Revisional studies on *Thoracophoracarus* K. Viets, 1914 (Arachnida, Acari, Hydrachnidia, Arrenuridae)

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ABSTRACT
Five species from Europe and Africa attributed to the genus *Thoracophoracarus* K. Viets, 1914 are redescribed from type material. *Thoracophoracarus sinearcus* (K. Viets, 1924), probably based on a deformed *Arrenurus* Dugès, 1834 male, is considered a *species incerta*. *Thoracophoracarus mammosus* (K. Viets, 1925) is synonymized with *T. petioluriger* (K. Viets, 1925). *Thoracophoracarus cooki* n. sp., *T. silvarum* n. sp. and *T. felix* n. sp. are described from Madagascar, representing a distinct species group endemic to the island, characterized by absence of idiosomal humps and round, not longish, acetabular fields. The phylogeny of the genus is discussed.

KEY WORDS
Arachnida,
Acari,
Hydrachnidia,
Arrenuridae,
Africa,
fresh waters,
diversity,
new species.

RÉSUMÉ
Révision de Thoracophoracarus *K. Viets, 1914 (Arachnida, Acari, Hydrachnidia, Arrenuridae).*
Cinq espèces européennes et africaines attribuées au genre *Thoracophoracarus* K. Viets, 1914 sont redécrites d'après le matériel type. *Thoracophoracarus sinearcus* (K. Viets, 1924), probablement décrit à partir d'un mâle endommagé du genre *Arrenurus* Dugès, 1834, est consideré *species incerta*. *Thoracophoracarus mammosus* (K. Viets, 1925) est placé en synonymie avec *T. petioluriger* (K. Viets, 1925). *Thoracophoracarus cooki* n. sp., *T. silvarum* n. sp. et *T. felix* n. sp. sont décrits de Madagascar, et représentent ensemble un groupe d'espèces distinct, endémique de l'île, caractérisé par l'absence d'élévations sur l'idiosoma, et la forme des champs d'acetabula circulaires et non allongés. La phylogénie du genre est discutée.

MOTS CLÉS
Arachnida,
Acari,
Hydrachnidia,
Arrenuridae,
Afrique,
eaux douces,
diversité,
espèces nouvelles.

INTRODUCTION

Thoracophoracarus K. Viets, 1914 was introduced as a subgenus in *Arrenurus* Dugès, 1834 (K. Viets 1914a). However, as in the preliminary species diagnosis (K. Viets 1914b), in all following papers dealing with the taxon, it was treated as a genus of its own. The type species of *Thoracophoracarus*, *T. arrhenuroides* K. Viets, 1914, differs from all previously known arrenurids in the complete absence of a dorsal furrow. In most *Arrenurus* species (and in heavily sclerotized representatives of many other water mite families also), this furrow as a membranous ring separates the cap-like dorsal shield from the remainder of the idiosoma. Since then, nine further species have been described from Europe, various parts of Africa, and Chile. Two subgenera were introduced, *Thoracaphorurus* K. Viets, 1942 for *Thoracophoracarus petioluriger* K. Viets, 1925 and *Xenthoracaphorus* Cook, 1988 for *T. chilensis* Cook, 1988 (see K. Viets 1942 and Cook 1988).

In his description of *T. gibberosus* from South Africa, K. Viets (1962) pointed out that the new species strongly resembled *Arrenurus* species of the subgenus *Megaluracarus* K. Viets, 1911 and included some thoughts about morphological diversity within the genus. His observation that *Thoracophoracarus* included species corresponding to several of the subgenera of *Arrenurus* lead him to propose a future subdivision of *Thoracophoracarus* into a similar number of subgenera. In contrast, Cook (1974) considered the morphological diversity of species attributed to this taxon as strongly supporting a polyphyletic origin of *Thoracophoracarus*.

The detection in several parts of Madagascar, of new populations of arrenurids with a reduced dorsal furrow was the starting point for reconsidering the problem. In fact, morphological features of both the formerly known species, and the species described here as new to science, could support the hypothesis that *Thoracophoracarus*-like mites as a whole "had arisen from independent loss of the dorsal furrow from very divergent *Arrenurus* stock" (Cook 1974). However, the following study will document common features of the species known from continental Africa on the one hand, and three new species from Madagascar on the other. It will be shown that the taxon could continue to be accepted, both in a restricted sense, including the Central African species only, or in a very wide sense as a monophyletic clade that branched into several evolutionary lines in early times.

Most of the type material revised in this study is in poor condition, partly due to damage and/or loss of appendages, partly as a consequence of a too thick layer of mounting medium or the precipitation of crystals. Consequently, in several cases, figures originate from a combination of details found in several specimens or they had to be produced at rather low magnification. The general idiosoma setation is found to be stable as typical for the family Arrenuridae. Lack of setae and/or glands in some figures is exclusively due to damage or bad visibility of the investigated specimens.

MATERIAL AND METHODS

The new material from Madagascar was collected during field work of Tom Goldschmidt and the author. Mites were collected with a hand net, sorted out on the spot and preserved in Koenike's fluid. Slide-mounting was done with Hoyer's fluid. The specimen selected for SEM investigations was dehydrated in a graded series of ethanol, critical point dried in CO_2 in a Polaron E 3000 Series II apparatus, sputter coated with gold/palladium in a Balzers SCD 030 Sputter-Coater, and investigated with a Cambridge Stereoscan 250 Mk 2.

All measurements are given in µm.

Abbreviations

CNC	Canadian National Collection, Ottawa;
FMC	The Field Museum, Chicago;
MNHN	Muséum national d'Histoire naturelle, Paris;
SMF	Senckenberg Museum, Frankfurt;
SMNH	Swedish Museum of Natural History, Stockholm;
Cx-3	third coxae;
I-L-5	first leg, fifth segment;
P-3	palp segment 3;
H	height;
L	length;
W	width.

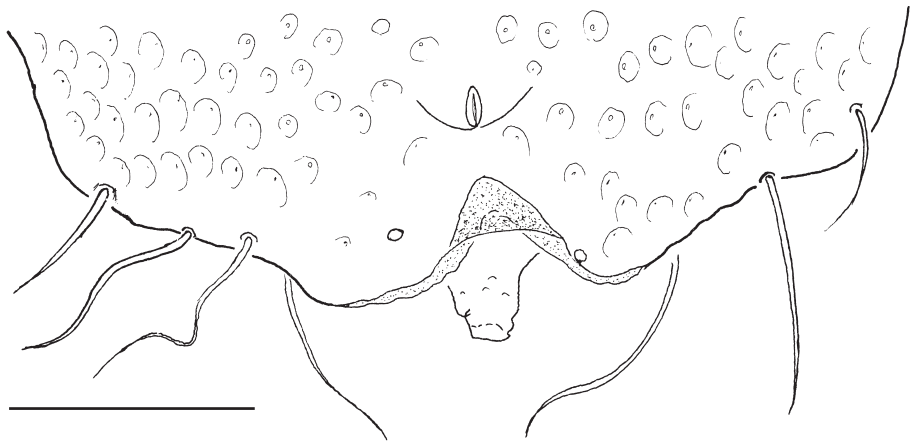

FIG. 1. — *Arrenurus sinearcus* K. Viets, 1924, holotype ♂ (SMF), caudal area in dorsal view. Scale bar: 100 µm.

SYSTEMATICS

Genus *Arrenurus* Dugès, 1834

TYPE SPECIES. — *Arrenurus viridis* Dugès, 1834.

Arrenurus sinearcus K. Viets, 1924 *species incerta* (Fig. 1)

Arrenurus sinearcus K. Viets, 1924: 81, figs 17-19.

Thoracophoracarus sinearcus – K. Viets, 1928: 48, fig. 116.

HOLOTYPE. — Germany, Holstein, Großer Plöner See, 14.X.1918, A. Thienemann leg., 3082, ♂ (SMF).

REMARKS

Notwithstanding intensive investigation of the water mite fauna in central European lowlands, this species has not been recorded since its first description, and K. O.Viets (1962) proposed that it could be a deformed representative of an *Arrenurus* species. In fact, from a careful re-examination it is obvious that the caudal part of the idiosoma is not symmetrical, as suggested by the figures for the original description. An evident asymmetry concerns the position of the gland openings posterior to the anal pore, the two membranes extending in the caudal concavity and the petiole that shows a distinct indentation on the right side (Fig. 1). Obviously, this is a deformed specimen – with a high probability, the absence of the dorsal furrow, a character never observed again in European arrenurids, is due to monstruous development as well. Due to these morphological abnormalities, synonymization with one of the numerous *Arrenurus* species recorded from the Großer Plöner See is not possible and *Arrenurus sinearcus* must be considered a *species incerta*.

Genus *Thoracophoracarus* K. Viets, 1914

TYPE SPECIES. — *Thoracophoracarus arrhenuroides* K. Viets, 1914.

Subgenus *Thoracophoracarus* K. Viets, 1914

TYPE SPECIES. — *Thoracophoracarus* (*Thoracophoracarus*) *arrhenuroides* K. Viets, 1914.

Thoracophoracarus (*s.s.*) ***arrhenuroides*** K. Viets, 1914 (Fig. 2)

Thoracophoracarus arrhenuroides K. Viets, 1914: 354, fig. 43a-e.

