*) strongly barbed, somewhat inflated basally. Insertions of *sc i* and *sc e* more or less in a straight line. *Sc e* and hysterosomal setae *h*, *d 3*, *d 4*, *l 2*, *l 3* with flattened apices, other opisthosomal setae filiform (*sc i*, *l 1*, *d 1*, *d 2*). For pattern see Fig. 2. There are four pairs of

cupules : *i a* between *l 1* and *l 2*, *i m* lateral to setae *l 2*, *i p* lateral between *l 3* and *d 4* and *i h* ventral (see Figs. 1, 2). Between *l 2* and *l 3* lies the opening of the lateral opisthosomal gland (o.g.), which is more sclerotized than the cupules and with a slitlike opening.

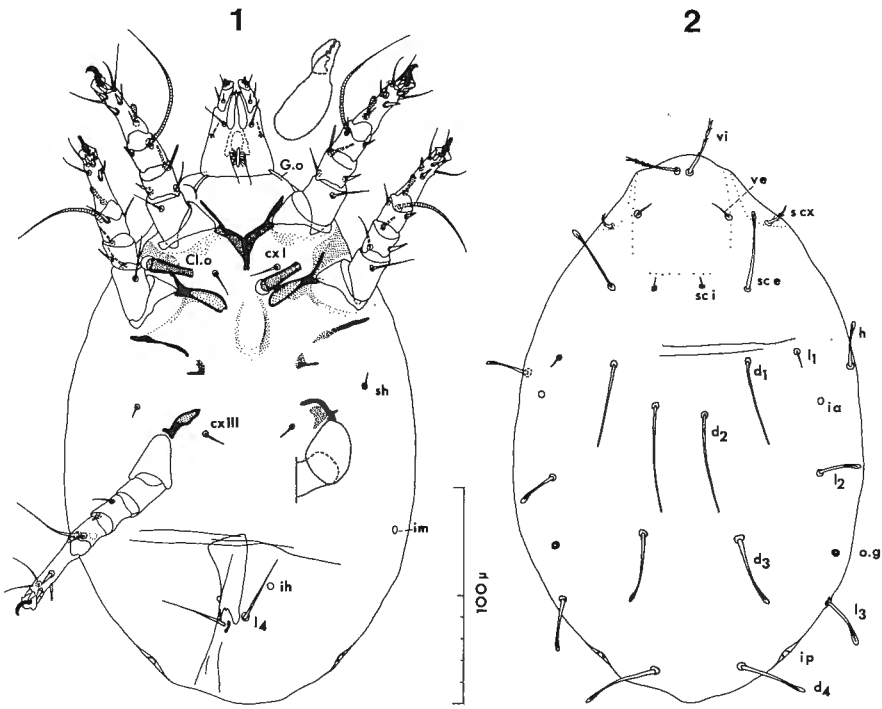

Fig. 1, 2. — *Cosmoglyphus inaequalis* FAIN & CACERES, 1973.
1) venter of larva; 2) dorsum of larva.

Legs (Figs. 3-5). Slender, with empodial claw and short ambulacrum, trochanter setae absent as in other acariform larvae. Femora I-II with one filiform seta (vF); genua I-II with setae (mG) spine-like, setae (cG) filiform; genu III with seta (nG) short and filiform; genu I with 2 subequal solenidia (σ 1, σ 2), genu II with σ shorter, genu III with very short σ. Setae (hT) of tibiae I-II somewhat spine-like, setae (gT) filiform; seta (kT) of tibiae III spine-like; all tibiae with elongate solenidia φ. Tarsus I with 13 normal setae : (aa) short, filiform; (ba) short, filiform; (wa), (la) spine-like; (ra), (d) filiform; (e), (s), (p), (q), (u), (v) short and spine-like; (f) inflated apically. Tarsus I with solenidion ω_1, strongly clubbed; famulus (ε) tapering to a point. Tarsus II similar to I except (aa), (ε) not present. Tarsus III with setae (r), (w), (s), (p), (q), (u), (v), (e) spine-like, setae (f) and (d) filiform.

