

Identity of *Haemaphysalis (Rhipistoma) muhsamae* Santos Dias, 1954 (Acari: Ixodidae) and *H. (R.) subterra* Hoogstraal, El Kammah & Camicas, 1992, parasites of carnivores and rodents in eastern and southern Africa

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Abstract

Haemaphysalis (Rhipistoma) muhsamae Santos Dias, 1954 (Acari: Ixodidae) and *H. (R.) subterra* Hoogstraal, El Kammah & Camicas, 1992, are redescribed based on males and females. Adults of *H. muhsamae* were mostly collected from various mongooses (Carnivora: Herpestidae) but also from the striped polecat, *Ictonyx striatus* (Perry) (Carnivora: Mustelidae), serval, *Leptailurus serval* (Schreber) (Carnivora: Felidae), red veld rat, *Aethomys chrysophilus* (de Winton) and Selinda veld rat, *Aethomys silindensis* Roberts (Rodentia: Muridae) in Botswana, Kenya, Mozambique, South Africa, Tanzania and Zimbabwe. Adults of *H. subterra* were mostly found on various species of African mole rats, *Tachyoryctes* spp. (Rodentia: Spalacidae) but also on striped polecat, *I. striatus* and slender mongoose, *Galerella sanguinea* (Rüppell) (Carnivora: Herpestidae) in Ethiopia and Kenya. Males and females of both species can be differentiated from each other and other *H. spinulosa*-like ticks by their size, pattern of punctations on conscutum/scutum, shape of genital structures, shape and size of posterodorsal and posteroventral spurs on palpal segment II, hypostome dentition, and shape and size of spurs on coxae. Taxonomic issues of both species and those related to the identity of *H. (R.) spinulosa* Neumann, 1906 are discussed and a neotype of *H. muhsamae* has been designated.

Introduction

Currently, there are nearly 900 described species of ticks worldwide (Guglielmone et al., 2014). The genus *Haemaphysalis* Koch, 1844 (Acari: Ixodidae) contains nearly 170 species and is second only to the genus *Ixodes* Latreille, 1795 in number of described species (Guglielmone et al., 2014). Studied species of *Haemaphysalis* are all three-host ticks that primarily parasitize mammals and birds.

The subgenus *Rhipistoma* Koch, 1844 is composed of 33 species and is probably the most recent subgenus of *Haemaphysalis*, mostly parasitizing carnivores, rodents, hyraxes, and hedgehogs, primarily occurring in sub-Saharan Africa as well as Europe and Asia (Hoogstraal & Kim, 1985; Camicas et al., 1998; Guglielmone et al., 2014). Among African *Rhipistoma* ticks, those in the *Haemaphysalis (Rhipistoma) leachi* group have been the most troublesome from a taxonomic standpoint. Initially, the vast majority of these species were identified as *H. leachi* (Audouin, 1826) but the group has gradually been revised over time and now consists of multiple species that were once believed to be *Haemaphysalis leachi* (Camicas et al., 1972, 1973, 1983; Hoogstraal, 1972, 1964; Hoogstraal & El Kammah, 1974; Hoogstraal & Wassef, 1983; Hoogstraal et al., 1992; Apanaskevich et al., 2007; Apanaskevich & Horak, 2008).

Within the *H. leachi* group, the *H. (Rhipistoma) spinulosa* subgroup has also been persistently troublesome from a taxonomic and nomenclatorial standpoint. There are currently 4 valid species in this subgroup, *H. muhsamae* Santos Dias, 1954, *H. norvali* Hoogstraal & Wassef, 1983, *H. spinulosa* Neumann, 1906 and *H. subterra* Hoogstraal, El Kammah & Camicas, 1992 and one synonymous name, *H. ethiopica* Santos Dias, 1958 (Camicas et al., 1998).

Haemaphysalis spinulosa was described from 2 females collected from the cane rat, *Thryonomys* Fitzinger (Rodentia: Thryonomyidae) in Entebbe, Uganda (Neumann, 1906). Besides reproduced descriptions and being published in lists of species in the decade following the original description, this species name was absent from the literature for nearly half a century. Hoogstraal (1964) designated the lectotype for *H. spinulosa* and provided its illustration and description. He also illustrated and described the male putatively identified as *H. spinulosa* by G. H. F. Nuttall. Following this redescription, *H. spinulosa* has become a catch all name for practically all small African *leachi* group ticks.

Haemaphysalis muhsamae (as *Haemaphysalis muhsami*) was described from 2 males, 1 female, and 1 nymph collected from the common dwarf mongoose, *Helogale parvula* (Sundevall) [Carnivora: Herpestidae] in Maputo, Mozambique (Santos Dias, 1954). Later Santos Dias (1955) recognized that the original female and nymph specimens belong to a different species and described the female and nymph of *H. muhsamae* from different specimens. Additionally Santos Dias (1956) provided more morphological details on *H. muhsamae*. Hoogstraal (1956) used the name *Haemaphysalis leachi muhsami* for all small *leachi* group ticks, and while this name did not catch on, it did add further confusion to the group. In his redescription of *H. spinulosa*, Hoogstraal (1964) questions the validity of *H. muhsamae* and how it relates to *H. spinulosa*. Nevertheless Santos Dias (1984) insists on the validity of *H. muhsamae* and in all recent lists this species is considered valid (Guglielmone et al., 2014). Since Santos Dias' (1954, 1955, 1956) original descriptions, there has been no confident identification of *H. muhsamae*, and no proper redescription has ever been made for this species.

Apparently closely related to *H. muhsamae* is *Haemaphysalis subterra*, the most recently described species and another exceptionally small tick in the *H. spinulosa* subgroup. *Haemaphysalis subterra* was described from 71 males, 101 females, 41 nymphs and 102 larvae

collected from various smaller carnivores and rodents in Democratic Republic of Congo, South Africa, Tanzania, Zambia, and Zimbabwe (Hoogstraal et al., 1992).

By means of an extensive morphological analysis of nearly 10,000 specimens identified as *H. spinulosa* collected throughout the Afrotropical region, and stored in the United States National Tick Collection (USNTC) we have found: 1) that none correspond to the original description of *H. spinulosa* and that this species rather represents a complex of several undescribed and misidentified species distributed throughout sub-Saharan Africa; 2) specimens that morphologically correspond to *H. muhsamae*; 3) that the original description and illustrations of *H. subterra* are based on at least 3 different species. The goal of this study is to clarify the taxonomic status of *H. muhsamae* and *H. subterra* and redescribe them.

Materials and Methods

Only field-collected ticks were available for study. The specimens that were examined are deposited in the USNTC (James H. Oliver, Jr. Institute for Coastal Plain Science, Georgia Southern University, Statesboro, Georgia, USA).

Adult ticks were examined using a stereoscopic microscope (Olympus SZX16, Olympus Corporation, Tokyo, Japan), compound microscope (Olympus BX53, Olympus Corporation, Tokyo, Japan) and a scanning electron microscope (JEOL JSM6610LV, JEOL Ltd., Tokyo, Japan). Measurements are presented in millimetres and are given as range followed by mean \pm standard deviation and the number of specimens measured (n) in parentheses.

Family Ixodidae Murray, 1877

Genus *Haemaphysalis* Koch, 1844

***Haemaphysalis muhsamae* Santos Dias, 1954**

Type-host: *Galerella sanguinea* (Rüppell) (Carnivora: Herpestidae).

Type-locality: Calgary Farm, Mashonaland Central, Zimbabwe.

Other hosts: *Galerella* sp., *H. parvula*, *Ichneumia albicauda* (Cuvier), “mongoose” (Carnivora: Herpestidae), *Ictonyx striatus* (Perry) (Carnivora: Mustelidae), *Leptailurus serval* (Schreber) (Carnivora: Felidae), *Aethomys chrysophilus* (de Winton) (Rodentia: Muridae).

Other localities: Botswana: 5 mi west of Gaborone; North-West: Kai Kai; 15 mi north of Nokaneng; Shakawe. Kenya: Narok: near Talek; Machakos: Lukenya Hill. Mozambique: Tete: Changara. South Africa: Mpumalanga: Mthethomusha Game Reserve; KwaZulu-Natal: Oribi Gorge. Tanzania: Arusha: Tengeru. Zimbabwe: Mashonaland Central: 20 mi north of Harare, Henderson Research Station; Mazoe Veterinary Farm; Matabeleland South: Essexvale Ranch. *Neotype:* Male, from *G. sanguinea*, Calgary Farm (~17°39'S, 31°3'E), Mashonaland Central, Zimbabwe, 18.viii.1977, R. A. I. Norval; deposited in the USNTC (USNMENT 00860187). It appears that the holotype and paratype males were lost. These specimens were not found in the Veterinary Laboratory in Maputo, Mozambique where they were stated to be deposited (Santos Dias, 1962), nor were they found in the collections of the Institute of Hygiene and Tropical Medicine of Lisbon and Science Museum of the University of Coimbra in Portugal. Since the holotype is lost or destroyed, we herein designate a neotype of *Haemaphysalis muhsamae* in an effort to clarify the taxonomic status of this species. Because *H. muhsamae* can easily be confused with *H. subterra* or with *H. spinulosa* as redescribed and illustrated by Hoogstraal (1964) in regards to size, spurs on gnathosoma and coxae, etc., and is also morphologically very similar to new species in a complex of species related to *H. spinulosa* which we will describe in forthcoming publications, we deem it necessary to provide a neotype to avoid any further confusion within the *H. spinulosa* subgroup. Our measurement data and description in conjunction with scanning electron micrographs are sufficient to ensure recognition of the specimen designated, and the neotype is both consistent with the original description and was collected as nearly as feasibly possible to the type locality. Immediately upon publication, the neotype will be deposited in the USNTC where it will be accessible for study.