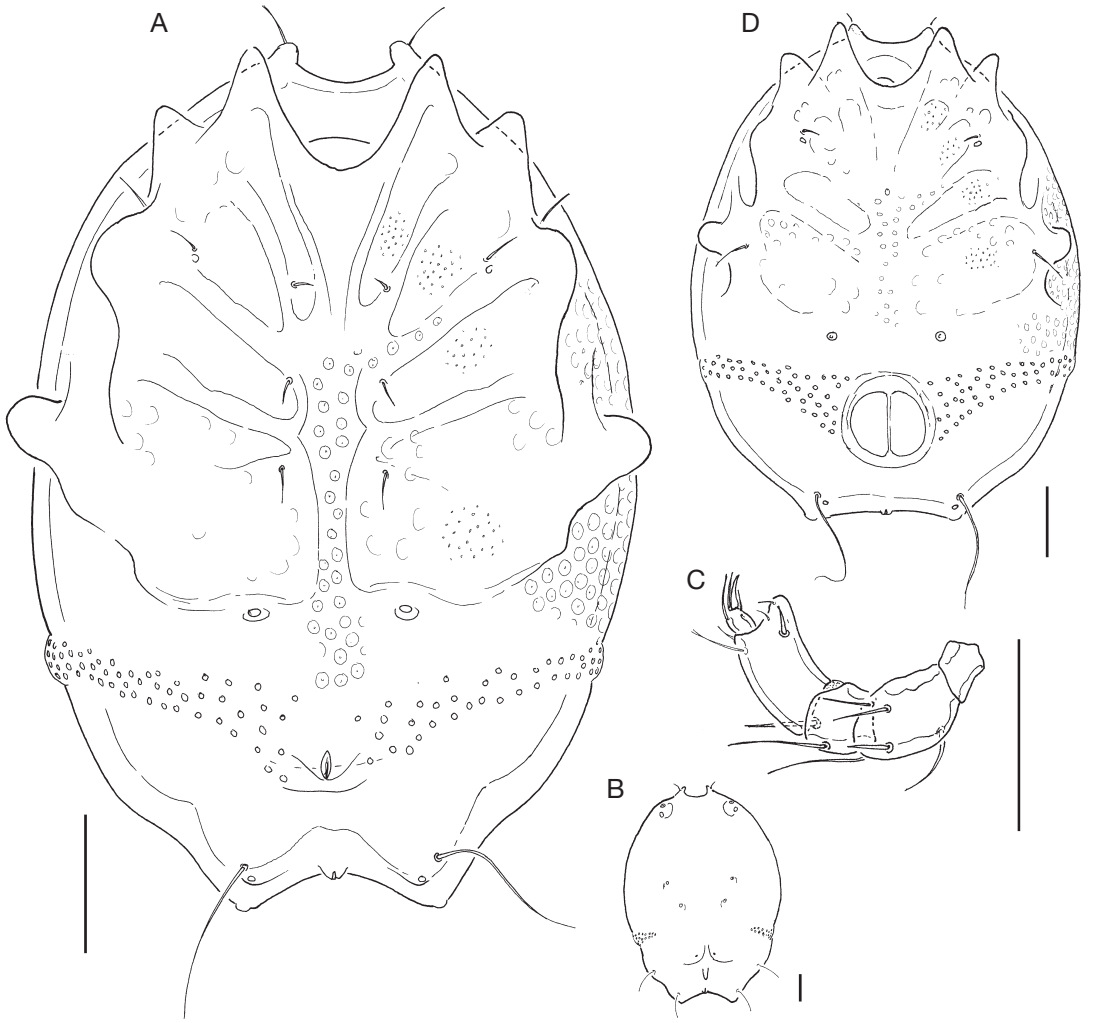

FIG. 2. — *Thoracophoracarus arrhenuroides* K. Viets, 1914: **A**, **B**, holotype ♂ (SMF 47455), idiosoma in ventral (**A**) and dorsal (**B**) views; **C**, ♀ (SMF 47458), palp; **D**, paratype ♀ (SMF 47431), idiosoma in ventral view. Scale bars: 100 µm.

TYPE MATERIAL. — Holotype: Cameroon, southern border of bay of Duala, fishermen village Manoka, larger permanent stream east of the village (water support place of the village during dry season), 1.I.1912, Damköhler leg., 1384, ♂ (SMF 47455).
Paratype: same area as holotype, temporary stream, 11.XI.1911, Damköhler leg., 1265, ♀ (SMF 47431).

MATERIAL EXAMINED. — **Cameroon.** Catchment of River Ebo (Dibamba), small affluent at Miap cascade, from stones, 4.XI.1913, Damköhler leg., 1831, ♀ (SMF 47458).

DESCRIPTION

Idiosoma egg-shaped, posterior margin concave (Fig. 2A, B, D). Body colour probably deep blue (traces of colour visible in the slide-mounted specimens). Anterior and posterior idiosoma margins with elevated humps – the anterior ones associated with the antenniformia (dorsoglandularia 1), the posterior ones flanking a bay with the excretory pore. Legs with numerous swimming setae, arranged in longitudinal lines on the anterior surface, in

transverse lines at the distal margin on the posterior surface. Distal margins of segments 3-5 of all legs anteriorly and posteriorly projecting, with pointed tips. Genital field about halfway between posterior margin of Cx-4 and posterior idiosoma margin, with slender, laterally narrowed acetabular fields, extending to the dorsolateral idiosoma. Acetabula number *c.* 40 + 40. Palp setation (Fig. 2C): P-1 without setae; P-2, 5 (2 on the mediodistal surface, 3 dorsally); P-3, 2 (1 fine medially, 1 stronger laterodistally); P-4, 1 stronger mediodistal seta, 4 or 5 fine hair-like setae dorsodistally and at the ventrodistal extension. P-4 relatively long, with subparallel dorsal and ventral margins. Sexual dimorphism little developed, mostly apparent in the shape of the genital field.

Male (Fig. 2A, B): anterior idiosoma humps strongly developed, with a pointed, triangular tip directed medially, setae inserting dorsally. Lateral idiosoma margin slightly bulging where the acetabular field reaches the flanks, more distinctly bulging between the acetabular fields and caudal humps, and forming an obtuse-angled caudal bay. In posterior part of dorsum a small, caudally directed finger-shaped extension, located posterior to a pair of glands lying on an inversely V-shaped transverse bar. Gonopore directed ventrocaudally, located at posterior edge of acetabular fields. Ventrodistal extension of P-4 with a rounded tip. Measurements: idiosoma L/W 570/400, Cx-4 W 420; acetabular field L/W 35/160; palp L/H P-1 23/20, P-2 50/38, P-3 33/36, P-4 58/31, P-5 -/- (measurement impossible).

Female (Fig. 2C, D): similar to male, but 1) idiosoma slightly larger; 2) anterior and posterior humps more rounded and caudal indentation less developed; 3) gonopore large, opening directed ventrally, with its anterior edge at the level of the acetabular field; and 4) ventrodistal extension of P-4 sharply pointed. Measurements: idiosoma L/W 570/520, Cx-4 W 500; acetabular field L/W 20/200; palp L/H P-1 18-25/20-25, P-2 48-61/33-40, P-3 33-39/33-38, P-4 55-65/28-33, P-5 25-28/9-10.

Remarks

This species differs from all other members of the genus in the presence of an obtuse-angled caudal indentation (in both sexes bearing the anal pore) and the finger-like projection on the posterior dorsum in males. Further important characters, partly found also in other species of the genus, are the plesiotypical ventral position of the gonopore, acetabular fields extending to the dorsum and P-2 bearing only two mediodistal setae.

Thoracophoracarus (*s.s.*) ***kuehnei*** K. Viets, 1916 (Fig. 3)

Thoracophoracarus kuehnei K. Viets, 1916: 369, fig. 46a-c.

Type material. — Holotype: Cameroon, river Mbome near village Mpobo (15 m large, 1.5 m deep), from stones, 21.VI.1913, Damköhler leg., 1872, ♂ (SMF 47459). Paratypes: Cameroon, river Njong river upstr. Njong cascades (2 ½ hours from railway km 180), on the way to village Lolo, near village Makomól (130 m large, 10 m deep, blackwater without vegetation), from mud with leaf litter, 28.XII.1914, Damköhler leg., 3150, 2 ♀♀ (SMF 47466); "allotypus", 3 ♂♂ (SMF 47465, 55028, 55029).

Description

Idiosoma egg-shaped, caudally truncated (Fig. 3A, B, D). Anteriorly with a pair of small humps associated with the antenniform setae. Legs as described for *T. arrhenuroides*. Genital field and caudal idiosoma with strong sexual dimorphism. In both sexes acetabular fields slender and extending to the dorsal idiosoma, with about 40 acetabula on each side. Palp setation similar to *T. arrhenuroides*, but P-1 with a dorsal seta (Fig. 3C). P-2 subrectangular, P-4 dorsal and ventral margins distally divergent, ventrodistal extension pointed, slightly bent dorsally.