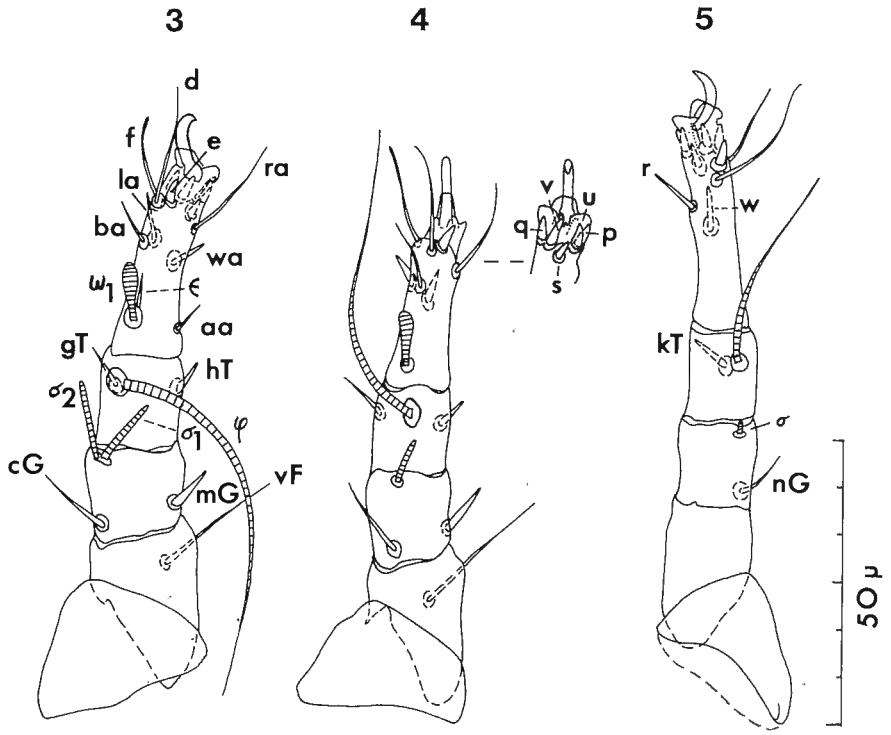

Fig. 3-5. — *Cosmoglyphus inaequalis* FAIN & CACERES, 1973.
Legs I-III of larva in dorsal view;
3) leg I; 4) leg II, apex in ventral view; 5) leg III.

P r o t o n y m p h (Figs. 6, 7). — Average of 10 specimens 375 (minimum 350 — maximum 399); width, average 229 (187-237). Normal ontogenetic additions at this stage include the primordial genital region with one pair of genital setae (*g p*) and one pair of papillae, opisthosomal setae *d 5*, *l 5*, and 3 pairs of short, filiform, anal setae (*a 2*, *a 3*, *a 5*). Legs as in larva, but with addition of legs IV, bearing 7 tarsal setae as in ancestral Sarcoptiformes. In addition to these normal ontogenetic changes, certain changes are observed in the hysterosomal chaetotaxy : setae *sc i* and *l 1* are no longer filiform, but have flattened apices, though less distinct than in other setae, and are distinctly longer than in larva (see Table I).

D e u t o n y m p h (Figs. 8-13). — Length averages in 10 specimens 243 (215-278); width 183 (162-215). Heteromorphic deutonymph or hypopus completely deviating from all other stages both morphologically and dimensionally. This hypopus has already been described by FAIN & CACERES (1973) from mammalian hosts namely *Crocidura* sp., *Lophuromys flavopunctatus rita*, *Rattus natalensis natalensis*, *Rattus morio jacksoni*, *Lemniscomys striatus striatus* and *Tatera afra angolae* all from Angola. FAIN & CACERES (1973) however, suspected that these hosts were probably accidental. Since all life-stages have been found in the nest

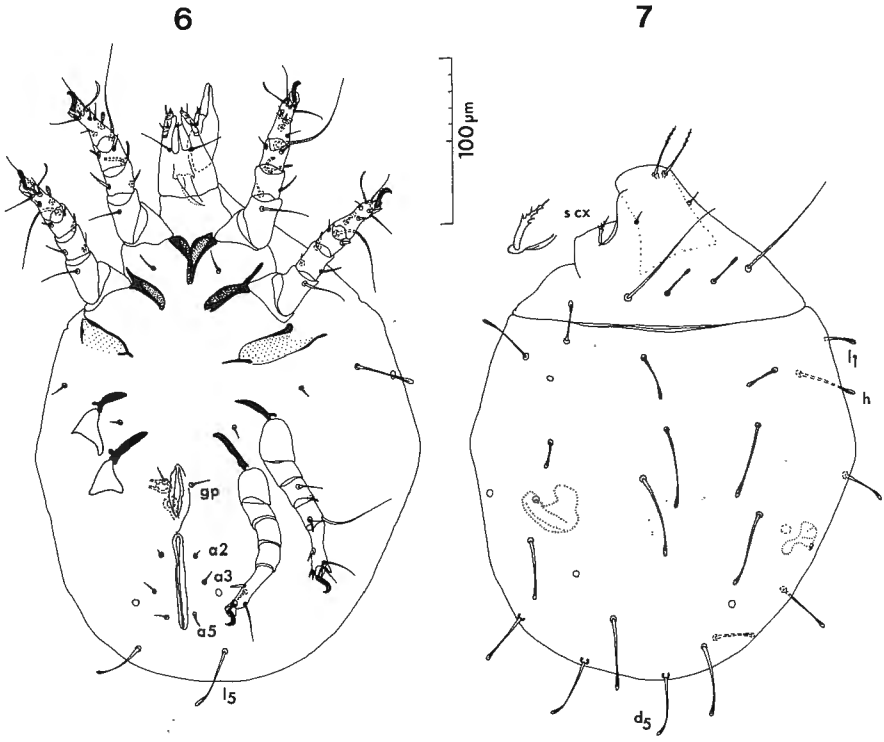

Fig. 6, 7. — *Cosmoglyphus inaequalis* FAIN & CACERES, 1973.
6) venter of protonymph; 7) dorsum of protonymph.