Other material: Ninety seven males and 27 females. Botswana: 5 mi west of Gaborone (~24°38'S, 25°54'E): 3 males, from *I. striatus*, 26.v.1966, T. N. Liversedge, USNMENT 00860695; North-West: Kai Kai (~19°52'S, 21°7'E): 2 males, from *G. sanguinea*, 5.vi.1967, T. N. Liversedge, USNMENT 00860696; 15 mi north of Nokaneng (~19°39'S, 22°16'E): 9 males and 7 females, from *G. sanguinea*, 17.vi.1967, S. W. Goussard, USNMENT 00860697; Shakawe (~18°21'S, 21°51'E): 14 males, from *I. striatus*, 17.v.1967, T. N. Liversedge, USNMENT 00860698. Kenya: 3 males, from mongoose, 1.xi.2010, E. K. Kariuki, USNMENT 00860699; Narok: near Talek (~1°25'S, 35°10'E), 1,737 m alt.: 1 male, from mongoose, 30.i.1948, USNMENT 00860700; Machakos: Lukenya Hill (~1°28'S, 37°2'E): 1 male, from *I. striatus*,

ii.1964, R. Harmsen, J. B. Sale, USNMENT 00860701; 3 males and 1 female, from *I. striatus*,
ii.1964, R. Harmsen, J. B. Sale, USNMENT 00860702. Mozambique: Tete: Changara (~15°49'S,
32°16'E): 1 female, from *A. chrysophilus*, 1.xi.1964, H. J. Herbert, USNMENT 00860703. South
Africa: Mpumalanga: Mthethomusha Game Reserve (~25°26'S, 31°17'E): 2 males and 1 female,
from *G. sanguinea*, USNMENT 00860704; 4 males and 1 female, from *G. sanguinea*,
23.viii.1999, USNMENT 00860705; KwaZulu-Natal: Oribi Gorge (~30°41'S, 30°16'E): 1 male,
from *G. sanguinea*, 20.vii.1965, G. Theiler, USNMENT 00860706. Tanzania: Arusha: Tengere
(~3°22'S, 36°49'E): 7 males and 3 females, from *Galerella* sp., 23.vii.1956, USNMENT
00860707. Zimbabwe: Mashonaland Central: 20 mi north of Harare, Henderson Research Station
(~17°33'S, 30°58'E): 7 males and 1 female, from *G. sanguinea*, 17.x.1967, S. W. Goussard,
USNMENT 00860708; 11 males, from *G. sanguinea*, 18.x.1967, S. W. Goussard, USNMENT
00860709; Calgary Farm (~17°39'S, 31°3'E): 1 female, from *L. serval*, 29.ii.1977, R. A. I.
Norval, USNMENT 00860710; 5 males and 9 female, from *G. sanguinea*, 18.viii.1977, R. A. I.
Norval, USNMENT 00860711; Mazoe Veterinary Farm (~17°31'S, 30°58'E): 2 females, from *G.*
sanguinea, 26.xi.1967, R. A. I. Norval, USNMENT 00860186; Matabeleland South: Essexvale
Ranch (~20°18'S, 28°55'E): 15 males, from *I. albicauda*, 26.i.1968, S. W. Goussard, USNMENT
00860712; 9 males, from *I. albicauda*, 26.i.1968, S. W. Goussard, USNMENT 0086071. All
specimens are deposited in the USNTC.

Etymology: The species is named after Bruria Feldman-Muhsam (1916–2008), an Israeli
entomologist who has largely contributed to the systematics of ticks.

Description (Figs. 1–4)

Male [Figs. 1, 2; based on 98 specimens.] Conscutum (Figs. 1A–C): length from scapular apices
to posterior margin 1.08–1.38 (1.22 ± 0.06 ; $n = 84$), width 0.72–0.90 (0.81 ± 0.04 ; $n = 84$), ratio
1.40–1.72 (1.51 ± 0.06 ; $n = 84$), broadly suboval, widest posterior to midlength, colour yellowish
brown; scapulae short, blunt; cervical grooves indistinct, very shallow; lateral grooves distinct,
extending from anterior 1/4 of conscutal length to first festoon, not enclosing or partially
enclosing first festoon; eleven distinct festoons; punctations distinct, relatively sparse, larger
bearing setae and fine; setae numerous, relatively long ($c.0.02$) and distinct (Figs. 1A–C). Genital
apron medial to coxae II, with numerous distinct denticles of moderate length on posterior

margin (Fig. 2A); postgenital sclerite (Fig. 1D) broad, twice as broad as long, slightly arcuate. Spiracular plates (Fig. 2B) suboval, slightly broader than long, dorsal prolongation indistinct, length 0.08–0.14 (0.11 ± 0.01 ; $n = 84$), width 0.08–0.14 (0.11 ± 0.01 ; $n = 84$), ratio 0.90–1.30 (1.05 ± 0.08 ; $n = 84$); nearly equal in length to first festoon.

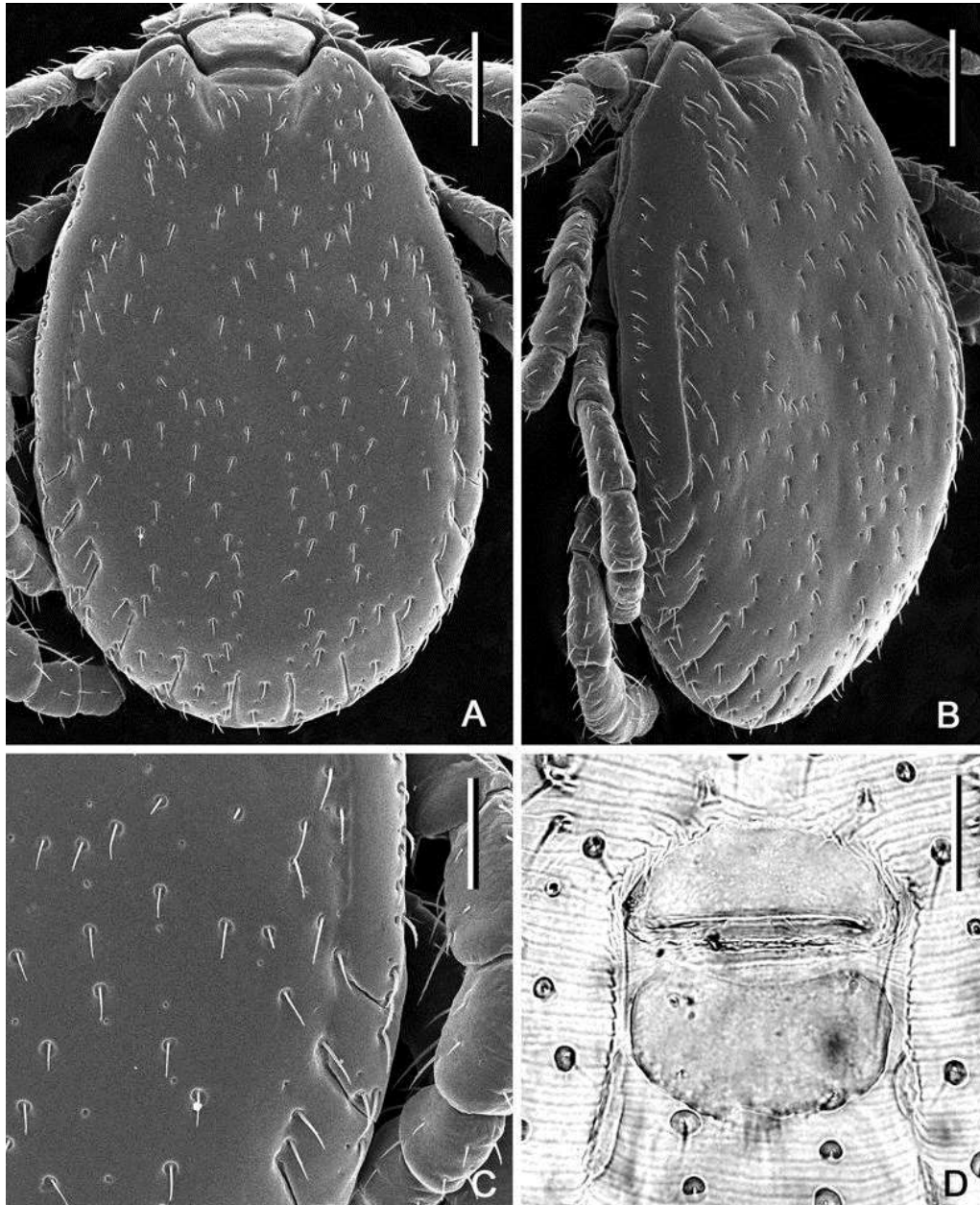


Fig. 1 *Haemaphysalis muhsamae* Santos Dias, 1954, scanning electron micrographs and digital photograph of male (Henderson Research Station, 20 mi north of Harare, Mashonaland Central, Zimbabwe, USNMENT 00860708). A, Conscutum, dorsal view; B, Conscutum, dorsolateral view; C, Conscutum showing punctations and setae, dorsal centrolateral surface; D, postgenital sclerite. *Scale-bars*: A, B, 0.2 mm; C, 0.1 mm; D, 0.05 mm