Male (Fig. 3A-C): in lateral view, posterior third of idiosoma abruptly flattened and forming a groove anteriorly delimited by an open, in dorsal view, inversely V-shaped transverse step. Posterior margin with a deep indentation, proximally a little wider than distally, at its deepest point the caudally-directed anal pore. Gonopore located immediately anterior to this indentation, at the posterior margin of the genital field and directed ventrocaudally. Acetabular fields nearly straight, perpendicular to the longitudinal body axis. Measurements: idiosoma L/W

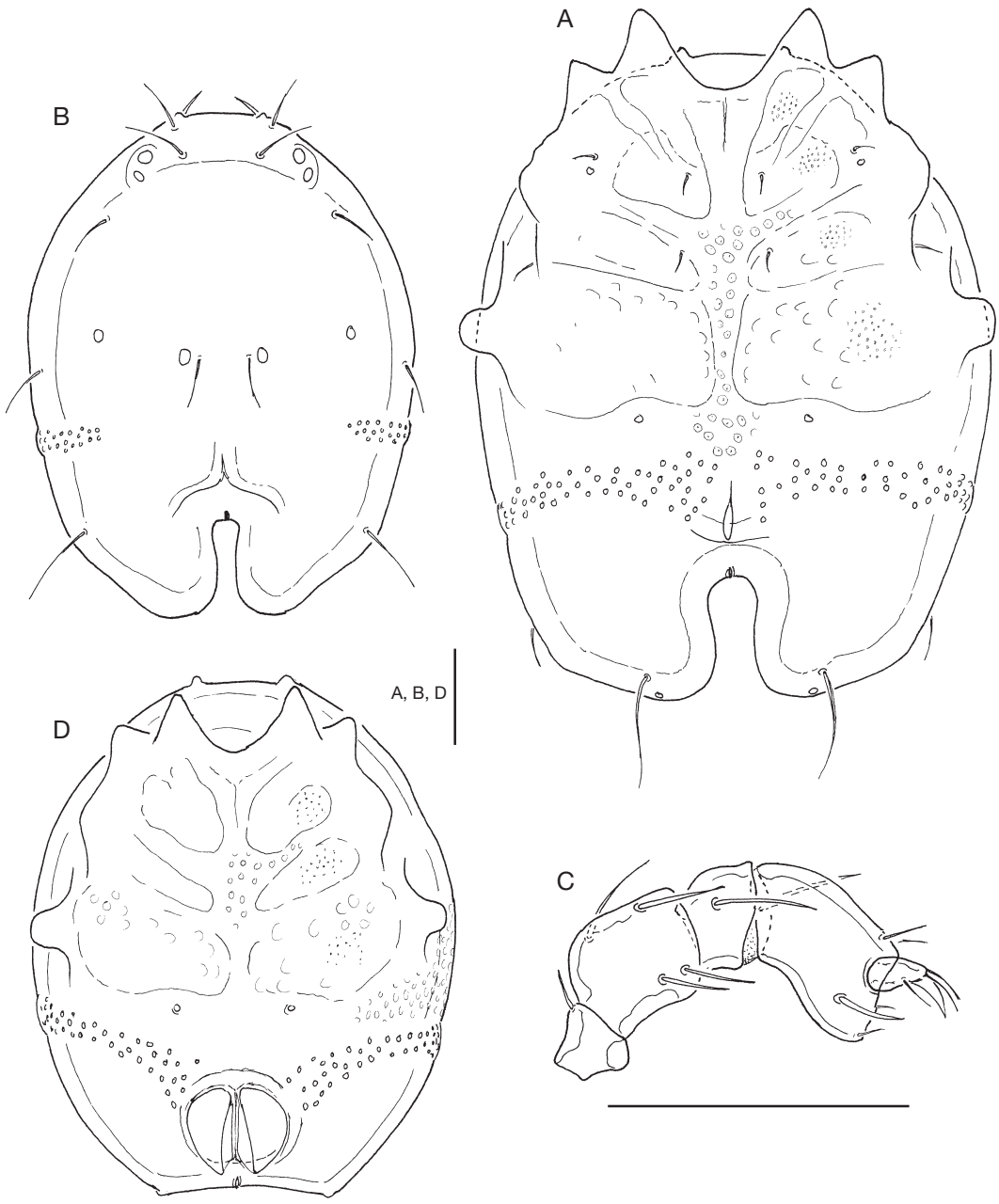

FIG. 3. — *Thoracophoracarus kuehnei* K. Viets, 1916: **A**-**C**, paratype ♂ (SMF 55029); **A**, ventral idiosoma; **B**, dorsal idiosoma; **C**, palp; **D**, paratype ♀ (SMF 47466), ventral idiosoma. Scale bars: 100 µm.

610/400, Cx-4 W 470; acetabular field L/W 35/160; palp L/H P-1 25/25, P-2 55/40, P-3 33/40, P-4 63/40, P-5 33/13.

Female (Fig. 3D): in lateral view, idiosoma in its posterior third gradually flattened; posterior margin in dorsal view slightly concave, with the

anal pore directed caudally. Gonopore rather large, directed ventrocaudally, located at posterior edge of acetabular fields; acetabular fields not well defined, medially reaching the gonopore in an obtuse angle, laterally bent as narrow strip perpendicular to the main body axis. Measurements: idiosoma L/W 585-590/485-490, Cx-4 W 485-490; gonopore 100/112; palp L/H P-1 25/25, P-2 54/37, P-3 29/37, P-4 60/38, P-5 29/10.

Remarks

Both sexes of *T. kuehnei* differ from *T. arrhenuroides* in the position of the gonopore which is shifted posteriorly (further from Cx-4 than from posterior idiosoma margin) and directed ventrocaudally, and in the presence of a seta on P-1. In addition, males of *T. kuehnei* are distinguished by the deep indentation of posterior idiosoma and the absence of a finger-like dorsocaudal extension.

Thoracophoracarus (*s.s.*) ***rivularis*** Lundblad, 1951 (Fig. 4)

Thoracophoracarus rivularis Lundblad, 1951: 161.

Type material. — Holotype: Kenya, Aberdare, 3000 m, 17.VII.1948, leg. Å. Holm, ♀ (SMNH 3810).

Description

Female (male unknown): body colour red. Idiosoma (Fig. 4B) egg-shaped, with straight posterior margin. Anterior margin dorsal to gnathosoma smoothly convex, a pair of elevated humps associated with the antenniformia (dorsoglandularia 1). Gnathosomal bay wide, medial margins of Cx-1 strongly diverging. Legs (both I-L lacking) with few swimming setae, numbers: II-L-4/5, 0; III-L-4, 2; III-L-5, 2; IV-L-4, 2; IV-L-5, 2. Genital field with slender, laterally not narrowed acetabular fields (L/W 90/285), extending to the flanks of the idiosoma; acetabula number *c.* 120 + 120. Gonopore at posterior margin of genital field, further from coxal field than from posterior idiosoma margin, directed ventrocaudally. Excretory pore a little anterior to posterior idiosoma margin. Palp (Fig. 4A) setation: P-1, 1; P-2, 10 (2 dorsally, 8 on the medial and mediodistal surface, with a longitudinal excavation); P-3, 1 or 2; P-4, 1 stronger mediodistal seta, 4 or 5 fine hair-like setae dorsodistally and at the ventrodistal extension. P-4 relatively long, dorsal and ventral margins distally diverging. Measurements: idiosoma L/W 885/775, Cx-4 W 730; palp L/H P-1 47/36, P-2 84/59, P-3 60/51, P-4 98/32, P-5 36/10.

Remarks

In view of the importance of the sexual dimorphism for species definition in this genus, a discussion of relationships is not possible until the male of *T. rivularis* is described. However, the palp setation (with increased number of mediodistal setae on P-2) is unique and surely sufficient for recognizing *T. rivularis* as a well-defined species.

Thoracophoracarus (*s.s.*) ***gibberosus*** K. Viets, 1962

Thoracophoracarus gibberosus K. Viets, 1962: 409, figs 1-9.

Type material. — Holotype: South Africa, Eastern Cape Province, Kaaimans river FRW. 154, 10.III.1960, Agnew leg., 2595, ♂ (SMF 54995).
Paratypes: same site and date as holotype, ♂ (SMF 54994); ♀ (SMF 55020) ("allotypus"); ♀ (SMF 55019).

Remarks

The original description is very carefully done and detailed. This species is similar to others known from Africa in the presence of symmetrically-arranged dorsal humps (in males most visible near the antenniformia), but completely different in the construction of the genital field (in both sexes gonopore large, flanked by rounded acetabular fields not extending to the body flanks, plesiotypically located immediately posterior to coxal field and directed ventrally). As in three of the preceeding species, P-2 has only 2, rarely 3, mediodistal setae. In both sexes, the anteroventral extension of P-4 is equally rounded, not pointed. Males of *T. gibberosus* are distinct due to the development of a large, subrectangular cauda separated from the remainder of the idiosoma by a narrowed neck.

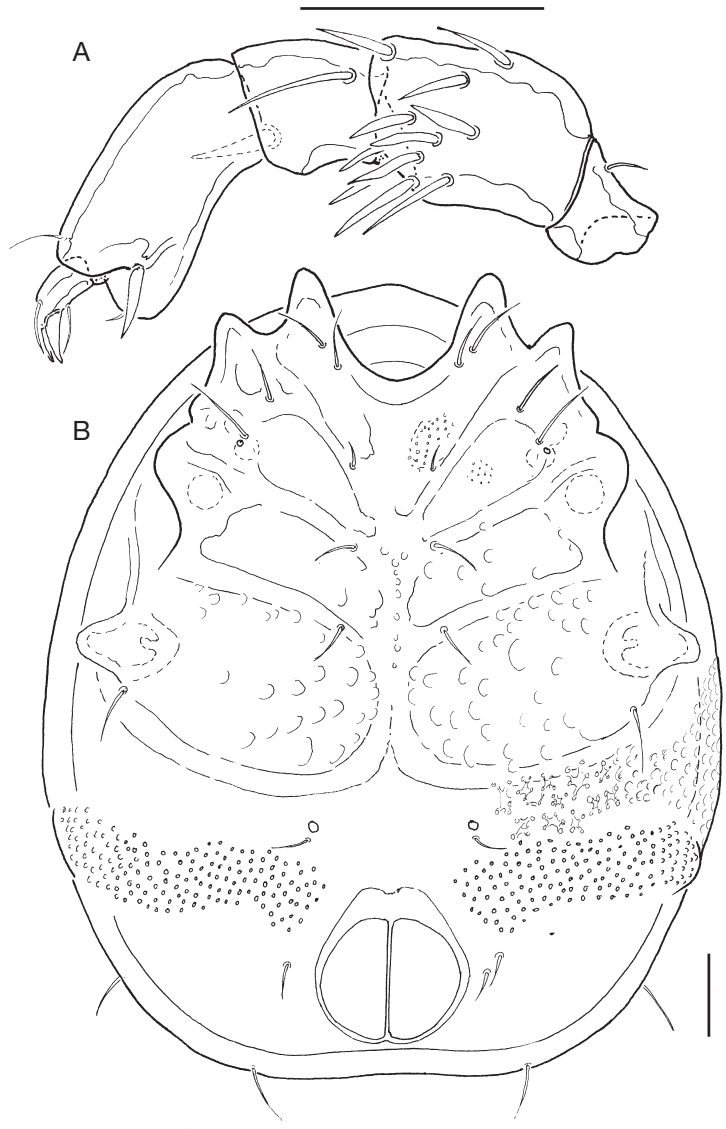

FIG. 4. — *Thoracophoracarus rivularis* Lundblad, 1951, holotype ♀ (SMNH 3810): **A**, palp; **B**, ventral idiosoma. Scale bars: 100 µm.