of termites, this species may be considered as termitophilous in natural situations. As FAIN & CACERES (1973) have presented an adequate description of the deutonymphs, we comment here only on the leg setation in detail. Tarsi I-II with 9 setae each; differing from previous stages in the absence of (s), (u) and (v) on both tarsi as in most other deutonymphs of the Astigmata; tarsus I also with seta (ba) absent; (ba) present on tarsi II but (aa) absent as in other stages. Tarsi I-II with most normal setae in apical half of segment; (wa) short and somewhat spine-like; (la), (ra), (d) filiform; (p), (q), (f) foliate and of equal lengths, (e) foliate and much longer; (aa) on tarsus I and (ba) on tarsus II filiform. Tarsus III with setae (s), (r), (w) filiform; (d), (e), (f), (p), (q) foliate. Tarsus IV similar but seta (w) much stronger and bearing a conspicuous barb. Tarsus I with 3 solenidia in basal half of tarsus; ω_3 added to protonymphal complement. Tarsus II with solenidion ω_1 similar in form to that of tarsus I. Setae (hT) of tibiae I-II very strong spines; setae (gT) somewhat spine-like; setae (kT) of tibiae III-IV bifurcate apically. Solenidia φ of tibiae I-IV present Genua I-II with setae (mG) large and spine-like; seta (cG) much weaker. Seta (nG) of genu III bifurcate. A single solenidion σ present on genua I-III. Femoral setae I-II filiform, that of femur IV bifurcate. Filiform trochanteral setae I-III appear in the deutonymph.

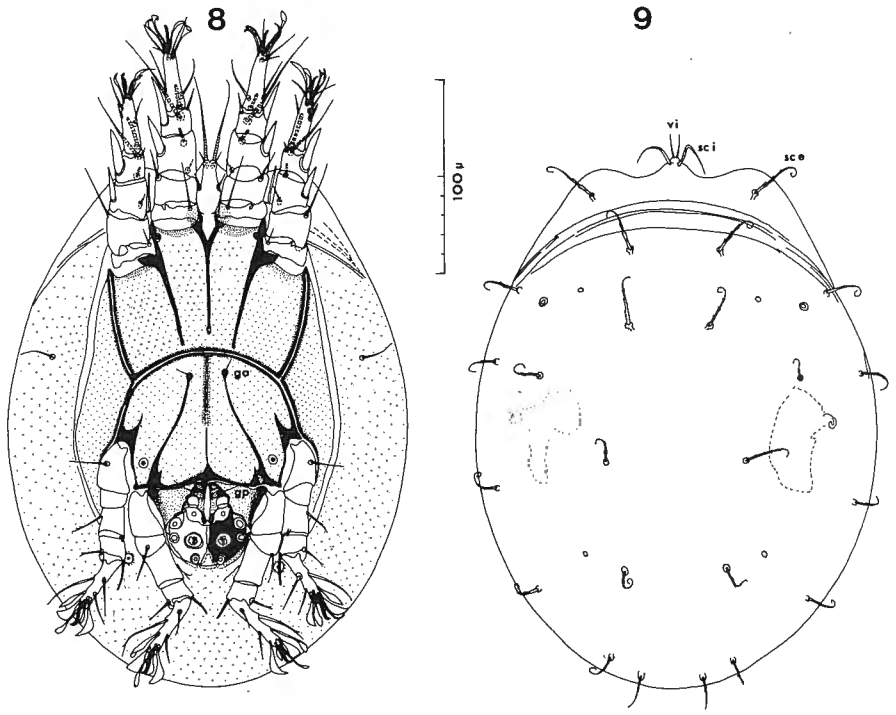

Fig. 8, 9.

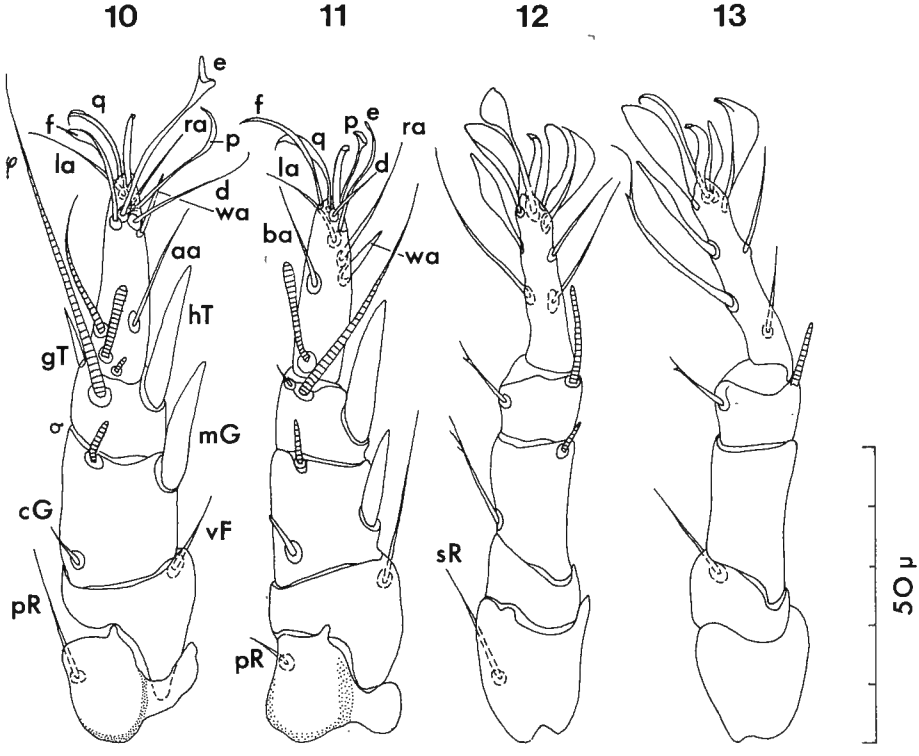

Fig. 10, 11, 12, 13.