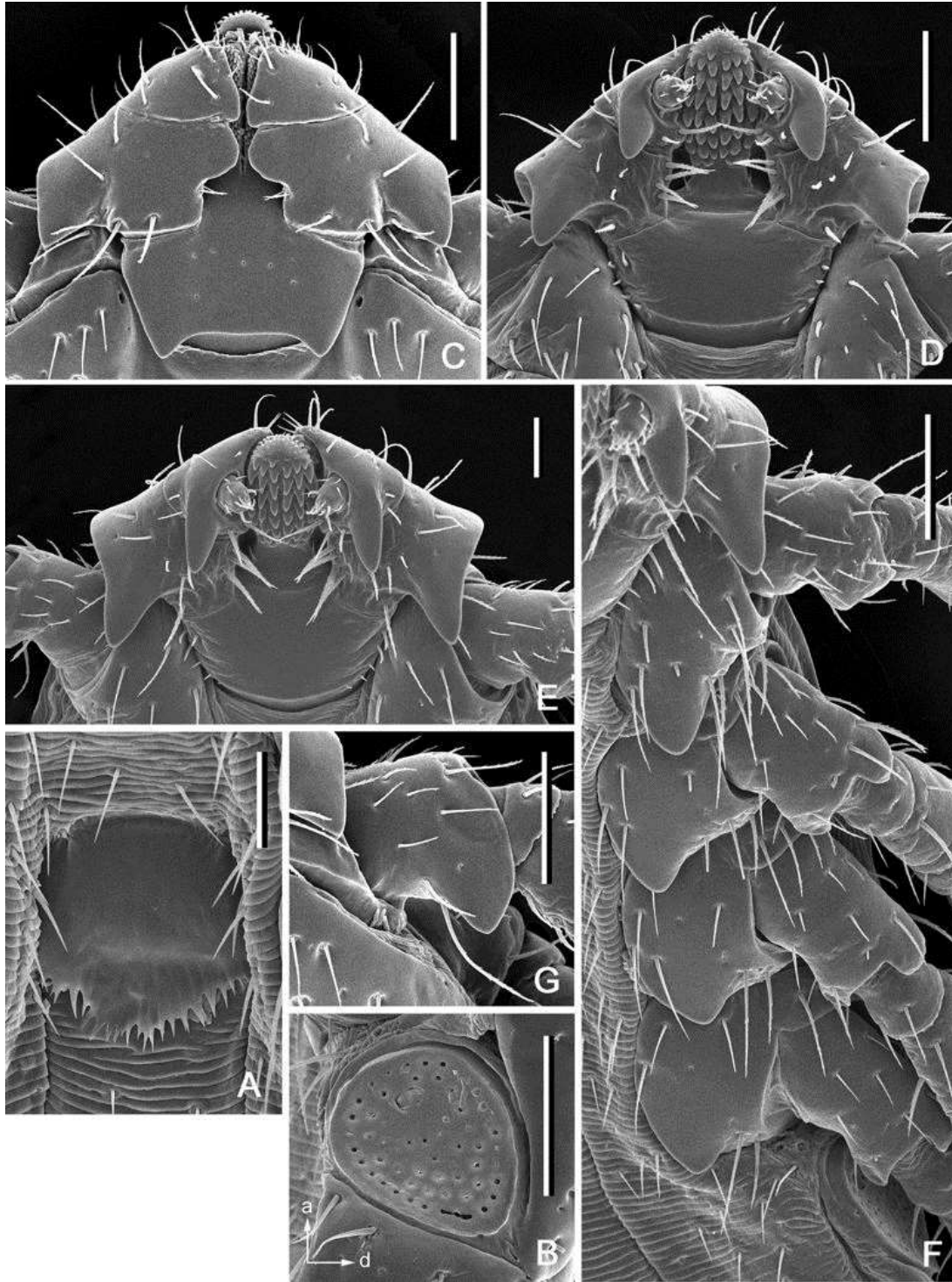


Fig. 2 *Haemaphysalis muhsamae* Santos Dias, 1954, scanning electron micrographs of male (Henderson Research Station, 20 mi north of Harare, Mashonaland Central, Zimbabwe, USNMENT 00860708). A, Apron; B, Spiracular plate (*arrows indicate orientation of spiracular plate: a, anterior; d, dorsal*); C, Gnathosoma, dorsal view; D, Gnathosoma, ventral view; E, Gnathosoma, anteroventral view; F, Coxae; G, Trochanter I, dorsal view. *Scale-bars:* A, 0.05 mm; B–G, 0.1 mm

Gnathosoma (Figs. 2C–E) length from palpal apices to cornual apices dorsally 0.25–0.32 (0.29 ± 0.01 ; $n = 84$), width of gnathosoma between lateral projections of palpal segment II dorsally 0.36–0.42 (0.39 ± 0.01 ; $n = 84$), ratio length to width 0.63–0.82 (0.74 ± 0.03 ; $n = 84$). Dorsal basis capituli (Fig. 2C) subrectangular with converging lateral margins; posterior margin straight; length 0.10–0.14 (0.12 ± 0.01 ; $n = 84$), width 0.20–0.25 (0.23 ± 0.01 ; $n = 84$), ratio width to length 1.67–2.08 (1.90 ± 0.11 ; $n = 84$); cornua moderately long, broadly triangular with tapering apex; total length of basis capituli, including cornua, 3.00–8.00 (4.94 ± 1.02 ; $n = 84$) cornual length. Ventral basis capituli (Fig. 2D) subrectangular. Palpi (Fig. 2C–E) short, broadly salient, ratio combined breadth to basis capituli breadth 1.61–1.92 (1.73 ± 0.07 ; $n = 84$); length dorsally (II–III segments) 0.17–0.25 (0.20 ± 0.02 ; $n = 84$), width 0.15–0.20 (0.18 ± 0.01 ; $n = 84$), ratio 0.91–1.53 (1.15 ± 0.11 ; $n = 84$); segment II nearly twice as long as segment III dorsally; segment I indistinct; dorsomedian margin of segment II abruptly widening anteriorly at its midlength; posterolateral margin slightly concave; posterodorsal spur moderately large, broadly triangular with tapering apex directed posterolaterally; posteroventral spur long and narrow with tapering apex directed slightly posterolaterally; segment III dorsally subtriangular, moderately long ventral spur of segment III roughly twice as long as broad tapering to apex. Hypostome (Fig. 2D) short, broadly rounded at apex; dental formula 3/3 throughout hypostomal length with approximately 6 to 7 denticles in file.

Legs moderately long, slender. Coxae (Fig. 2F): coxae I with relatively long, broadly triangular spur with bluntly rounded apex, directed posteriorly; coxae II–IV each with large, broadly triangular spur with narrowly rounded apex, directed posteriorly. Trochanter I (Fig. 2G) with long, broadly triangular dorsal spur with tapering apex; trochanters I–IV without spurs ventrally. Tarsi I–IV slightly humped subapically.

Female [Figs. 3, 4; based on 27 specimens.] Idiosoma (Fig. 3A) broadly suboval, widest slightly posterior to midlength. Scutum (Figs. 3A–D) moderately broad, diverging in anterior quarter and converging to nearly straight posterior margin; length 0.66–0.85 (0.75 ± 0.05 ; $n = 21$), width 0.66–0.79 (0.71 ± 0.03 ; $n = 21$), ratio 0.96–1.17 (1.05 ± 0.05 ; $n = 21$); cervical grooves distinct, narrow and moderately deep, extending to scutum midlength; punctations relatively sparse, larger bearing setae and smaller; setae (Figs. 3A–D) numerous, relatively long ($c.0.03$), distributed as figured. Setae of alloscutum (Figs. 3A, D) numerous, evenly distributed, roughly

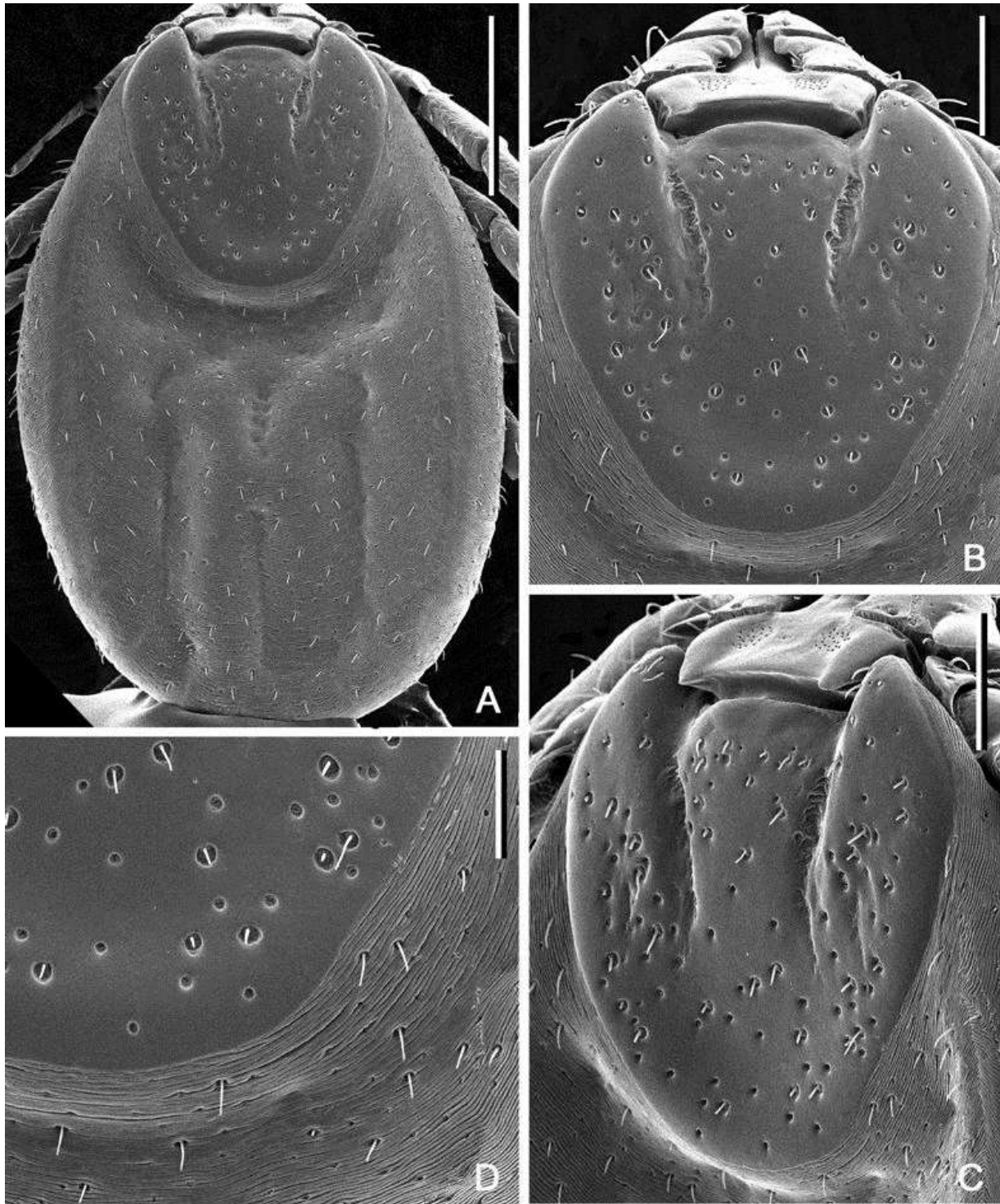


Fig. 3 *Haemaphysalis muhsamae* Santos Dias, 1954, scanning electron micrographs of female (Henderson Research Station, 20 mi north of Harare, Mashonaland Central, Zimbabwe, USNMENT 00860708). A, Idiosoma, dorsal view; B, Scutum, dorsal view; C, Scutum, dorsolateral view; D, Idiosoma showing scutum and alloscutum with punctations and setae, dorsal centrolateral surface . *Scale-bars*: A, 0.5 mm; B, C, 0.2 mm; D, 0.1 mm