Thoracophoracarus (*s.s.*) *whartoni* Cook, 1966 (Fig. 5)

Thoracophoracarus whartoni Cook, 1966: 246, figs 856, 859.

TYPE MATERIAL. — Holotype: Liberia, Bomi Hills road, lx. stream, 18.XII.1957, leg. Cook, 88, ♂ (FMC). Paratypes: same site and date as holotype, 2 ♂♂ (CNC). — Liberia, Near Suehn, ex. pond near stream bed, 21.II.1957, leg. Cook, 44, 1 ♂ (CNC).

DESCRIPTION

Male (Fig. 5, female unknown): idiosoma elongated, dorsally with characteristically pointed anterior humps, symmetrically-arranged humps in other parts of dorsum rather flat. Posterior half of body

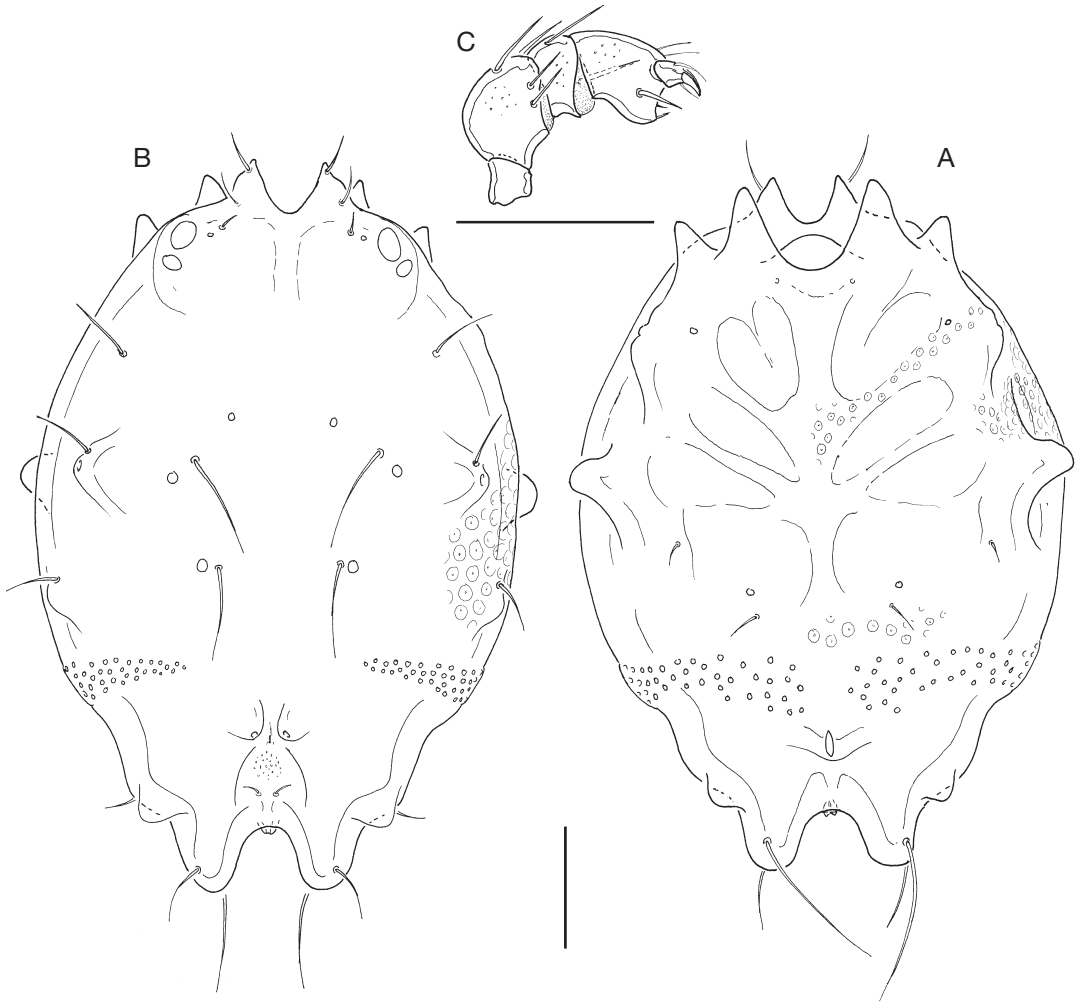

FIG. 5. — *Thoracophoracarus whartoni* Cook, 1966: **A**, paratype ♂ (CNC), ventral idiosoma; **B**, **C**, holotype ♂ (FMC); **B**, dorsal idiosoma, **C**, palp. Scale bars: 100 µm.

gradually narrowed and with a pair of pointed tips flanking an inversely U-shaped mediocaudal indentation. Excretory pore at the deepest point of this indentation. A deep, rounded pit (diameter 56-62) immediately anterior to the caudal indentation. Centre of this pit elevated, immediately anterior to the pit a pair of large glandularia. Legs as described for *T. arrhenuroides*. Gonopore further from coxal field than from posterior idiosoma margin, located posterior to the acetabular field on the level of the dorsal pit. Acetabular field forming a transverse strip extending to the dorsal idiosoma surface. Palp stout, P-2 with 2 or 3 mediodistal setae, P-4 shortened, ventrodistal extension bluntly pointed. Measurements: idiosoma L/W 506-576/358-384; palp L/H P-1 19-23/20, P-2 44-45/40, P-3 31-33/35, P-4 48-50/32-37, P-5 22-24/17.

REMARKS

As pointed out by Cook (1966), this species agrees with *T. arrhenuroides* and *T. petioluriger* in the presence of prominent extensions associated with

the anterior antenniform setae. It differs from males of both species in the deep caudal indentation and the presence of a dorsocaudal pit in the area where they bear a variously-shaped extension. From *T. arrhenuroides* it differs furthermore in the less projecting humps on the dorsal and caudal idiosoma and absence of a male caudal petiole. The formation of the caudal area (deeply indented, with a dorsocaudal pit) resembles *T. kuehnei*. This species differs in the indentation being more narrow, the pit flatter, and the presence of a seta on P-1.

Subgenus *Thoracophorurus* K. Viets, 1942

TYPE SPECIES. — *Thoracophoracarus* (*Thoracophorurus*) *petioluriger* K. Viets, 1925.

Thoracophoracarus (*Thoracophorurus*) *petioluriger* K. Viets, 1925 (Fig. 6)

Thoracophoracarus petioluriger K. Viets, 1925: 234, figs 1, 55.

Thoracophoracarus mammosus K. Viets, 1925: 235, figs 2, 56, 57, n. syn.

TYPE MATERIAL. — Lectotype of *T. petioluriger* (here designated): Cameroon, Mbúle stream near village Mbúle (4 m large, 0.4 m deep, running into river Njong in front of village Mangélle) at railway km 215, 5.I.1916, Damköhler leg., 3146, leg-bearing ♂ specimen on slide SMF 47464.
Paralectotypes: 2 ♂♂ without legs, slide-mounted together with lectotype.

MATERIAL EXAMINED. — Lectotype of *T. mammosus* (here designated), same site and date as type specimens of *T. petioluriger*, the ♀ with undissected idiosoma on slide SMF 47467; paralectotype ♀ with dissected idiosoma, slide-mounted together with lectotype.

DESCRIPTION

Body colour probably deep blue (traces of the colour still visible in the slide-mounted specimens). Most glandular openings associated with distinct humps that rise above the idiosoma surface, in particular in the dorsocaudal area (Fig. 6A, B, D, E). Extensions associated with anterior antenniformia strongly projecting. Legs as described for *T. arrhenuroides*. Genital field and caudal idiosoma with strong sexual dimorphism, acetabular fields narrow, their tips reaching the lateral parts of the dorsum, with about 40-50 acetabula on each side. Excretory pore terminal. Palp in shape and setation (Fig. 6C) as described for *T. arrhenuroides*.

Male (Fig. 6A, B): in lateral view, idiosoma in the posterior third gradually flattened, in dorsal view posterior margin truncated, but with an irregular surface due to symmetrically-arranged humps. Humps at anterior margin strongly developed and pointed. On posterior surface of dorsum a strong triangular projection directed caudally. Caudal tip of idiosoma bearing a slender petiole located dorsally to the excretory pore, with two slightly developed lateral wings bent dorsally, in shape like a tongue rolled-up along the longitudinal axis; its distal margin indented. Gonopore away from the posterior margin of Cx-4, immediately anterior to excretory pore, directed ventrocaudally; acetabular fields forming a large obtuse angle directed caudally. Measurements: idiosoma L/W 560/355, Cx-4 W 410; acetabular field L/W 50/250; palp L/H P-1 -/- (lacking), P-2 46/33, P-3 29/30, P-4 51/25, P-5 20/9.