Idiosoma. Cupules *i m* and *i p* are absent. All dorsal idiosomal setae are slightly barbed. Trochanters I, II with dorsal ring-like sclerotizations. Normal ontogenetic additions : second pair of genital papillae, one pair of aggenital setae (*g a*), trochanter setae on legs I-III, setae of coxal fields IV.

T r i t o n y m p h (Figs. 14, 15). — Average length of 10 specimens 530 (483-630); average width 317 (271-385).

Venter (Fig. 14). Two pairs of setae in genital region, one between epimerae IV (aggenitals, *g a*), the other posterior one on border of genital valve (*g p*). Ventral anal opening slit-like with three pairs of protonymphal setae.

Dorsum (Fig. 15). Propodosomal and lateral podocephalic sclerites more sclerotized than in preceding stages, clearly contrasting with surrounding region. All idiosomal setae flattened at apices, except *sc e* filiform, *v i* barbed only at apex. Setae (mG) and (cG) of genua I, II slightly serrate, (f) setae of tarsi I, II distinctly foliate terminally.

F e m a l e (Figs. 16-21). — Average length of 7 specimens 744 (650-827); width 417 (335-502).

Venter (Fig. 16). Genital region between epimera III and IV with two genital valves, two pairs of genital papillae and two pairs of setae : *g a* (aggenitals) between epimerae III, *g p* (genitals) between epimerae IV; region underneath valves expanded and curved inwards. Epigynium very faint. Anal region completely ventral with 3 pairs of short, fine setae added to tritonymphal complement.

Dorsum (Fig. 17). As tritonymph but setae *sc e*, *d 2-d 5*, *h*, *l 2*, *l 5* filiform. Idiosomal setae : *cx I*, *cx III*, *cx IV*, *sh*, *h*, *g a*, *g p*, *a 1-a 6*, *v i*, *v e*, *sc i*, *sc e*, *s cx*,*d 1-d 5*, *l 1-l-5*.

Legs (Figs. 18-21). Legs as figured. Tarsi I, II with three inflated setae, tarsi III, IV with filiform setae slightly inflated.

M a l e (Figs. 22-27). Average length of 6 specimens 581 (527-670); width 308 (276-374).

Differing from female in being more heavily sclerotized in region between epimerae and on legs.

Venter (Fig. 22). Genital region between epimerae IV. Anal region close to genital region with one pair of setae associated with para-anal suckers and two pairs posterior to anus.

Fig. 8, 9. — *Cosmoglyphus inaequalis* FAIN & CACERES, 1973.
8) venter of deutonymph; 9) dorsum of deutonymph.

Fig. 10-13. — *Cosmoglyphus inaequalis* FAIN & CACERES, 1973.
Legs I-IV of deutonymph in dorsal view;
10) leg I; 11) leg II; 12) leg III; 13) leg IV.