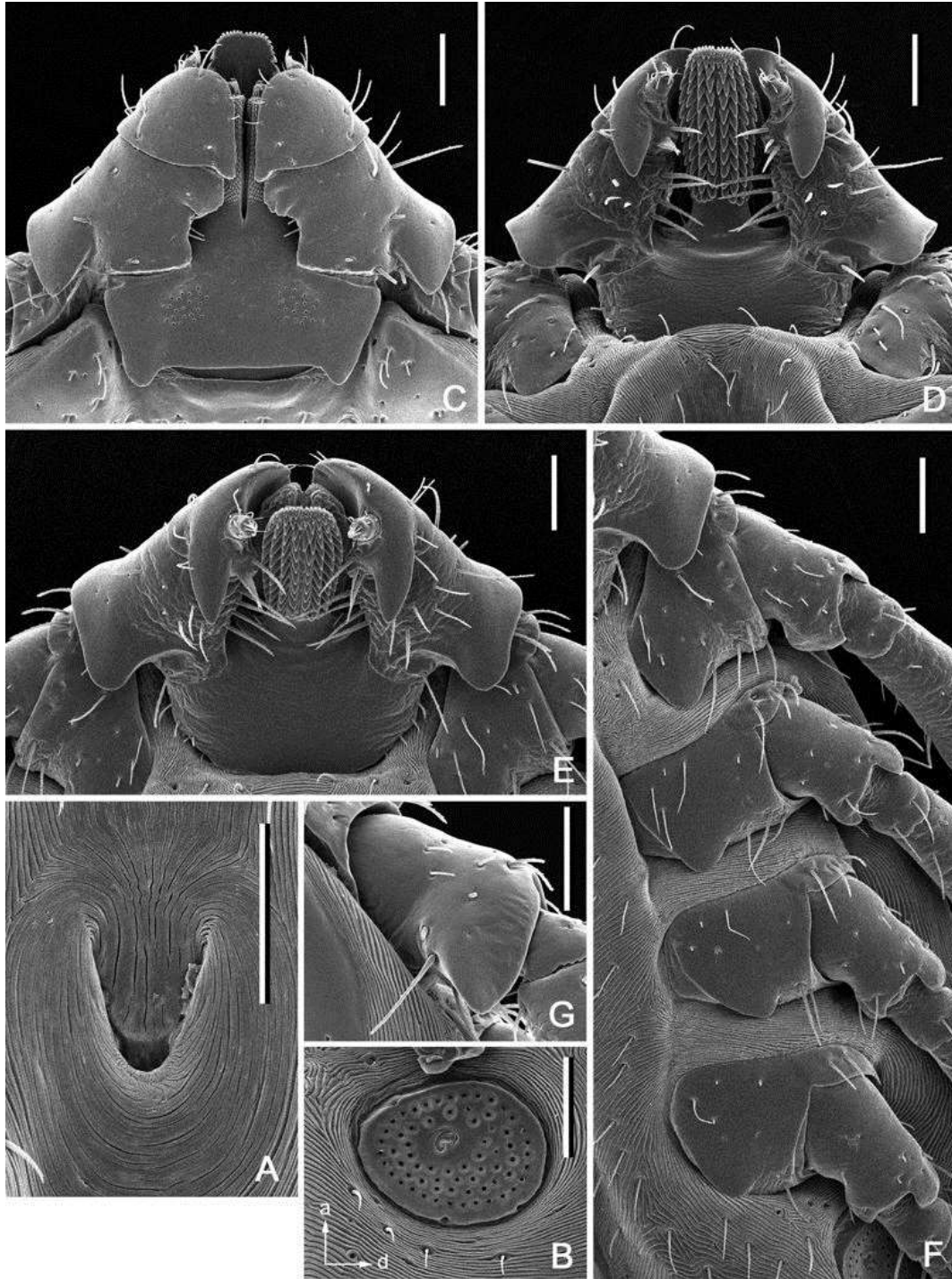


Fig. 4 *Haemaphysalis muhsamae* Santos Dias, 1954, scanning electron micrographs of female (Henderson Research Station, 20 mi north of Harare, Mashonaland Central, Zimbabwe, USNMMENT 00860708). A, Genital aperture; B, Spiracular plate (*arrows* indicate orientation of spiracular plate: a, anterior; d, dorsal); C, Gnathosoma, dorsal view; D, Gnathosoma, ventral view; E, Gnathosoma, anteroventral view; F, Coxae; G, Trochanter I, dorsal view. *Scale-bars*: A–G, 0.1 mm

as long as scutal setae ($c.0.03$). Genital aperture (Fig. 4A) medial to coxae II, narrowly V-shaped with rounded apex, lateral margins straightly convergent, genital sclerites small, indistinct. Spiracular plates (Fig. 4B) broadly oval, wider than long, length 0.12–0.17 (0.14 ± 0.01 ; $n = 21$), width 0.13–0.18 (0.16 ± 0.01 ; $n = 21$), ratio 0.71–1.13 (0.89 ± 0.13 ; $n = 21$).

Gnathosoma (Figs. 4C–E) length from palpal apices to cornual apices dorsally 0.38–0.49 (0.43 ± 0.32 ; $n = 21$), width of gnathosoma between lateral projections of palpal segment II 0.53–0.65 (0.58 ± 0.03 ; $n = 21$), ratio 0.67–0.82 (0.74 ± 0.03 ; $n = 21$). Dorsal basis capituli (Fig. 4C) subrectangular with converging lateral margins; posterior margin straight; cornua moderately long, broadly triangular with rounded apices, total length of basis capituli, including cornua, 4.75–9.00 (6.72 ± 1.05 ; $n = 21$) cornual length; porose areas suboval with no clear circumscribed borders, poorly indented, greatest dimension inclined posterolaterally, separated by distance nearly twice their width. Ventral basis capituli (Fig. 4D) subrectangular. Palpi (Figs. 4C–E) short, broadly salient; ratio combined breadth to basis capituli breadth 1.50–1.75 (1.61 ± 0.07 ; $n = 21$); length dorsally (II–III segments) 0.28–0.35 (0.31 ± 0.02 ; $n = 21$), width 0.24–0.31 (0.28 ± 0.02 ; $n = 21$), ratio 1.00–1.28 (1.13 ± 0.08 ; $n = 21$); segment I indistinct; dorsomedian margin of segment II abruptly widening anteriorly at its midlength; posterodorsal spur moderately large, broadly triangular with tapering apex; posteroventral spur moderately long and broad with broadly rounded apex directed slightly posterolaterally; segment III dorsally subtriangular, moderately long ventral spur of segment III nearly twice as long as broad tapering to apex. Hypostome (Fig. 4D) short with bluntly rounded apex; dental formula 4/4 with 13 to 14 denticles in file.

Legs moderately long, slender. Coxae (Fig. 4F): coxae I with relatively long, broadly triangular spur with bluntly rounded apex, directed posteriorly; coxae II–IV with large, broadly triangular spur with rounded apex, directed posteriorly. Trochanter I (Fig. 4G) with broadly triangular dorsal spur, tapering to apex; trochanters I–IV without spurs ventrally. Tarsi I–IV humped subapically.

Remarks

It appears that the holotype and paratype males of *H. muhsamae* were lost. These specimens were not found in the Veterinary Laboratory in Maputo, Mozambique where they were stated to be deposited (Santos Dias, 1962), nor were they found in the collections of the Institute of

Hygiene and Tropical Medicine of Lisbon and Science Museum of the University of Coimbra in Portugal. Since the holotype is lost or destroyed, we herein designate a neotype of *Haemaphysalis muhsamae* in an effort to clarify the taxonomic status of this species. Because *H. muhsamae* can be easily confused with *H. subterra* or with *H. spinulosa* as redescribed and illustrated by Hoogstraal (1964) in regards to size, spurs on gnathosoma and coxae, etc., and is also morphologically very similar to new species in a complex of species related to *H. spinulosa* which we will describe in forthcoming publications, we deem it necessary to provide a neotype to avoid any further confusion within the *H. spinulosa* subgroup. Our measurement data and description in conjunction with scanning electron micrographs are sufficient to ensure recognition of the specimen designated, and the neotype is both consistent with the original description and was collected as nearly as feasibly possible to the type locality. The neotype has been deposited in the USNTC where it will be accessible for study.

We have identified 125 adult specimens as *H. muhsamae* that agree with nearly all key characters provided in the original description, e.g. size, punctuation pattern of scutum/conscutum, setation, and size and shape of palpal and coxal spurs. Many of the specimens we identified as *H. muhsamae* occur within the geographic range in the original description. We have examined a few thousand *spinulosa*-like specimens from southern Africa and did not find any other tick that would match the one in the original description. The one exception in our specimens that does not agree with the descriptions provided by Santos Dias (1954) is the hypostome dentition of males; we have found that the males have 3/3 dental formula whereas Santos Dias described the male as having 4/4 dental formula. We assume that Santos Dias inadvertently miscounted the number of denticle rows on hypostome in males, which is likely a result of the extraordinary small size of these ticks. In addition, *H. muhsamae* are the only ticks in the *H. (Rhipistoma) spinulosa* subgroup with 3/3 dental formula, so there is also the possibility that character may have been overlooked.

Being a small tick with relatively short cornua and somewhat longer spurs on palpal segment II and III ventrally *H. muhsamae* is closer to other species in the *H. (R.) spinulosa* subgroup. Other species of this group are *H. norvali*, *H. spinulosa* [positively known only from lectotype and paralectotype females described in Hoogstraal (1964)] and *H. subterra* (see Hoogstraal, 1964; Hoogstraal & Wassef, 1983).