Female (Fig. 6C-E): idiosoma humps nearly as strongly developed as in males, particularly in the dorsocaudal area. Anterior humps more rounded than in males. Posterior margin between posteriormost humps concave. Gonopore directed ventrocaudally. Shape of acetabular fields not clearly discernible (destroyed and given only sketchy in the specimen depicted by K. Viets; hardly visible in the other, undissected specimen), extending as slender transverse strips laterally from the anterior gonopore edge. Measurements: idiosoma L/W 480-560/400, Cx-4 W 420; acetabular field L/W 145/350; palp L/H P-1 20/18, P-2 46/33, P-3 33/33, P-4 55/25, P-5 20/8.

REMARKS

Due to generally strong sexual dimorphism, attribution of males and females is a problem in arrenurid species and the number of erroneous interpretations, or open questions, is considerable. As a general rule, character states not (or little)

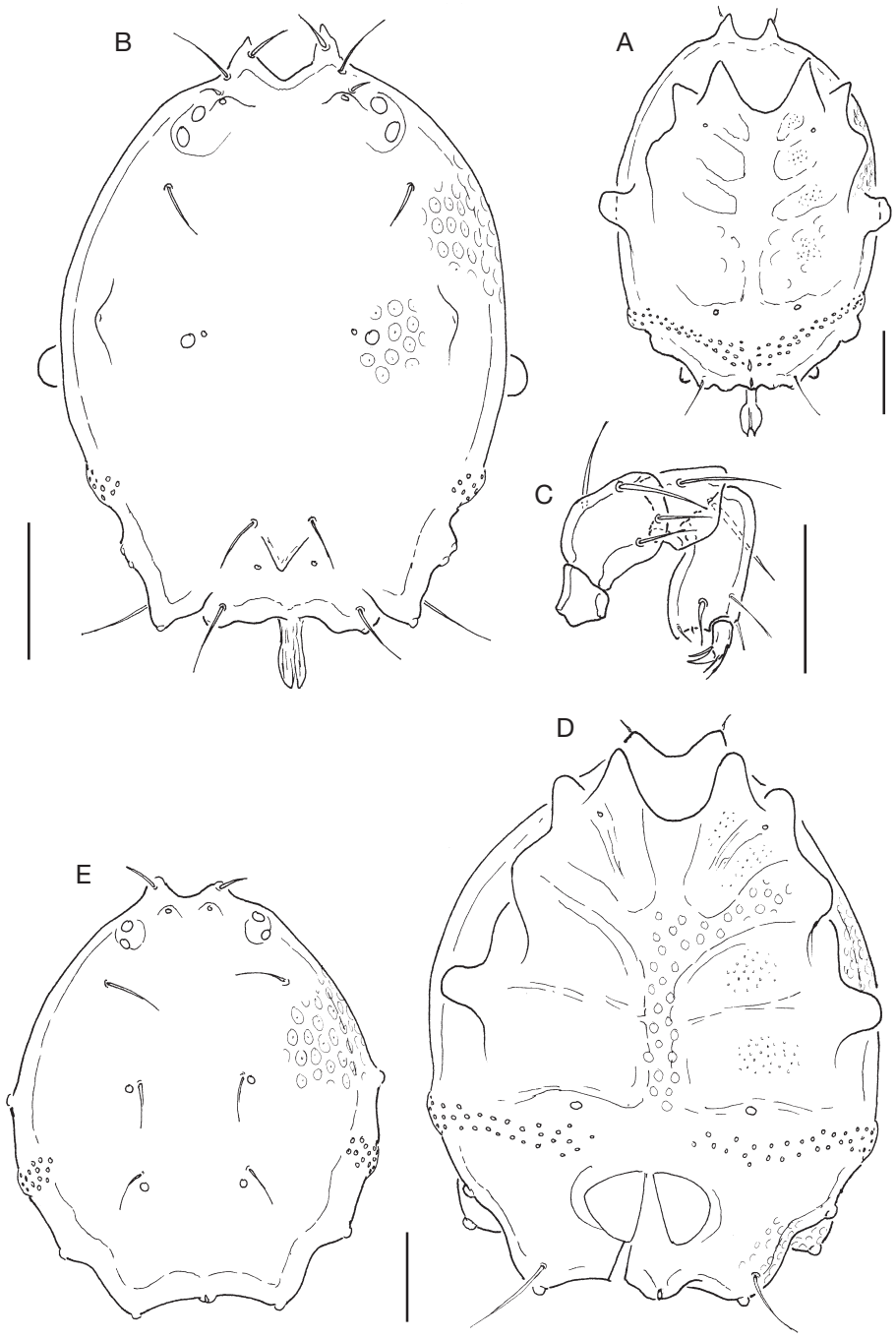

FIG. 6. — *Thoracophoracarus petioluriger* K. Viets, 1925: **A**, **B**, lectotype ♂ (SMF 47464); **A**, ventral idiosoma; **B**, dorsal idiosoma; **C**-**E**, ♀ (SMF 47467) ("*T. mammosus*", type specimens); **C**, palp, paralectotype; **D**, ventral idiosoma, paralectotype; **E**, dorsal idiosoma (drawn combining observations from lecto- and paralectotype on the same slide SMF 47467). Scale bars: 100 µm.

subject to sexual differentiation regard colour, formation of integument, shape of coxae, dimensions and shape and setation of palps. In species collected together, a similar development of these characters suggests conspecifity. This hypothesis can be verified (or falsified) by: 1) repeated collecting of both genders in the same locality and habitat; 2) increased knowledge of intraspecific variability; and 3) rearing experiments. Without giving reasons, K. Viets (1925) did not follow this tradition in the case of *T. mammosus*, collected at the same site and date as *T. petioluriger*. Development of the symmetrically-arranged integumental humps, similarity in colour (not mentioned in the description of *T. petioluriger*) and agreement in palp setation suggest that female *T. mammosus* and male *T. petioluriger* represent the same species. Minor differences between genders in the shape of the extensions flanking the anterior antenniform setae (in males more pointed and bent medially) and of P-4 (in males more stout and with the ventrodistal edge less projecting) are found in a similar manner in *T. arrhenuroides*. On this background I consider *T. mammosus* a junior synonym of *T. petioluriger*. This species differs from all other species of the genus in more distinctly projecting humps on the idiosoma surface (in particular the posterior ones). Both sexes are furthermore characterized (but similar to some other species) in P-1 being without a seta, P-2 with two mediodistal setae only and the gonopore directed ventrocaudally. The male of *T. petioluriger* is unique within the genus in the presence of the caudal petiole. However, a closer relationship between *T. petioluriger* and *T. arrhenuroides* (that would suggest the synonymy of the subgenus *Thoracophorurus* with *Thoracophoracarus* s.s.) cannot be excluded. A common character is the presence of a dorsocaudal extension in males.

Thoracophoracarus cooki species-group

Species included. — *Thoracophoracarus cooki* n. sp., *T. silvarum* n. sp. and *T. felix* n. sp.

Diagnosis. — Idiosoma oval in shape, with truncated anterior margin (Fig. 8A) and sexual dimorphism in dorsocaudal area. Dorsal idiosoma surface without humps. Coxae separated from remainder of ventral idiosoma by obvious suture lines, Cx-1+2 with rounded, not pointed tips. Legs as described for *T. arrhenuroides*. Acetabular fields compact, roundish, not reaching the idiosomal flanks. Palp robust, P-1 always with a dorsal seta, P-2 with 2-8 mediodistal setae, never bearing a setae bristle. Males: dorsocaudal idiosoma with a steep slope formed by a transverse sclerotized bar (Fig. 8B). Gonopore and, immediately above, excretory pore in terminal position (Fig. 8A-D), flanked by a pair of flat, transverse extensions. Females: dorsocaudal idiosoma equally rounded, without a transverse bar. Gonopore directed ventrally, closer to coxal field than to posterior margin. Excretory pore in ventrocaudal position.

Remarks

With certainty, the following three species represent a monophyletic clade, separated from the remaining *Thoracophoracarus* species primarily by the unique sexual dimorphism. In shape of the acetabular field, they resemble *T. gibberosus*. The species from Madagascar are best defined as representing a species-group. Their systematic placement cannot be defined without more insight in the relationships between the other species of the genus.