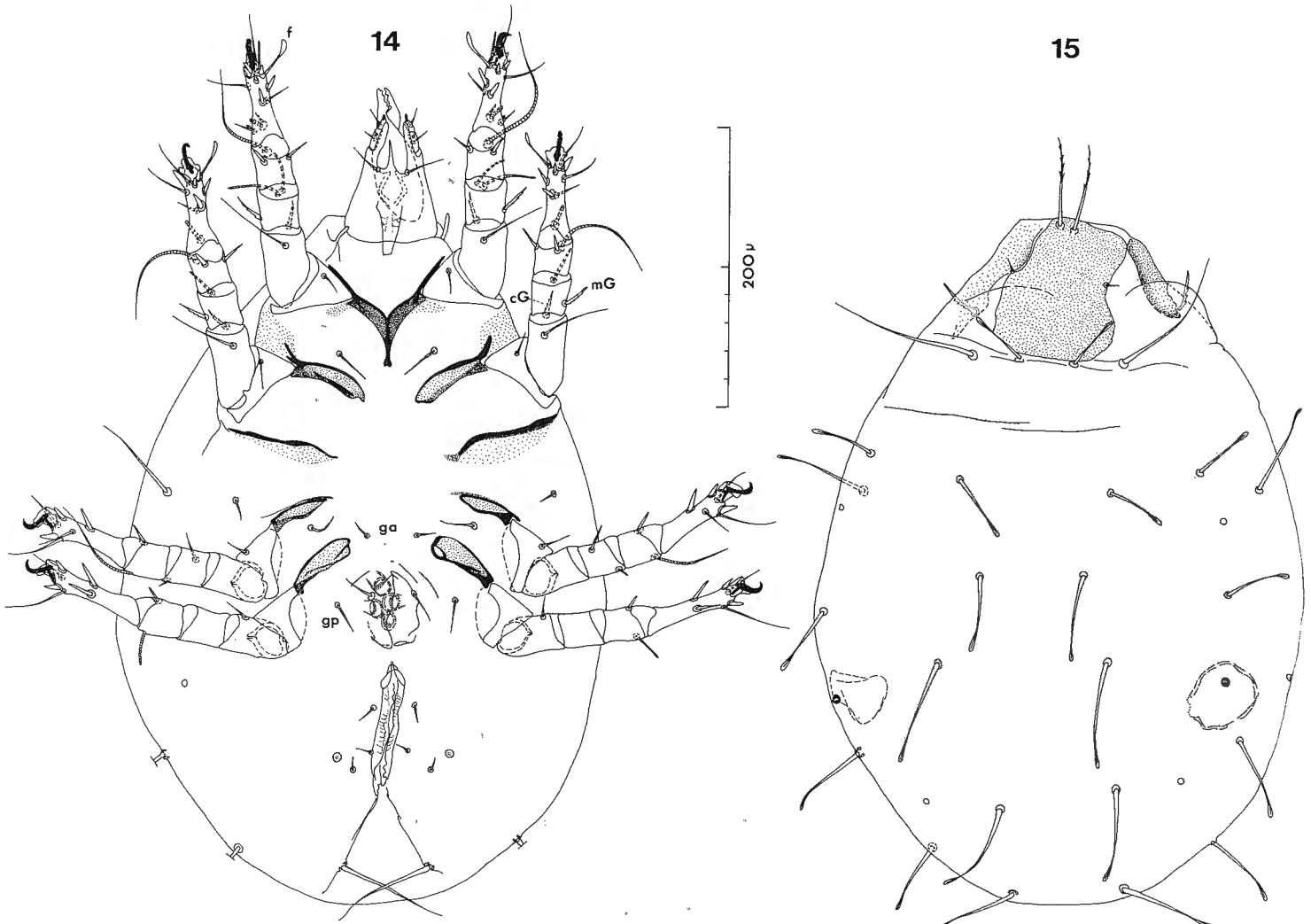

Fig. 14, 15. — *Cosmoglyphus inaequalis* FAIN & CACERES, 1973. 14) venter of tritonymph; 15) dorsum of tritonymph.

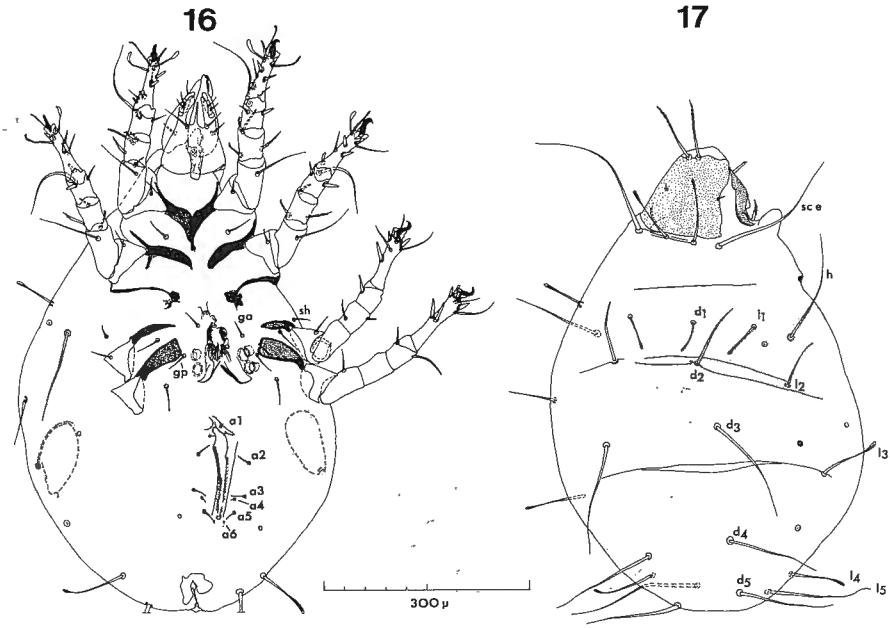

Fig. 16, 17. — *Cosmoglyphus inaequalis* FAIN & CACERES, 1973.
16) venter of female; 17) dorsum of female.