The male of *H. muhsamae* can readily be distinguished from males of other species in the subgroup by their 3/3 dental formula (vs 4/4 dental formula in all other species). Additionally males of *H. muhsamae* can easily be distinguished from those of *H. norvali* by long and narrow ventral spurs on palpal segment II (vs short spurs in *H. norvali*). Additional characters for *H. muhsamae* discriminating it from *H. subterra* are: long setae of conscutum, *c.*0.03 (vs short setae, *c.*0.01 in *H. subterra*), shorter and broader cornua: mean ratio basis capituli length to cornual length 4.94 (vs longer and narrower cornua, mean ratio basis capituli length to cornual length 3.29 in *H. subterra*), shorter and broader posterodorsal and posteroventral spurs on palpal segment II, directed posterolaterally (vs longer and narrower spurs directed posteriorly in *H. subterra*) and broader spurs on coxae directed posteriorly (vs narrower spurs directed medially in *H. subterra*).

Females of *H. muhsamae* can be easily distinguished from those of *H. norvali* by long and broad ventral spurs with broadly rounded apices on palpal segment II (vs very short spurs in *H. norvali*). The female of *H. muhsamae* can readily be distinguished from those of *H. spinulosa* and *H. subterra* by: long setae on scutum and alloscutum, *c.*0.03 (vs short setae in *H. subterra*, *c.*0.01), lateral margins of genital aperture straight and convergent (vs convex lateral margins giving funnel-shape appearance to genital aperture in *H. spinulosa* and *H. subterra*), shorter cornua: mean ratio basis capituli length to cornual length 6.72 (vs longer and narrower cornua, mean ratio basis capituli length to cornual length 3.72 in *H. subterra*), broad posteroventral spur with broadly rounded apex directed posterolaterally of palpal segment II (vs narrow tapering to apex, posteriorly directed spur in *H. spinulosa* and *H. subterra*) and broader and blunter spurs on coxae directed posteriorly (vs narrower and tapering to apices spurs directed medially in *H. spinulosa* and *H. subterra*).

Collection data for *H. muhsamae* are listed in the material above. This species is confined to Botswana (Gaborone and North-West Districts), Kenya (Narok and Machakos Counties), Mozambique (Tete Province), South Africa (KwaZulu/Natal and Mpumalanga Provinces), Tanzania (Arusha Region) and Zimbabwe (Mashonaland Central and Matabeleland South Provinces) (Fig. 5). In the only case indicated, the collection was made at 1,737 metres above sea level. Adults of this species were mostly collected from mongooses such as slender mongoose, *G. sanguinea*, unidentified mongoose, *Galerella* sp., white-tailed mongoose, *I. albicauda* and unidentified mongoose. Some collections were made from striped polecat, *I. striatus* and

singularly they were found on serval, *L. serval* and red veld aethomys, *A. chrysophilus* during January, February, May–August, October and November. The lost holotype and paratype males were collected from common dwarf mongoose, *H. parvula* in Maputo Province of Mozambique during June (Santos Dias, 1954). Due to the existing uncertainties in the identity of *H. muhsamae*, any other previously published locality and host records should be ignored and avoided. The identity of the described nymph (Santos Dias, 1955) should be considered questionable and requiring verification.

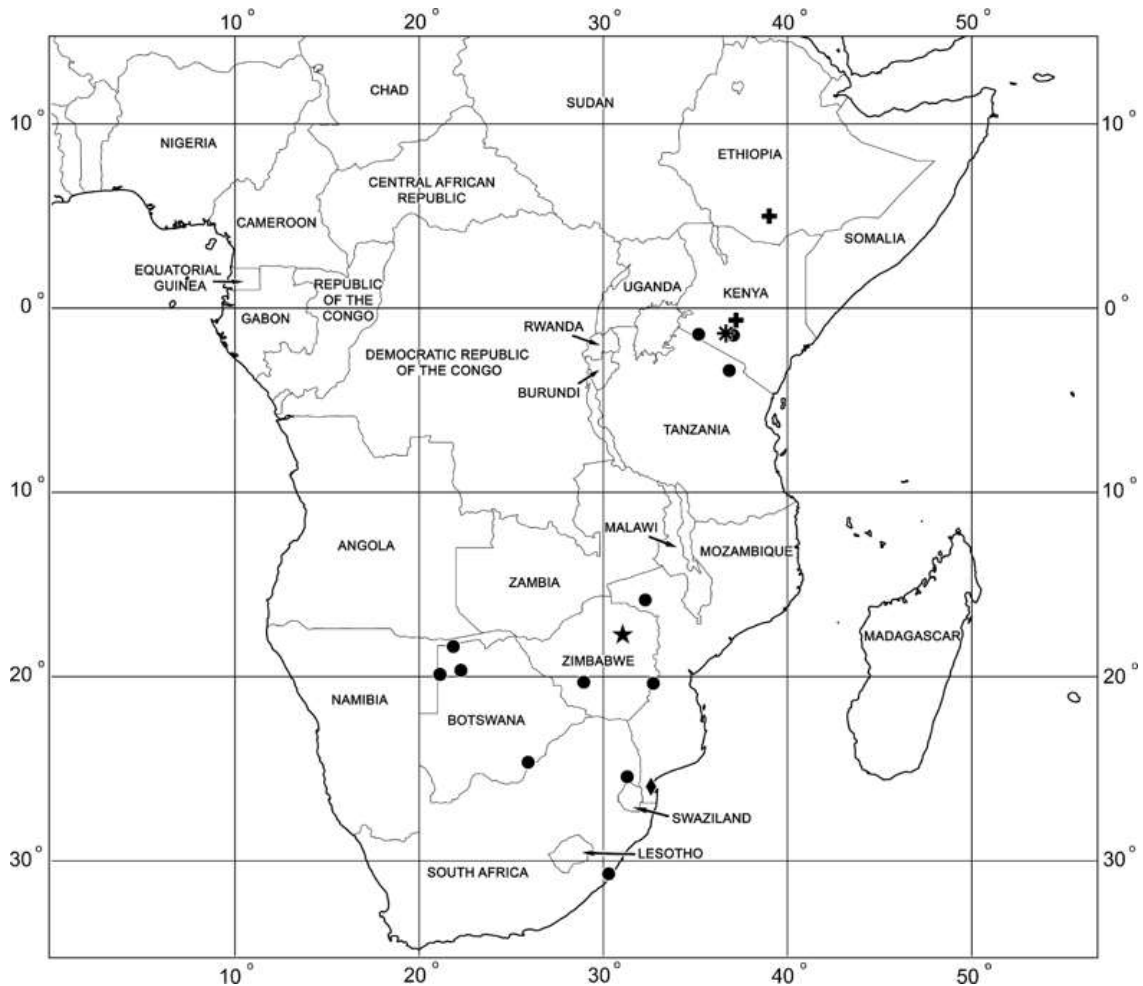


Fig. 5 Map showing the known geographical distribution of *Haemaphysalis muhsamae* Santos Dias, 1954 and *H. subterra* Hoogstraal, El Kannah & Camicas, 1992. Filled star shows the type-locality of neotype, diamond shows the type-locality of the lost holotype and filled circles show confirmed localities of *H. muhsamae*; Asterisk shows the type-locality and crosses show confirmed localities of *H. subterra*

***Haemaphysalis subterra* Hoogstraal, El Kammah & Camicas, 1992**

Type-host: *Galerella sanguinea* (Rüppell) (Carnivora: Herpestidae).

Type-locality: Ngong, 25 mi south-west of Nairobi on Magadi Road, Kajiado, Kenya.

Other hosts: *Tachyoryctes ibeanus* Thomas, *Tachyoryctes splendens* (Rüppell), *Tachyoryctes* sp. (Rodentia: Spalacidae), *I. striatus*.

Other localities: Ethiopia: Sidamo Province. Kenya: Kiambu: Kikuyu, North Muguga; Kirinyaga: Muranga, Sagana; Nairobi: Nairobi; Nairobi, Choroma; Nairobi, Kabete; Nairobi, Spring Valley.

Holotype: Male, from *G. sanguinea*, Ngong (~1°22'S, 36°38'E), 25 mi south-west of Nairobi on Magadi Road, Kajiado, Kenya, 914 m alt., 9.vii.1956, H. Hoogstraal; deposited in the USNTC (USNMENT 00860188).

Allotype: Female, from *T. ibeanus* nest, Sigona (~1°13'S, 36°39'E), Kikuyu, Kenya, 2,073 m alt., 22.vi.1948, H. Hoogstraal; deposited in the USNTC (USNMENT 00860189). In their original description Hoogstraal et al. (1992) provided contradictory information on the allotype label. Under the allotype paragraph they stated that the allotype has the same label data as holotype, but under paratype paragraph they state that paratype females have the same label data as allotype which is different from those of holotype. Based on actual label in the allotype vial we assume that the first statement is wrong. Morphological examination of the allotype female reveals that it is a different and possibly undescribed species, but not *H. subterra*.

Paratypes: 11 males with the same collection data as for holotype; 13 females with the same collection data as for allotype. According to Hoogstraal et al. (1992) the paratypes are deposited in the J. L. Camicas Collection in ORSTOM and the H. Hoogstraal Collection (currently part of the USNTC). We were unable to find any paratypes in the USNTC.

Other material: Forty two males, 23 females. Ethiopia: Sidamo Province (~5°N, 39°E), 1,829 m alt: 3 males and 2 females, from *T. splendens*, 27.v.1959, F. R. Allison, USNMENT 00860177.

Kenya: Kiambu: Kikuyu, North Muguga (~1.10°S, 36.38°E): 6 males and 3 females, from *I. striatus*, 1.vii.1956, H. Hoogstraal, M. Kaiser, USNMENT 00860178; Kirinyaga: Muranga, Sagana (~0.39°S, 37.12°E), 2,073 m alt: 1 male, from *T. ibeanus*, 1956, H. Hoogstraal, USNMENT 00860179; Nairobi: Nairobi (~1°16'S, 36°49'E): 5 females, from *T. ibeanus*, 20.ii.1921, Van Someran, USNMENT 00860180; 2 males, from *Tachyoryctes* sp., 17.iii.1964, Karen, USNMENT 00860181; Nairobi, Choroma: 18 males and 7 females, from *T. ibeanus*,

1967, J. M. Jarvis, USNMENT 00860182; Nairobi, Kabete (1°16'S, 36°43'E): 12 males and 3 females, from *T. ibeanus*, 31.v.1974, G. C. Backhurst, USNMENT 00860183; Nairobi, Spring Valley (1°15'S, 36°46'E): 3 females, from *T. ibeanus*, 16.vii.1967, J. M. Jarvis, USNMENT 00860184. All specimens are deposited in the USNTC.