Thoracophoracarus (*s.s.*) ***cooki*** n. sp.
(Figs 7; 8)

Type material. — Holotype: Madagascar, MD 014, Anjozorobe (Antananarivo), Ravoandrina, left affluent of riv. Ampanakamonty upstream from MD 013, draining a forest clearing, 1230 m, 24.VII.2001, 15.4°C, 0.091 mS/cm, ♂ (MNHN Ac1118).
Paratypes: same site and date, 1 ♂ (MNHN Ac1119); 2 ♀♀ (MNHN Ac1120); 1 deutonymph (MNHN Ac1121). — MD 154a, Joffreville (M. d'Ambre, Antsiranana), R. de Manques in Reserve Fontenay, 550 m, 17.XI.2001, 21.9°C, 0.025 mS/cm, 1 ♀ in liquid (coll. Gerecke, Tübingen). — MD 154d, as 154a, 1 juvenile ♂ in liquid (coll. Gerecke, Tübingen). — MD 159a, same area, R. Antomboka between station forestière and cascade, 950 m, 19.XI.2001, 19.7°C, 0.018 mS/cm, 1 ♀ (coll. Gerecke, Tübingen). — MD 160, same area, riparian springs at right border of R. Antomboka downstream sacred cascade, 1000 m, 19.XI.2001, 18.0°C, 0.020 mS/cm, 1 ♂, 1 ♀ (coll. Gerecke, Tübingen). — MD 164, same area, riparian springs at R. de Manques in Reserve Fontenay, 580 m, 20.XI.2001, 21.0°C, 0.031 mS/cm, 1 ♂, 1 deutonymph (coll. Gerecke, Tübingen). — MD 165, same area, R. Antomboka downstr. large cascade, 850 m, 21.XI.2001, 20.0°C, 0.020 mS/cm, 1 ♂ mounted for SEM

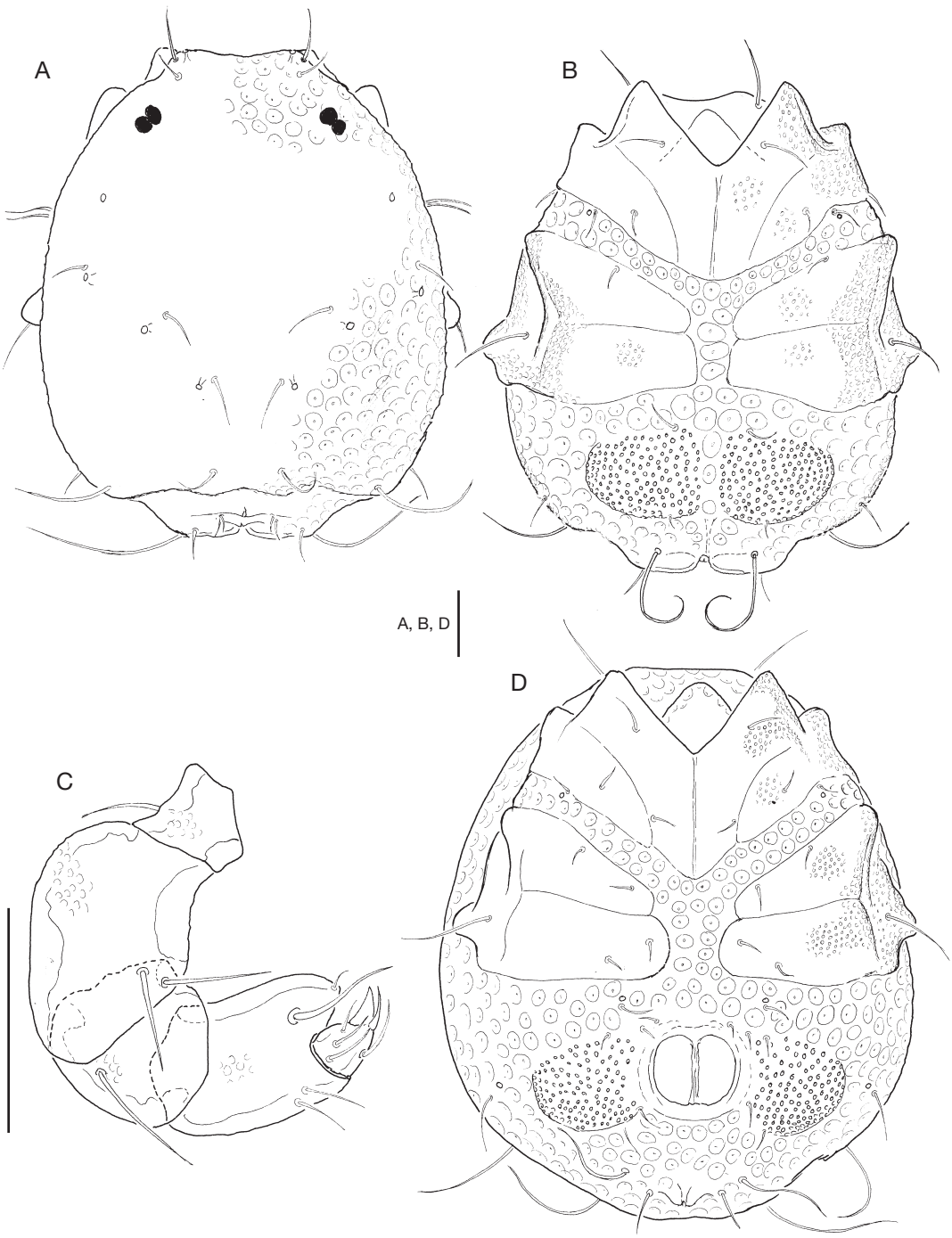

FIG. 7. — *Thoracophoracarus cooki* n. sp.: **A**-**C**, paratype ♂ (MNHN Ac1119); **A**, dorsal idiosoma; **B**, ventral idiosoma; **C**, palp; **D**, paratype ♀ (MNHN Ac1120), ventral idiosoma. Scale bars: 100 µm.

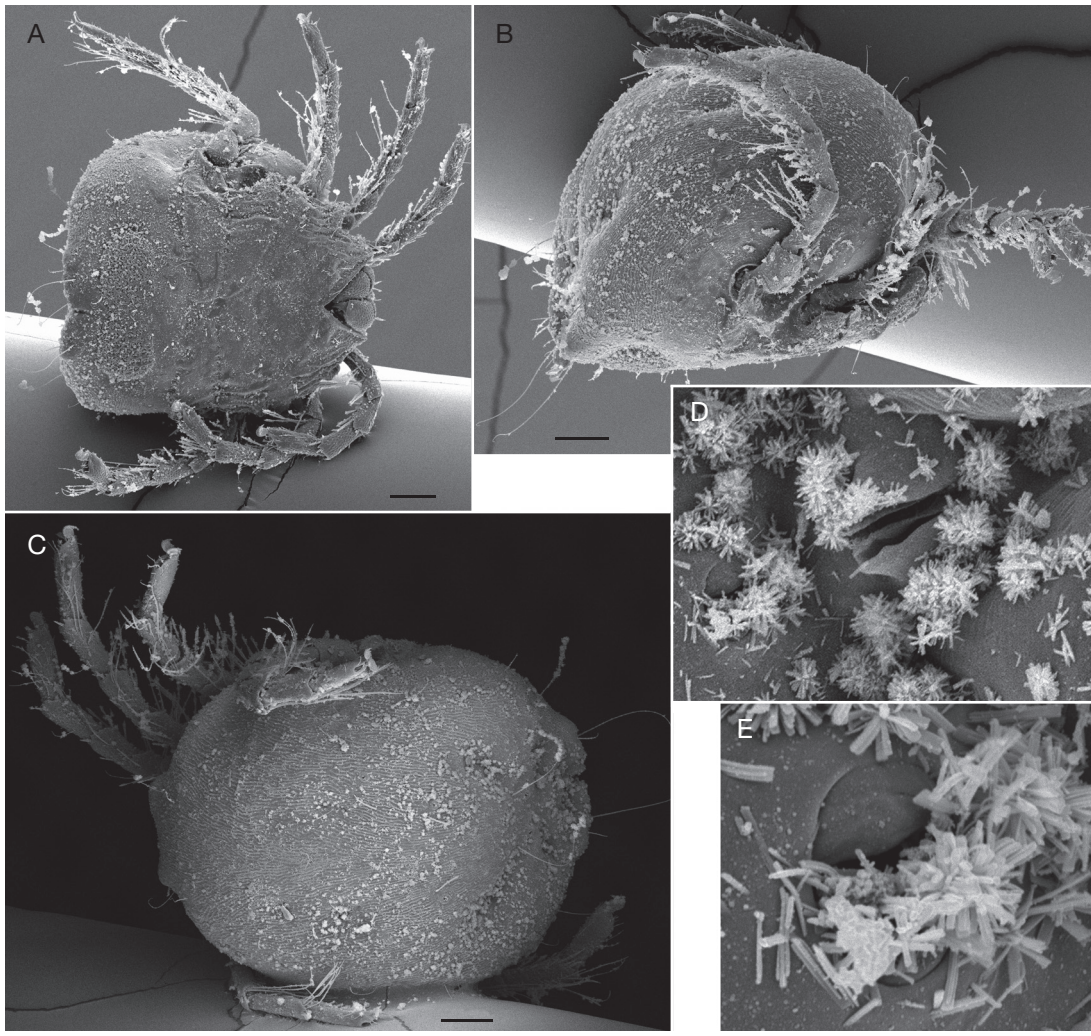

FIG. 8. — *Thoracophoracarus cooki* n. sp., paratype ♂ (coll. Gerecke, Tübingen), SEM photographs: **A**, ventral view; **B**, lateral view; **C**, dorsal view; **D**, excretory pore and gonopore; **E**, excretory pore (detail of D). Scale bars: 100 µm.

investigation, 1 ♀ in liquid (coll. Gerecke, Tübingen).

ETYMOLOGY. — This species is dedicated to Dave Cook who generously made possible the investigation of the water mite fauna of Madagascar and continuously supports the author's research with helpful suggestions and encouragement.

DESCRIPTION

Gnathosomal bay V-shaped, a bluntly pointed extension of the frontal idiosoma dorsally covering the gnathosoma insertion (Fig. 7B, D). Acetabular fields a little wider than long, with straight anterior and rounded latero-caudal margins, bearing 130-160 acetabula each. In a juvenile male, integument between acetabula with porosity made up of fine slits; these pores mediocaudally continuing in a narrow medial line directed to the gonopore. Palp (Fig. 7C) P-2 with 2 or 3 dorsal and 2 mediodistal setae; P-3 with 2 setae, 1 long and fine medioproximally, 1 stronger and shorter laterodistally; P-4 L/H 1.3, maximum H proximally, with rather long mediodistal

seta; P-5 stout. Male gonopore flanked by a pair of step-like extensions.