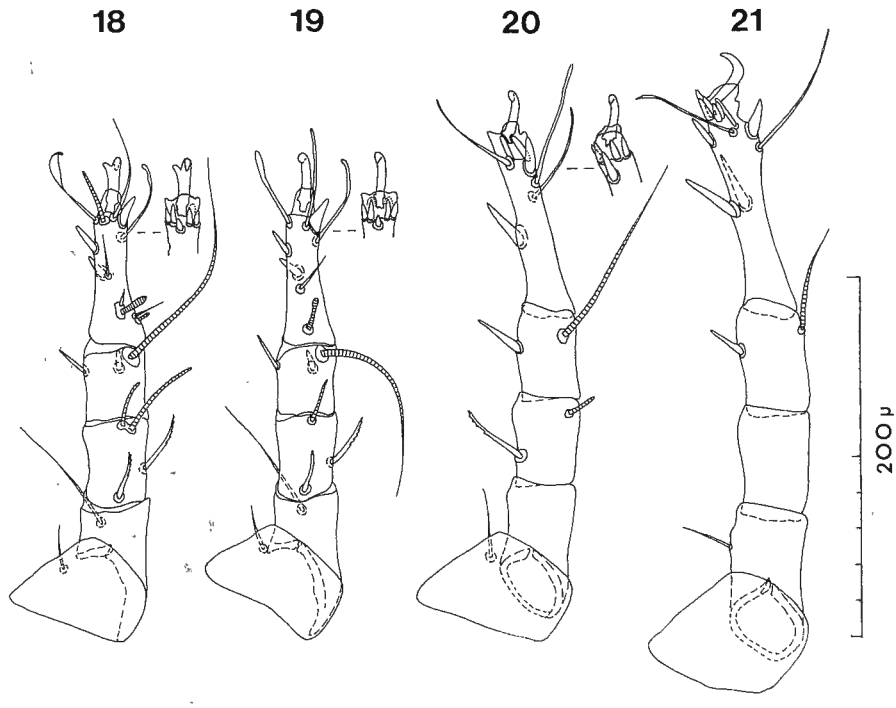

Fig. 18-21. — *Cosmoglyphus inaequalis* FAIN & CACERES, 1973.
Legs I-IV of female in dorsal view;
18) leg I, apex in ventral view; 19) leg II, apex in ventral view;
20) leg III, apex in ventral view; 21) leg IV.

Dorsum (Fig. 23). As figured, with setae *l 2-l 4*, *d 3-d 5* distinctly longer than in female (bimorphic male in terminology of TÜRK & TÜRK, 1957). All idiosomal setae filiform except *sc i*, *d 1* barbed apically and *l 1* flattened.

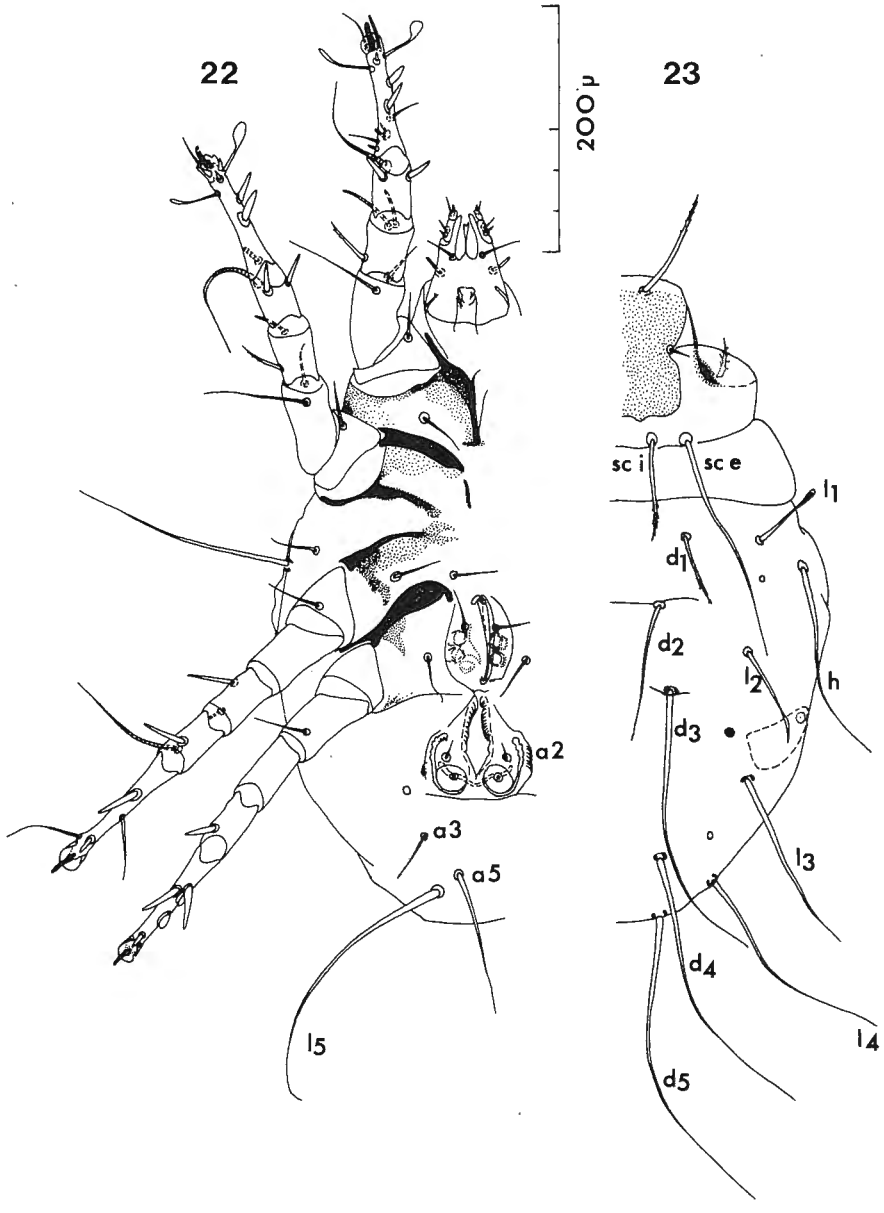

Fig. 22, 23. — *Cosmoglyphus inaequalis* FAIN & CACERES, 1973.
22) venter of male; 23) dorsum of male.