Etymology: The specific name is apparently derived from the Latin *sub* meaning “under” and *terra* meaning “ground” and seems to refer to the underground habitat of the tick’s principal host, African mole rats.

Description (Figs. 6–9)

Male [Figs. 6, 7; based on 43 specimens.] Conscutum (Figs. 6A–C): length from scapular apices to posterior margin 1.16–1.40 (1.27 ± 0.05 ; $n = 37$), width 0.82–0.98 (0.89 ± 0.04 ; $n = 37$), ratio 1.19–1.46 (1.32 ± 0.07 ; $n = 37$), broadly oval, widest posterior to midlength, colour yellowish brown; scapulae short, blunt; cervical grooves indistinct, very shallow; lateral grooves distinct, extending from anterior 1/4 of conscutal length to first festoon, enclosing first festoon; eleven distinct festoons; punctations distinct, relatively sparse, larger bearing setae and fine; setae numerous, very short ($c.0.01$) and indistinct (Figs. 6A–C). Genital apron medial to coxae II, with numerous distinct denticles of moderate length on posterior margin (Fig. 7A); postgenital sclerite (Fig. 6D) narrow, nearly three times as broad as long, arcuate. Spiracular plate (Fig. 7B) subrectangular, slightly longer than broad, dorsal prolongation indistinct, length 0.09–0.13 (0.11 ± 0.01 ; $n = 37$), width 0.09–0.12 (0.11 ± 0.01 ; $n = 37$), ratio 0.93–1.18 (1.07 ± 0.57 ; $n = 37$); nearly equal in length to first festoon.

Gnathosoma (Figs. 7C–E) length from palpal apices to cornual apices dorsally 0.26–0.30 (0.28 ± 0.01 ; $n = 37$), width of gnathosoma between lateral projections of palpal segment II dorsally 0.38–0.43 (0.40 ± 0.01 ; $n = 37$), ratio length to width 0.66–0.74 (0.70 ± 0.02 ; $n = 37$). Dorsal basis capituli (Fig. 7C) subrectangular with converging lateral margins; posterior margin nearly straight; length 0.12–0.14 (0.13 ± 0.01 ; $n = 37$), width 0.21–0.24 (0.23 ± 0.01 ; $n = 37$), ratio width to length 1.67–2.00 (1.81 ± 0.08 ; $n = 37$); cornua relatively long, narrowly triangular, sharply pointed, total length of basis capituli, including cornua, 2.80–4.67 (3.29 ± 0.40 ; $n = 37$) cornual length. Ventral basis capituli (Fig. 7D) subrectangular. Palpi (Figs. 7C–E) short, broadly salient, ratio combined breadth to basis capituli breadth 1.67–1.92 (1.76 ± 0.07 ; $n = 37$); length

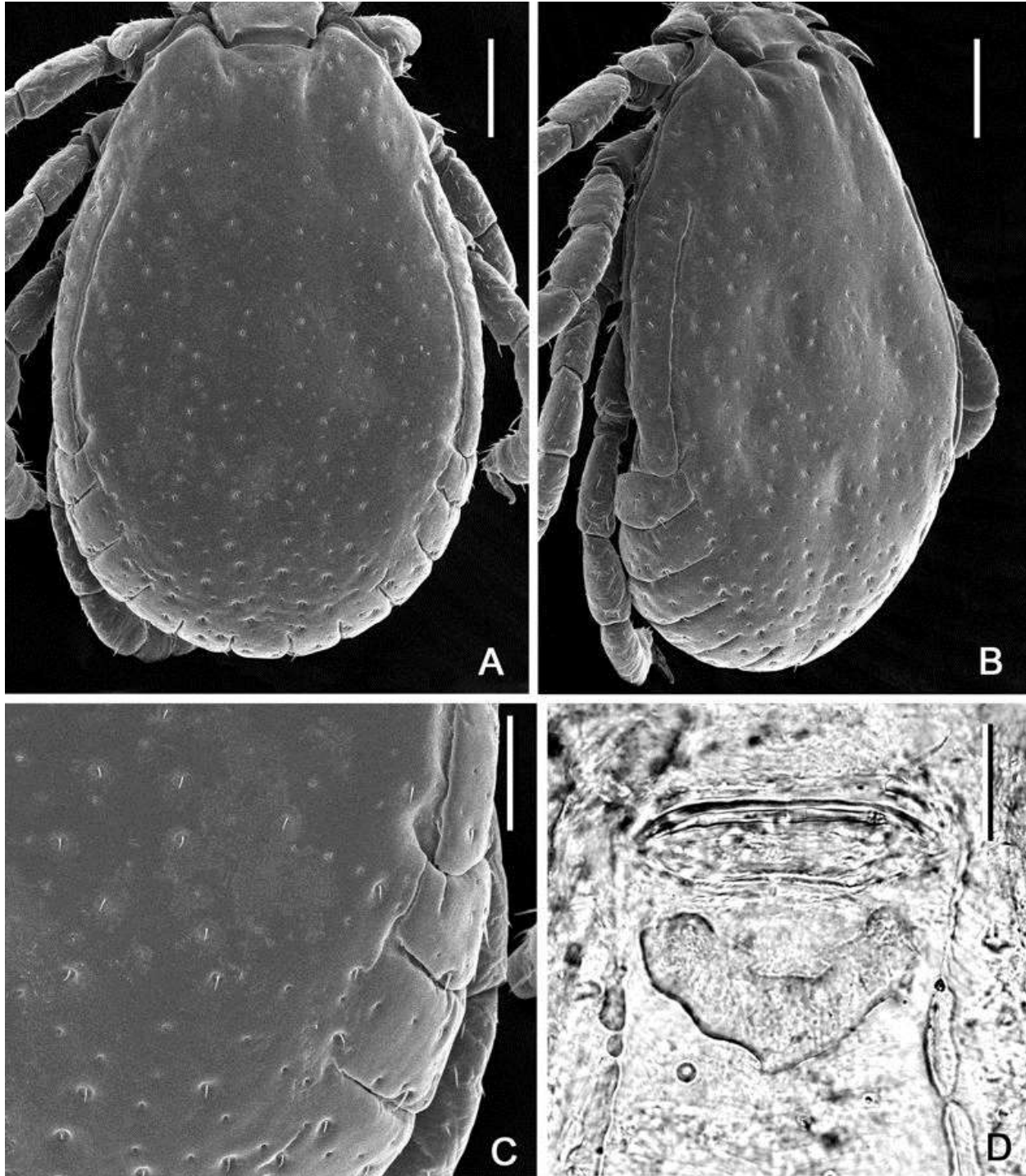


Fig. 6 *Haemaphysalis subterra* Hoogstraal, El Kammah & Camicas, 1992, scanning electron micrographs and digital photograph of male (Kikuyu, north of Muguga, Kiambu, Kenya, USNMENT 00860178). A, Conscutum, dorsal view; B, Conscutum, dorsolateral view; C, Conscutum showing punctations and setae, dorsal centrolateral portion; D, postgenital sclerite. *Scale-bars*: A, B, 0.2 mm; C, 0.1 mm; D, 0.05 mm