Male (Figs 6A-C; 8): idiosoma L/W 750/600-630 (slightly sclerotized juvenile 550/510), W Cx-4-tips 665-670 (slightly sclerotized juvenile 540), acetabular field L/W 125/180. Palp measurements (L/H): P-1 45/50, P-2 120/80, P-3 70/70, P-4 80/60, P-5 45/25. Leg measurements (L/H, segments 1-6): I-L 60/50, 60/45, 75/50, 95/50, 110/50, 145/40; II-L 60/52, 70/50, 90/50, 115/52, 135/52, 160/45; III-L -/-, 85/50, 198/50, 110/55, 140/55, 145/38; IV-L 110/72, 133/56, 125/55, 160/50, 145/40, 140/35. Swimming setae numbers (anterior/posterior): I-L-2 2/0, I-L-3 2/0, I-L-4 0/2, I-L-5 0/2; II-L-2 2/0, II-L-3 2/1, II-L-4 0/4, II-L-5 0/4; III-L-2 4/0, III-L-3 3/3, III-L-4 0/7, III-L-5 0/6; IV-L-2 8/0, IV-L-3 5/4, IV-L-4 8/8, IV-L-5 1/5.

Female (Fig. 7D): idiosoma L/W 690-950/580-780, W Cx-4-tips 580-760, genital field L/W 50/480. Palp measurements (L/H): P-1 45/50, P-2 130/90, P-3 76/75, P-4 104/63, P-5 50/26. Leg measurements (L/H, segments 1-6): IV-L 120/80, 120/60, 135/55, 175/52, 165/45, 155/38.

REMARKS

In comparison with the other species of the group, *T. cooki* n. sp. is characteristic in the combination of a V-shaped gnathosomal bay, acetabular fields little wider than long and with more than 100 + 100 acetabula, rather wide step-like extensions in the male genital area, P-2 with only two mediodistal setae, and stout P-4 and P-5.

Thoracophoracarus (*s.s.*) *silvarum* n. sp. (Fig. 9)

TYPE MATERIAL. — Holotype: Madagascar, MD 027, Ionilahy (Fianarantsoa), small stream crossing the railroad E from the village, 200 m, 15.VIII.2001, 19.9°C, 0.083 mS/cm, ♂ (MNHN Ac1122).
Paratypes: Same site as holotype, 1 ♂ slide-mounted (MNHN Ac1127). — MD 029, Ionilahy (Fianarantsoa), riv. Avatamboka *c.* 1 km NW from the village, 210 m, 15.VIII.2001, 21.2°C, 0.077 mS/cm, 1 ♂ in liquid (MNHN Ac1123). — MD 035, Ranomena (Fianarantsoa), stream NW from the 1.07 km-railway-tunnel (right affluent of MD 034), 19.VIII.2001, 14.8°C, 0.029 mS/cm, 1 ♂ in liquid (coll. Gerecke, Tübingen). — MD 038, Andrambovato (Fianarantsoa), stream 3 km E from the village upstream from the cascade, 900 m, 20.VIII.2001, 1 ♂ in liquid (coll. Gerecke, Tübingen).

ETYMOLOGY. — From the Latin *silva*, meaning forest. This species appears restricted to a belt of primary and secondary rain-forest on the eastern coast of Madagascar.

DESCRIPTION

Male (Fig. 9, female unknown): gnathosomal bay broadly U-shaped. Acetabular fields wider than long, with straight anterior and posterior margins, laterally rounded, bearing about 60 acetabula each. P-2 with 5 or 6 mediodistal setae, P-4 L/H 1.5, maximum H distally. Male gonopore flanked by a pair of flat, rounded extensions (in some specimens a little more prominent than given in Figure 8A). Measurements: idiosoma L/W 600-700/470-560, W Cx-4-tips 590-580); acetabular field L/W 76-80/280-320; palp (L/H): P-1 30/28, P-2 92/69, P-3 60/60, P-4 92/62, P-5 50/16. Legs (L/H): IV-L-4 135/42, IV-L-5 135/38. Swimming setae numbers (anterior/posterior): IV-L-4 4/5, IV-L-5 0/5.

REMARKS

In comparison with the other species of the group, *T. silvarum* n. sp. is characteristic in the combination of a U-shaped gnathosomal bay, the acetabular fields distinctly wider than long and with less than 100 + 100 acetabula, the narrow step-like extensions in the male genital area, P-2 with more than 4 mediodistal setae, P-4 with maximum H near distal margin, and slender P-5.

At the type locality, a female was found that agrees with the males of *T. silvarum* n. sp. in important details (anterior idiosoma shape, acetabula number, palp shape and setation), but differs in the presence of a well-developed dorsal furrow (measurements of this specimen: idiosoma L/W 760/640, W Cx-4-tips 620, gonopore L/W 115/120, genital field W 410, acetabular field W125. Palp measurements (L/H): P-1 33/35, P-2 93/75, P-3 60/63, P-4 102/67, P-5 52/20). Current investigations on the stream- and spring-dwelling *Arrenurus*-species will possibly help to identify the corresponding male – for the time being, we cannot exclude conspecifity with *T. silvarum* n. sp. (that would definitively destroy the concept of a monophyletic genus *Thoracophoracarus*).

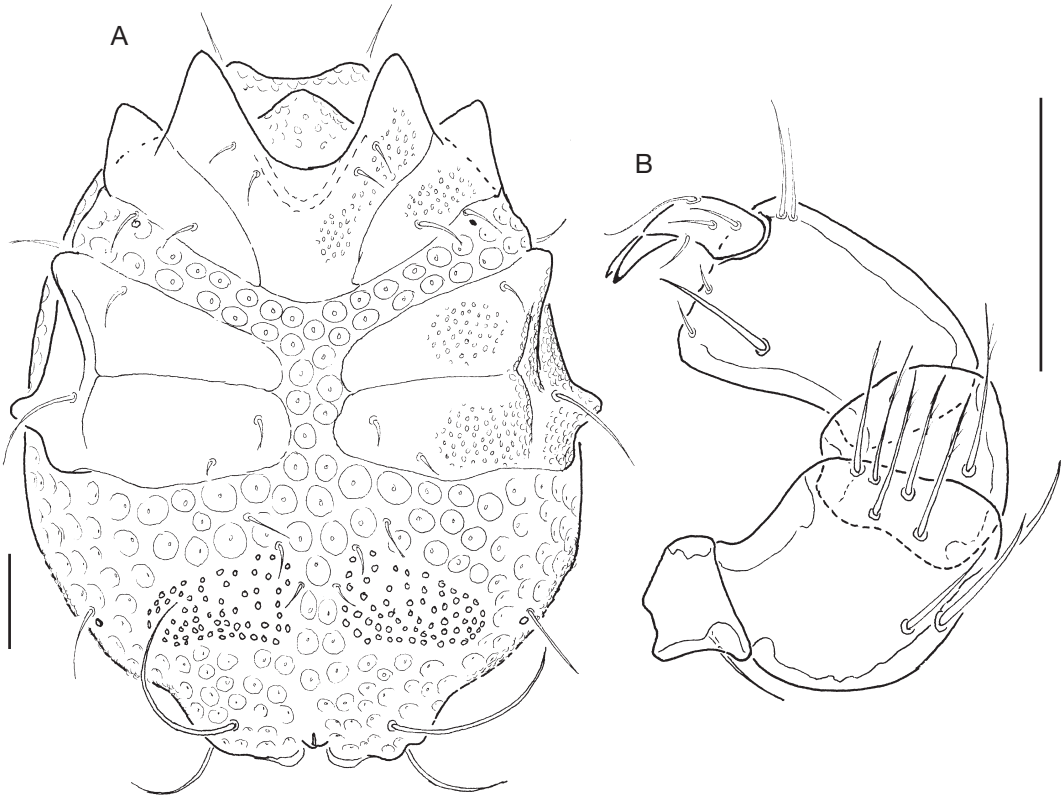

FIG. 9. — *Thoracophoracarus silvarum* n. sp., holotype ♂ (MNHN Ac1122): **A**, ventral idiosoma; **B**, palp. Scale bars: 100 µm.

Thoracophoracarus (*s.s.*) *felix* n. sp.
(Fig. 10)

TYPE MATERIAL. — Holotype: Madagascar: MD 069, Andohahela (Tulear), Isaka, W stream at the S National Park border (W RIP 118), 200 m, 9.IX.2001, 19.2°C, 0.091 mS/cm, ♂ (MNHN Ac1124).
Paratypes: MD 064, Andohahela (Tulear), Fenoevo, stream at N margin of forest (milky turbid waters), 330 m, 8.IX.2001, 19.4°C, 0.100 mS/cm, 1 ♀ (MNHN Ac1125). — MD 039, Andrambovato (Fianarantsoa), spring at left margin of the stream 3 km from the village (upstream from the cascade), 900 m, 20.VIII.2001, 17.3°C, 0.050 mS/cm, 1 ♀ in liquid (MNHN Ac1126).

MATERIAL EXAMINED. — MD 133, Marofototra (Antalaha, Antsiranana), spring stream 2, right affl. of R. Fandramanana (affl. of MD 132), 120 m, 2.XI.2001, 22.0°C, 0.019 mS/cm, 1 ♂ (coll. Gerecke, Tübingen).

ETYMOLOGY. — This species is dedicated to Felix Rakotondraparany (Antananarivo) who helped us in many different ways during our field work in Madagascar.