Legs (Figs. 24-27). Legs slender and somewhat longer than of female. Setae (ra) on tarsus I, II much more foliate than in female. Legs IV with two setae ((d), (e)) modified into suckers, positioned in the median and apical region of the tarsus. There is no male polymorphism in specimens examined, as has been described in some other *Cosmoglyphus* species (SAMŠIŇÁK, 1966).

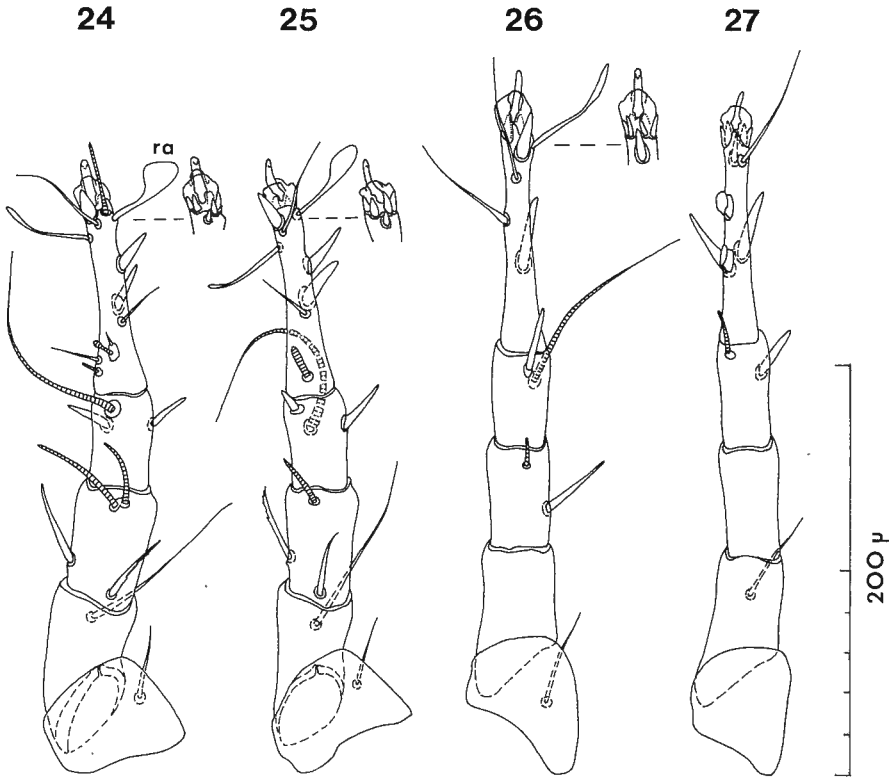

Fig. 24-27. — *Cosmoglyphus inaequalis* FAIN & CACERES, 1973.
Legs I-IV of male in dorsal view;
24) leg I, apex in ventral view; 25) leg II, apex in ventral view;
26) leg III, apex in ventral view; 27) leg IV.

DISCUSSION

The species we describe here has been tentatively associated with the species, *Cosmoglyphus inaequalis* FAIN & CACERES, 1973, on the basis of the morphology of the deutonymph. In their original description, FAIN & CACERES (1973) characterized this species by the inflated base of the gnathosomal remnant in the deutonymph. This characteristic, however, is also found in *Cosmoglyphus arushensis* (MAHUNKA, 1961) New Combination, described from unidentified beetles from Tanzania, *C. limbata* (MAHUNKA, 1974) New Combination, described from un-

identified insects from Ghana, and *C. absoloni* (SAMŠIŇÁK, 1961), described from the termite, *Coptotermes formosanus*, from China. Of these species, only *C. absoloni* is known from adults as well as deutonymphs.

Deutonymphs of *Cosmoglyphus inaequalis* share with *C. limbata* the bifurcate setae of genu III, tibia III-IV and tarsus IV, character states not found in other species. The only apparent difference between these two species is in the length of the internal scapular setae which are only slightly shorter than the external scapulars in *C. inaequalis* but considerably shorter in *C. limbata*. We have not examined specimens of *C. limbata* in this study, and as the original description and figures are not clear as to the setae at the anterior edge of the propodosomal dorsum, it remains possible that *C. limbata* may be a synonym of *C. inaequalis*.

Deutonymphs of *C. inaequalis* differ from those of *C. arushensis* notably in the longer trochanteral setae and the relative lengths of the dorsal idiosomal setae. The original figures of *C. arushensis* do not indicate that the setae of the posterior legs are bifurcate, although this character should be verified in any revisional study.

Of described adults, *C. inaequalis* most closely resembles *C. absoloni*, differing from that species primarily in the spatulate shape of certain dorsal idiosomal setae in the female and male and in the barbed internal vertical setae. In *C. absoloni*, all idiosomal setae are indicated as simple and filiform.