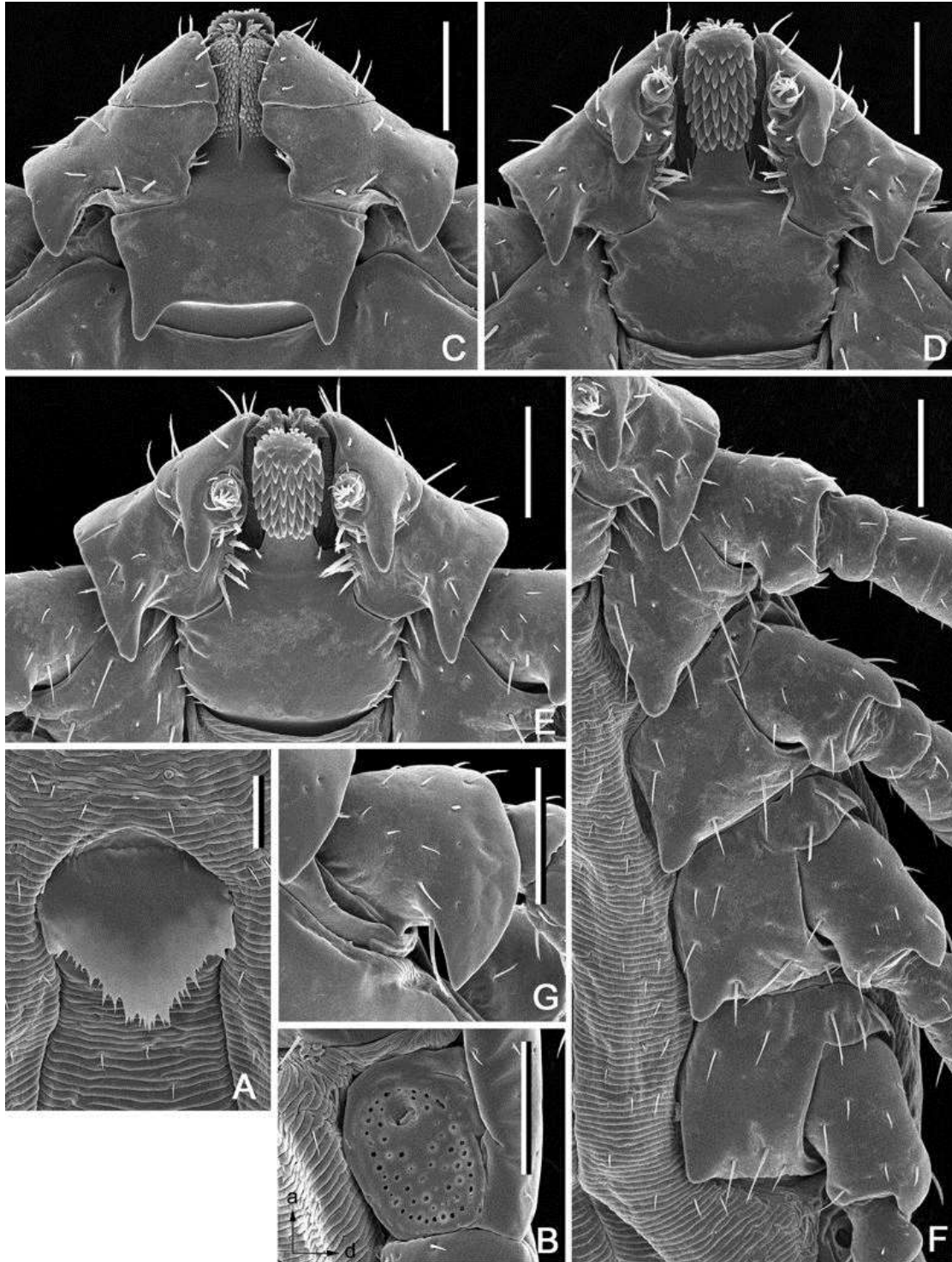


Fig. 7 *Haemaphysalis subterra* Hoogstraal, El Kammah & Camicas, 1992, scanning electron micrographs of male (Kikuyu, north of Muguga, Kiambu, Kenya, USNMENT 00860178). A, Apron; B, Spiracular plate (arrows indicate orientation of spiracular plate: a, anterior; d, dorsal); C, Gnathosoma, dorsal view; D, Gnathosoma, ventral view; E, Gnathosoma, anteroventral view; F, Coxae; G, Trochanter I, dorsal view. Scale-bars: A, 0.05 mm; B–G, 0.1 mm

dorsally (II–III segments) 0.18–0.21 (0.19 ± 0.01 ; $n = 37$), width 0.17–0.19 (0.18 ± 0.01 ; $n = 37$), ratio 0.95–1.25 (1.09 ± 0.07 ; $n = 37$); segment II nearly twice as long as segment III; segment I indistinct; dorsomedian margin of segment II gradually widening anteriorly at its midlength; posterolateral margin nearly straight; posterodorsal spur large, narrowly triangular with sharp apex directed posteriorly; posteroventral spur long and narrow with sharp apex directed posteriorly; ventral spur of segment III nearly twice as long as broad tapering to apex. Hypostome with bluntly rounded apex; dental formula 4/4 throughout hypostomal length with approximately 6 to 7 denticles in each file.

Legs medium length, slender. Coxae (Fig. 7F): coxae I with relatively long, narrowly triangular spur with bluntly rounded apex, directed posteriorly; coxae II–IV each with large narrowly triangular spur tapering to blunt apex, directed posteromedially. Trochanter I (Fig. 7G) with long broadly triangular spur with sharp apex, directed posteriorly, trochanters I–IV without spurs ventrally. Tarsi I–IV slightly humped subapically.

Female [Figs. 8, 9; based on 23 specimens.] Idiosoma (Fig. 8A) broadly suboval, widest slightly posterior to midlength. Scutum (Figs. 8A–D) broad, diverging in anterior half and converging to broadly rounded posterior margin, length 0.69–0.81 (0.75 ± 0.04 ; $n = 23$), width 0.66–0.85 (0.72 ± 0.05 ; $n = 23$), ratio 0.90–1.12 (1.05 ± 0.06 ; $n = 23$); cervical grooves distinct, narrow and moderately shallow, extend to midlength of scutum; punctations relatively sparse, larger bearing setae and smaller; setae (Figs. 8A–D) numerous, relatively short ($c.0.01$), distributed as figured. Setae of alloscutum (Figs. 8A, D) numerous, evenly distributed, nearly as long as scutal setae ($c.0.01$). Genital aperture (Fig. 9A) medial to posterior margin of coxae II, moderately wide V-shaped with distinct medially convex lateral margins, genital sclerites distinct. Spiracular plates (Fig. 9B) broadly oval, wider than long, length 0.11–0.14 (0.13 ± 0.01 ; $n = 23$), width 0.14–0.18 (0.16 ± 0.01 ; $n = 23$), ratio 0.68–0.89 (0.81 ± 0.05 ; $n = 23$).

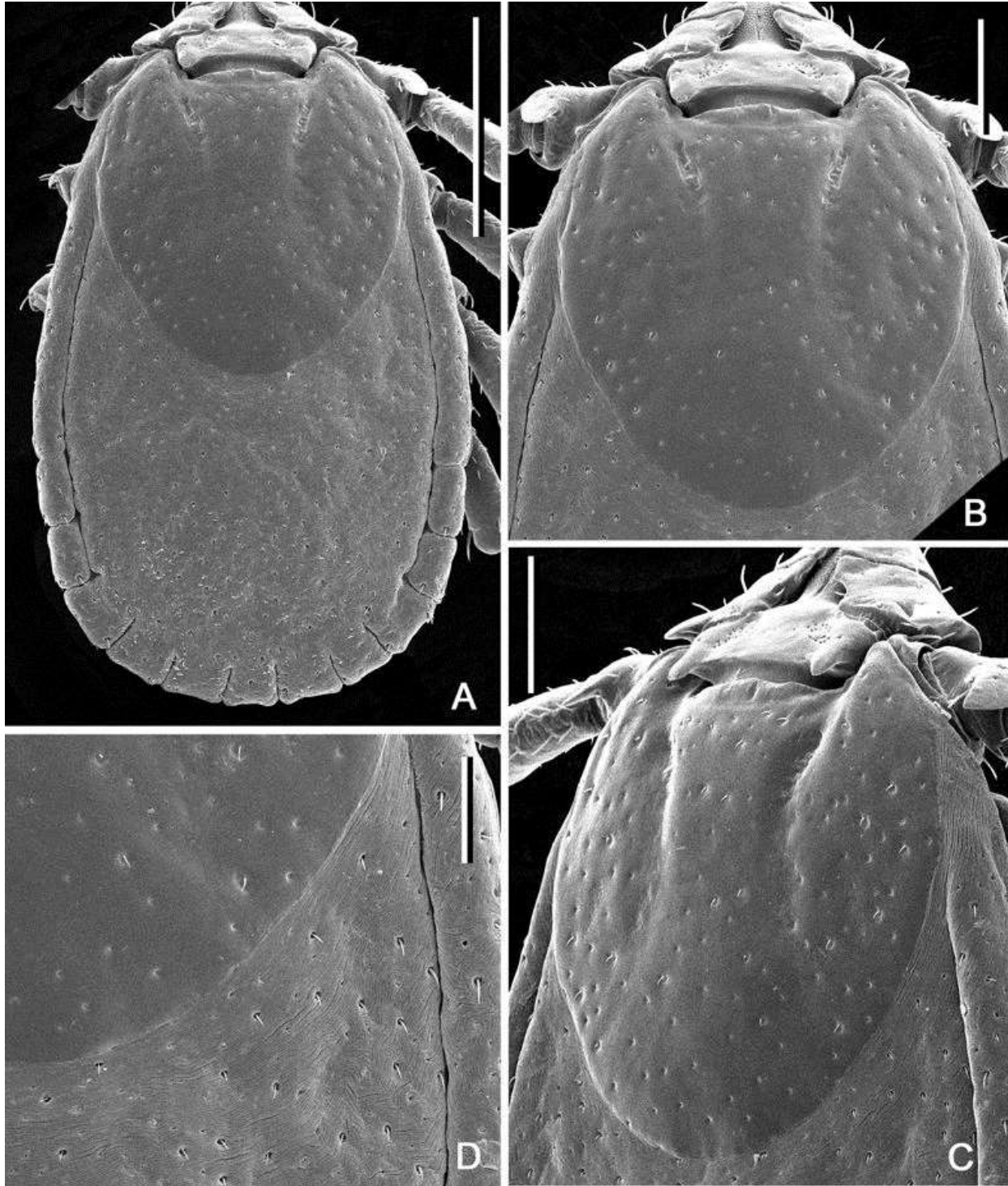


Fig. 8 *Haemaphysalis subterra* Hoogstraal, El Kammah & Camicas, 1992, scanning electron micrographs of female (Kikuyu, north of Muguga, Kiambu, Kenya, USNMENT 00860178). A, Idiosoma, dorsal view; B, Scutum, dorsal view; C, Scutum, dorsolateral view; D, Idiosoma showing scutum and alloscutum with punctations and setae, dorsal centrolateral portion. *Scale-bars*: A, 0.5 mm, B, C, 0.2 mm; D, 0.1 mm