DESCRIPTION

Gnathosomal bay broadly V-shaped, a sharply pointed extension of the frontal idiosoma dorsally covering the gnathosoma insertion. Acetabular fields slightly wider than long, with straight anterior and round latero-caudal margins, bearing 60-90 acetabula each. P-2 with 2 or 3 dorsal and 2 mediodistal setae; P-3 with 2 setae, 1 long and fine medioproximally, 1 stronger and shorter laterodistally; P-4 L/H 1.5, equal in H from the base to the tip, with a rather long mediodistal seta; P-5 stout. Male gonopore flanked by a pair of rounded caudal extensions.

Male: idiosoma (Fig. 10A) L/W 600-650/490-540, W Cx-4-tips 535-580, acetabular field L/W

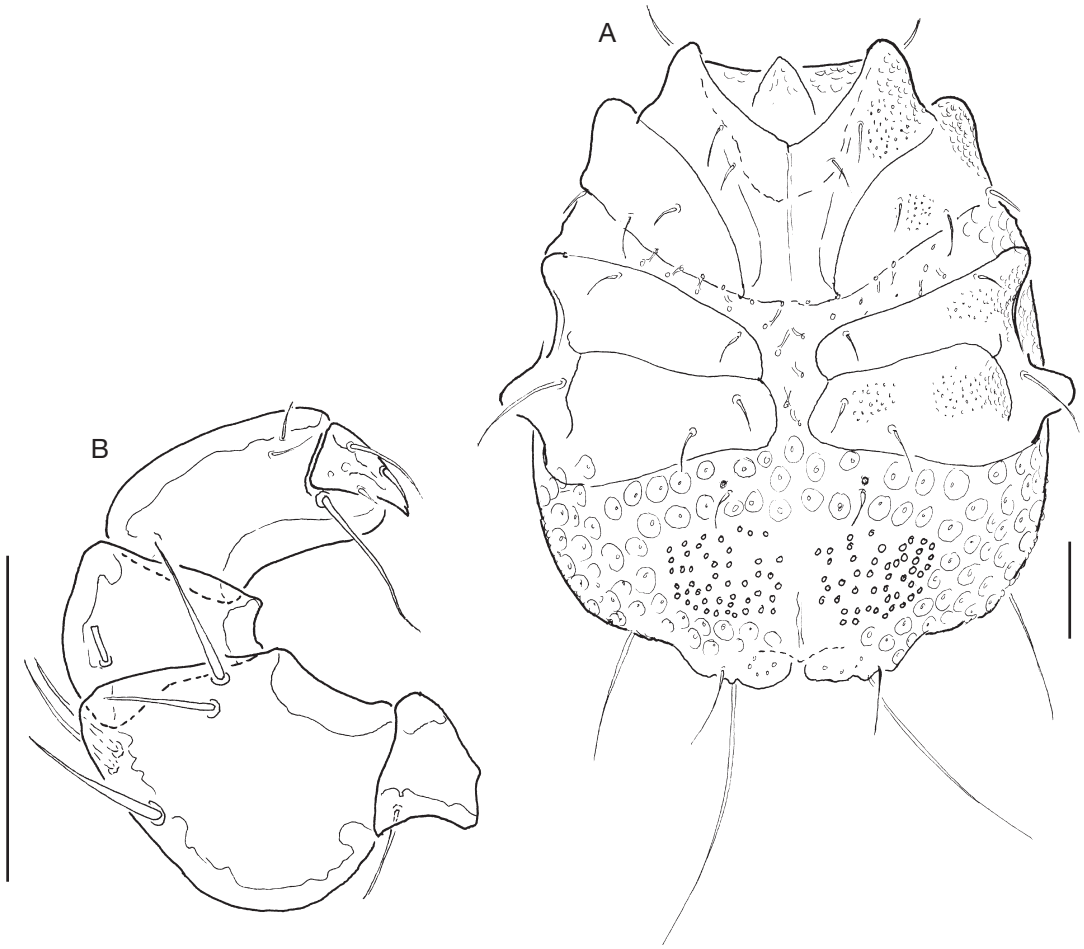

FIG. 10. — *Thoracophoracarus felix* n. sp., holotype ♂ (MNHN Ac1124): **A**, ventral idiosoma; **B**, palp. Scale bars: 100 µm.

80-110/285-340. Palp (Fig. 10B) measurements (L/H): P-1 33-37/35-40, P-2 90-95/70-73, P-3 60-62/55-60, P-4 77-80/48-50, P-5 37-45/20-25. Leg measurements (L/H): I-L-4 80-85/38-48, I-L-5 85-95/40-45, I-L-6 110-125/32-40; IV-L-4 110-125/35-40, IV-L-5 110/30-40, IV-L-6 110/38. Swimming setae numbers (anterior/posterior): I-L-4 1/0, I-L-5 1/0; IV-L-4 4-5/5-6, IV-L-5 0/3-4.

Female: idiosoma (similar to Figure 7D, differing in acetabular number only) L/W 750/630, W Cx-4-tips 640, gonopore L/W 120/130, genital field W 400, acetabular field W130. Palp measurements (L/H): P-1 30/40, P-2 100/75, P-3 75/65, P-4 90/65, P-5 40/20. Leg measurements (L/H): I-L-4 85/42, I-L-5 100/42, I-L-6 120/40; IV-L-4 140/40, IV-L-5 130/38 IV-L-6 117/30. Swimming setae numbers (anterior/posterior): I-L-4 1/0, I-L-5 2/0; IV-L-4 4/5, IV-L-5 0/4.

REMARKS

Thoracophoracarus felix n. sp. is similar to *T. cooki* n. sp. in the V-shaped gnathosomal bay, acetabular fields little wider than long, P-2 with only 2 mediodistal setae and stout P-5. It differs from that species in lower acetabula numbers (less than 100 + 100), a slightly more slender P-4 and the step-like extensions in the male genital area more narrow. Due to some minor differences, the specimen from site

133 is attributed questionably to this species. The extension covering the dorsal insertion of gnathosoma is right-, not acute-angled, and the step-like caudal projections are larger and more prominent laterally than in the middle. Better knowledge about individual variability is needed in order to understand the significance of such differences. The large geographic distance between site 133 (in the north of Madagascar) and the southern collecting sites of *T. felix* n. sp. would explain a taxonomic difference between these populations.

PHYLOGENETIC CONSIDERATIONS

The following agreements among the Central African species suggest that they have a common evolutionary origin: 1) regularly-arranged humps on the dorsal surface, probably associated with muscle insertions – characteristically developed at least in the area of dorsoglandularia 1 ("antenniformia"); 2) palp segments rather uniform in shape, P-2 bearing only 2 mediodistal setae; 3) IV-L without pronounced sexual dimorphism (male IV-L-4 without terminal projection); and 4) genital opening tending to shift caudally. In the latter character state the type species of the genus, *T. arrhenuroides* with the genital field directed ventrally in females, most resembles the plesiotypical *Arrenurus*-like condition. Other species such as *T. kuehnei* and *T. petioluriger* represent intermediate situations. Characters 2) and 3) are of rather little phylogenetic weight, but could at least indicate that all Central African *Thoracophoracarus* derive from similar *Arrenurus*-like ancestors.

Thoracophoracarus gibberosus from South Africa is apparently distant from the remaining species of the continent. However, in character states 1)-3) it agrees with the Central African species. It is plesiomorphic in the ventral position of the gonopore with rounded, not strip-shaped acetabular fields, and highly derivative in the development of an enormous cauda in the male sex. This species could represent an early derivative clade, both of the genus *Thoracophoracarus* having evolved a cauda in convergence to *Megaluracarus*, or of this subgenus, having lost the dorsal furrow and developed idiosomal humps in convergence to *Thoracophoracarus*.

The two species from South America, *T. simplex* and *T. chilensis*, both with gonopore in plesiotypical ventral position, differ from the African taxa in the absence of dorsal humps on the idiosoma surface, and palp setation (Cook 1988). In the latter character they also differ strongly from each other (mediodistal setae P-2 absent in *T. simplex*, developed to a dense bristle in *T. chilensis*). *Thoracophoracarus chilensis*, similar to *T. gibberosus* in the development of a large cauda, is unique within the whole family in the presence of one pair of acetabula located in the gonopore.

All three new species from Madagascar differ strongly from the continental African taxa in the combination of rounded acetabular fields not extending to the idiosoma flanks in both sexes (as in *T. gibberosus*) and a strong sexual dimorphism in the position of the gonopore (in plesiotypical ventral position in females, shifted to the posterior idiosoma edge in males). They differ also in the absence of humps on the idiosoma surface, but are similar with regard to palp- and leg-morphology.

Questions concerning the phylogeny of *Thoracophoracarus*-like mites cannot be answered satisfactorily without investigations on the life cycles, the morphology of preadult instars and molecular phylogeny. In its present state, this taxon could be composed by two or more clades that independently reduced the dorsal furrow. However, the four species known from Central Africa could represent a monophyletic clade and maintain the genus name, possibly with the species from South Africa representing an early derivative subgroup. The South American *Thoracophoracarus* species could represent one or two phylogenetically independent lines or further early derivative branches of this clade. Finally, the Madagascan species, described here as new to science, represent probably a further separate phylogenetic line. If the reduction of the dorsal furrow happened only once in evolution, resulting in a monophyletic genus *Thoracophoracarus*, this clade probably split early into two subgroups with female acetabular fields rounded (species from South America, South Africa and Madagascar) or strip-shaped (species from Central Africa). The high morphological differentiation of the southern species group suggests further strongly divergent evolution

while the northern group obviously maintained a higher morphological stability in many conditions. Contrarily, if we assume the reduction of the dorsal furrow having taken place several times independently, these two taxonomic groups could represent two (the southern group also more) independent taxa whose relationships with other arrenurids should be cleared in the course of a revision of subgenera and species-groups of *Arrenurus*.

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