The characterization of the genus *Cosmoglyphus* and its systematic position in the family Acaridae are in need of revision. Many previous workers have considered this genus either as a subgenus or synonym of *Acotyledon* OUDEMANS, 1903. The confusion of this name and the generic name *Eberhardia* OUDEMANS, 1924, with *Cosmoglyphus* has been reviewed by FAIN & PHILLIPS (1978) regarding the identity of the genus *Acotyledon*. Those workers restricted the name *Acotyledon* to those species with a number of regressive characteristics in the deutonymph, but they did not indicate the correct systematic position of species such as *A. limbata* and *A. arushensis*, originally described in *Acotyledon* but excluded by them on the basis of their new definition. In the latest revision of the genus *Cosmoglyphus*, SAMŠIŇÁK (1966) defined the genus only on the basis of the inflated and barbed supracoxal setae of the adults. Deutonymphal characteristics were not considered, nor were species described only from deutonymphs.

In an attempt to provide a first approximation of the proper phylogenetic position of the genus *Cosmoglyphus*, we suggest the following character states (following OCONNOR, 1981) as indicating that the genus *Cosmoglyphus* is a valid genus and should be considered the earliest derivative lineage in the subfamily Rhizoglyphinae. In order to properly characterize the phylogenetic position of any taxon, the taxon must be shown to be monophyletic on the basis of shared derived character states present in all species. Secondly, the taxon must be com-

pared with its sister-taxon, with which it shares other derived character states, in that the taxon in question must retain at least one ancestral state compared with its sister-taxon.

For the genus *Cosmoglyphus*, we suggest that the sister-group of the genus is a group comprising all other genera in the subfamily Rhizoglyphinae. *Cosmoglyphus* shares with these taxa, the derived character states of the posterior position of the external vertical setae, and the formation of more than one male morph. These character states are derived with respect to other taxa in the Acaridae (usually placed in a paraphyletic taxon, Acarinae), indicating that the subfamily Rhizoglyphinae is a natural, monophyletic group. Within this group, all taxa except *Cosmoglyphus* share the character state of the supracoxal seta of the adults being very thin, not inflated. On the basis of outgroup comparison with earlier derivative acarid lineages (e.g. *Acarus, Tyrophagus, Forcellinia*), the ancestral state of this character in the family is to have the supracoxal seta inflated basally and strongly barbed, the condition found in *Cosmoglyphus*. As this character state is ancestral, it cannot be used to define a monophyletic genus, *Cosmoglyphus*. However, another character state may be used to define *Cosmoglyphus*, this being the elongation of the genual segments of legs III-IV of the deutonymph. In all species now assigned to *Cosmoglyphus* in which the deutonymph is known, this character is present, although not well developed in *C. chantalae* FAIN & CACERES, 1973. As outgroup comparison with the aforementioned acarid genera indicates that the ancestral state of this character is for the genua to be short rather than elongate, the genus *Cosmoglyphus* may be thus properly placed in a phylogenetic analysis of the Acaridae as the sister-group of all other Rhizoglyphinae.

On the basis of the presence of this derived character state the monobasic genera, *Stunkardacarus mirabilis* FAIN, 1978, and *Rettaracus rettenmeyerorum* MAHUNKA, 1979, both known only from the deutonymph, may be hypothesized to belong to the genus *Cosmoglyphus*. FAIN (1978) listed a number of character states as defining the genus *Stunkardacarus*. Of these, almost all are found in *Cosmoglyphus* as well, either as shared derived states or retained ancestral states. That author stated that « femora III-IV about 4 times longer than wide », an apparent lapsus for the elongate genua clearly visible in the figure. Similarly, « the *v e* are very strong and as long as the body », probably refers to the setae we believe are the *sc i* in the deutonymph and which range from very short to moderately elongate in other species of *Cosmoglyphus*. The great length of the *sc i* setae and the trifurcate form of the other dorsal idiosomal setae are the only character states mentioned which are unique to *Stunkardacarus*. These are autopomorphies, not found in any other Acaridae and are not useful in determining relationships. Two additional character states, not mentioned by FAIN but present in *S. mirabilis*, the form of the gnathosoma which is inflated basally, and the bifurcate form of seta (w) of tarsus IV are shared with the other African species of

Cosmoglyphus noted above. On the basis of these shared, derived character states, we propose that *Stunkardacarus* should be considered as a formal synonym of *Cosmoglyphus*, and that *Cosmoglyphus mirabilis* (New Combination) is closey related to *C. inaequalis, C. limbata* and *C. arushensis*.

The situation with *Rettacarus rettenmeyerorum* is quite different, with that species sharing very few character states with other species of *Cosmoglyphus*. For the present, we believe that the elongate posterior genua may be independently evolved in the two taxa and thus the result of convergence. Because the original hypothesis of a close relationship between *Rettacarus* and *Cosmoglyphus* is not supported by additional character states, we do not propose the synonymy of these taxa. Discovery of the adults corresponding to these and other taxa should provide much needed information by which these hypotheses may be tested.

DEPOSITION OF SPECIMENS

Figured specimens : South African Institute for Medical Research, Johannesburg.

Other specimens : Institut Royal des Sciences Naturelles de Belgique, Brussels; Institute of Parasitology, Czechoslovakian Academy of Science, Prague; Institut de Medicine Tropicale « Prince Leopold », Antwerpen; Museum of Zoology, University of Michigan, Ann Arbor, Michigan; Catholic University Nijmegen, Netherlands.

ACKNOWLEDGEMENTS

We thank Mrs. MARTINDALE (Institute for Medical Research, Johannesburg) for providing us with the material studied in this paper.

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