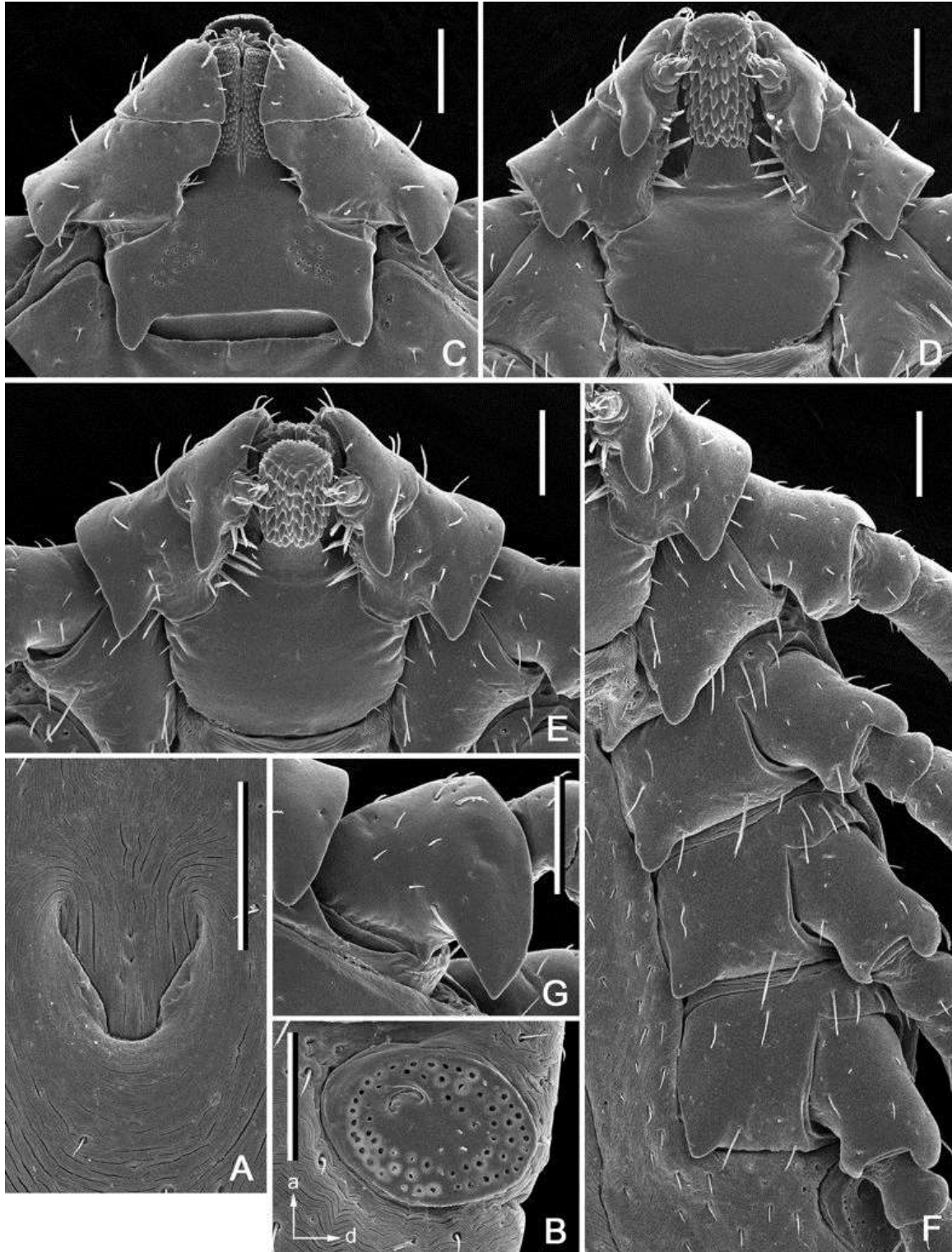


Fig. 9 *Haemaphysalis subterra* Hoogstraal, El Kammah & Camicas, 1992, scanning electron micrographs of female (Kikuyu, north of Muguga, Kiambu, Kenya, USNMENT 00860178). A, Genital aperture; B, Spiracular plate (arrows indicate orientation of spiracular plate: a, anterior; d, dorsal); C, Gnathosoma, dorsal view; D, Gnathosoma, ventral view; E, Gnathosoma, anteroventral view; F, Coxae; G, Trochanter I, dorsal view. Scale-bars: A–G, 0.1 mm

Gnathosoma (Figs. 9C–E) length from palpal apices to cornual apices dorsally 0.35–0.42 (0.38 ± 0.02 ; $n = 23$), width of gnathosoma between lateral projections of palpal segment II 0.48–0.56 (0.53 ± 0.02 ; $n = 23$), ratio 0.70–0.75 (0.72 ± 0.02 ; $n = 23$). Dorsal basis capituli (Fig. 9C) subrectangular with converging lateral margins; posterior margin straight; length 0.14–0.23 (0.17 ± 0.02 ; $n = 23$), width 0.31–0.35 (0.33 ± 0.01 ; $n = 23$), ratio width to length 1.90–2.35 (2.09 ± 0.12 ; $n = 23$); cornua long, narrowly triangular with rounded apices, total length of basis capituli, including cornua, 3.17–4.22 (3.72 ± 0.30 ; $n = 23$) cornual length; porose areas suboval with no clear circumscribed borders, poorly indented, greatest dimension inclined posterolaterally, separated by distance nearly twice their width. Ventral basis capituli (Fig. 9D) subrectangular. Palpi (Figs. 9C–E) short, broadly salient; ratio combined breadth to basis capituli breadth 1.50–1.65 (1.59 ± 0.04 ; $n = 23$); length dorsally (II–III segments) 0.21–0.30 (0.26 ± 0.02 ; $n = 23$), width 0.20–0.25 (0.23 ± 0.01 ; $n = 23$), ratio 0.93–1.35 ($1.13 \pm 0. ; n = 23$); segment I indistinct; dorsomedian margin of segment II gradually widening anteriorly at its midlength; posterodorsal spur moderately large, broadly triangular with tapering apex; posteroventral spur moderately long and narrow with moderately sharp apex directed posteriorly; segment III dorsally subtriangular, moderately long ventral spur of segment III nearly twice as long as broad tapering to apex. Hypostome (Fig. 9D) with bluntly rounded apex; dental formula 4/4 with 6 to 7 denticles in file.

Legs medium length, slender. Coxae (Fig. 9F): coxae I with relatively long, narrowly triangular spur with narrowly rounded apex; coxae II–IV each with large, narrowly triangular spur tapering to apex, directed slightly posteromedially. Trochanter I (Fig. 9G) with long broadly triangular spur, tapering to apex. Trochanters I–IV without spurs ventrally. Tarsi I–IV slightly humped subapically.

Remarks

In their original description of *H. subterra* Hoogstraal et al. (1992) provided contradictory information on the allotype label. Under the allotype paragraph they stated that the allotype has the same label data as holotype, but under paratype paragraph they state that paratype females have the same label data as allotype which is different from those of holotype. Based on actual

label in the allotype vial we assume that the first statement is wrong. Morphological examination of the allotype female reveals that it is a different and possibly undescribed species, but not *H. subterra*.

According to Hoogstraal et al. (1992) the paratypes of *H. subterra* are deposited in the J. L. Camicas Collection in ORSTOM and the H. Hoogstraal Collection (currently part of the USNTC). We were unable to find any paratypes in the USNTC.

After examination of nearly 10,000 *spinulosa*-like specimens and the holotype of *H. subterra* stored in the USNTC we have concluded that the original description and illustrations of *H. subterra* are based on at least 3 different species of *Haemaphysalis*. Besides the valid *H. subterra* identity which is based on the holotype male specimen there are: 1) the illustration of the male in Hoogstraal et al. (1992) is that of *H. muhsamae*; 2) the illustration of the female in Hoogstraal et al. (1992) is that of an unknown species closely resembling *H. spinulosa*. Moreover, true females of *H. subterra* are morphologically very close to the lectotype female of *H. spinulosa* described in Hoogstraal (1964). Unfortunately, the type specimens of *H. spinulosa* cannot be found in the Natural History Museum (London, UK) at the moment (J. Beccaloni, personal communication) and the description in Hoogstraal (1964) is not entirely sufficient for proper comparison with *H. subterra*.

Being a small tick with relatively short cornua and somewhat longer spurs on palpal segment II and III ventrally *H. subterra* is closer to other species in the *H. (R.) spinulosa* subgroup in regard to its morphology. Other species of this group are *H. muhsamae*, *H. norvali* and *H. spinulosa* [positively known only from lectotype and paralectotype females described in Hoogstraal (1964)] (see Hoogstraal, 1964; Hoogstraal & Wassef, 1983).

The males of *H. subterra* can easily be distinguished from those of *H. norvali* by long and narrow ventral spurs on palpal segment II (*vs* short spurs in *H. norvali*) and from those of *H. muhsamae* by 4/4 dental formula on hypostome (*vs* 3/3 in *H. muhsamae*). Additional characters for *H. subterra* distinguishing it from *H. muhsamae* are: short setae of conscutum, *c.*0.01 (*vs* long setae, *c.*0.03 in *H. muhsamae*), longer and narrower cornua: mean ratio basis capituli length to cornual length 3.29 (*vs* shorter and broader cornua, mean ratio basis capituli length to cornual length 4.94 in *H. muhsamae*), longer and narrower posterodorsal and posteroventral spurs on

palpal segment II, directed posteriorly (*vs* shorter and broader spurs directed posterolaterally in *H. muhsamae*) and narrower spurs on coxae directed medially (*vs* broader spurs directed posteriorly in *H. muhsamae*).

Females of *H. subterra* can easily be distinguished from those of *H. norvali* by long and broad ventral spurs with broadly rounded apices on palpal segment II (*vs* very short spurs in *H. norvali*). The females of *H. subterra* can readily be distinguished from those of *H. muhsamae* by: short setae on the scutum and alloscutum, *c.*0.01 (*vs* long setae in *H. muhsamae*, *c.*0.03), convex lateral margins of genital aperture giving it a funnel-shaped appearance (*vs* lateral margins of genital aperture straight and convergent in *H. muhsamae*), longer and narrower cornua: mean ratio basis capituli length to cornual length 3.72 (*vs* shorter cornua: mean ratio basis capituli length to cornual length 6.72 in *H. muhsamae*), narrow, tapering to its apex and directed posteriorly posteroventral spur of palpal segment II (*vs* broad spur with broadly rounded apex directed posterolaterally in *H. muhsamae*) and narrower and tapering to apices spurs on coxae directed medially (*vs* broader and blunter spurs directed posteriorly in *H. muhsamae*). Unfortunately we can provide only tentative and preliminary comparison of females of *H. subterra* with those of *H. spinulosa*. From the characters that can be seen in the redescription of *H. spinulosa* in Hoogstraal (1964) we can state that it is very similar to *H. subterra*. The only clear difference of *H. subterra* that we notice is longer cornua: mean ratio basis capituli length to cornual length 3.72 (*vs* shorter cornua: ratio basis capituli length to cornual length 5.33 in *H. spinulosa*).

Collection data for *H. subterra* are listed in the material above. This species is confined to Ethiopia (Sidamo Province) and Kenya (Kajiado, Kiambu, Kirinyaga and Nairobi Counties) (Fig. 5). Where indicated, collections were made at elevations 914–2,073 metres above sea level. Adults of this species were mostly collected from African mole rats such as Kenyan African mole rat, *T. ibeanus*, northeast African mole rat, *T. splendens* and unidentified African mole rat, *Tachyoryctes* sp. Some adults were also collected from striped polecat, *I. striatus* and slender mongoose, *G. sanguinea*. Collections were made during February, March, May and July. Any previously published locality and host records, including those in the original description (Hoogstraal et al., 1992) should be ignored and avoided. The identity of the described nymph and larva (Hoogstraal et al., 1992) should be considered questionable and verified.

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Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All applicable institutional, national and international guidelines for the care and use of animals were followed.

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