

# The Genus *Hyalomma*: VII. Redescription of all Parasitic Stages of *H. (Euhyalomma) dromedarii* and *H. (E.) schulzei* (Acari: Ixodidae)

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**ABSTRACT** The ticks, *Hyalomma (Euhyalomma) dromedarii* Koch, 1844 and *Hyalomma (Euhyalomma) schulzei* Olenov, 1931, are considered to be the species most closely associated with camels. *H. dromedarii* can behave as a three-, two-, or one-host species, with the two-host life cycle seemingly most common. Camels are the main hosts of the adults, which also parasitize other domestic animals. Nymphs and larvae can use the same hosts, especially camels, as the adults, but can also parasitize rodents, leporids, hedgehogs, and birds. *H. dromedarii* is widely distributed in North Africa, the northern regions of West, Central, and East Africa, Arabia, Asia Minor, the Middle East, and Central and South Asia. *H. schulzei* is a two-host species. Camels are the principal hosts of the adults, with some records from cattle and goats, whereas the immature stages infest hares, burrowing rodents, and hedgehogs. *H. schulzei* has a more limited geographic distribution in Asia and Egypt than *H. dromedarii*, and with the exception of southeastern Iran, it is a fairly uncommon tick. Among other features that are fairly similar, males of *H. dromedarii* can be distinguished from those of *H. schulzei* by a narrow, subtriangular parma, usually very large subanal shields, and a long dorsal prolongation of the spiracular plates. Males of *H. schulzei* have a broad and rectangular parma, paramedian festoons that protrude posteriorly, smaller subanal shields, and a very short dorsal prolongation of the spiracular plates. The females of *H. dromedarii* can be distinguished from those of *H. schulzei* by a narrow V-shaped genital aperture compared with a very wide, deep, U-shaped genital aperture. Here all the parasitic stages of both species are illustrated and redescribed, and characteristics that distinguish the adults from those of other closely related species are supplied. Data on their hosts, geographic distribution and disease relationships are also provided.

**KEY WORDS** *Hyalomma (Euhyalomma) dromedarii*, *Hyalomma (Euhyalomma) schulzei*, systematics, geographic distribution, hosts

*Hyalomma (Euhyalomma) dromedarii* Koch, 1844 was originally described as an independent species (Koch 1844). Later, however, Neumann (1901) considered it to be a variety of the catch-all species *Hyalomma (Hyalomma) aegyptium* (Linnaeus, 1758). *Hyalomma (Euhyalomma) schulzei* Olenov, 1931 was also originally described as a full species (Olenov 1931), and the unusual morphological features of its males should preclude it from being confused with any other *Hyalomma* species. Perusal of several tick collections has led us to believe that, with the exception of the males of *H. schulzei*, the adults of *H. dromedarii* and *H. schulzei* have often been confused with those of other *Hyalomma* species. An apparent reason for this confusion is the lack of detailed descriptions of the adults,

taking the variability that may be encountered in either species into account. The only adequate preliminary comparison of their immature stages has been provided by Apanaskevich (2002).

Based on their morphology, we tentatively consider that both *H. dromedarii* and *H. schulzei* belong to the *H. (Euhyalomma) asiaticum* group of species. The other species in this group are *H. (Euhyalomma) asiaticum* Schulze and Schlottke, 1930; *H. (Euhyalomma) impeltatum* Schulze and Schlottke, 1930; and *H. (Euhyalomma) erythraeum* Tonelli Rondelli, 1932.

The chief purpose of this study is to illustrate and redescribe all parasitic stages of both species in detail. This should assist parasitologists, epidemiologists, virologists, and others with the identification of these ticks, which may be involved in the transmission of various disease agents in Asia and Africa.

## Materials and Methods

A total of ≈8,300 males, 4,200 females, 500 nymphs, and 300 larvae of *H. dromedarii*, originating from Afghanistan, Azerbaijan, Bahrain, Chad, Djibouti, Egypt, Eritrea, Ethiopia, India, Iran, Iraq, Israel, Jordan, Ke-

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nya, Kuwait, Lebanon, Libya, Morocco, Namibia, Nigeria, Oman, Pakistan, Qatar, Saudi Arabia, Senegal, Somalia, Syria, Sudan, Tajikistan, Tunisia, Turkey, Turkmenistan, United Arab Emirates, Uzbekistan, and Yemen, and 231 males, 110 females, 16 nymphs, and 35 larvae of *H. schulzei*, originating from Afghanistan, Egypt, Iran, Iraq, Israel, Jordan, Kuwait, Pakistan, Saudi Arabia, and Syria, were examined in this study. The lectotype and paralectotypes of *H. schulzei* have also been examined by Apanaskevich (D.A.A.). Both field-collected and laboratory-reared specimens were scrutinized. The specimens examined are housed in the United States National Tick Collection (USNTC; Institute of Arthropodology and Parasitology, Georgia Southern University, Statesboro, GA), the Zoological Institute, Russian Academy of Sciences (ZIN RAS, Saint Petersburg, Russia), the Natural History Museum of Berlin (NHMB; Berlin, Germany), the Field Museum of Natural History (FMNH; Chicago, IL), the Royal Museum for Central Africa (RMCA; Tervuren, Belgium), the Gertrud Theiler Tick Museum at the Onderstepoort Veterinary Institute (OVI; Onderstepoort, South Africa), and in the personal tick collection of Dr. J. B. Walker (South Africa).

The immature stages and the more delicate structures of the adults were mounted on glass slides and examined under a light microscope, and the macrostructures of males and females were examined under a stereoscopic microscope. The spiracular plates of the nymphs were studied by means of a scanning electron microscope. Measurements for the male conscutum and female scutum are given in millimeters and those for the various features of the immature stages in micrometers. The measurements are arranged as follows: minimum – maximum (mean  $\pm$  SD,  $n$  = number of specimens measured). Their schematic layout is to be found in Apanaskevich (2003) and Apanaskevich and Horak (2006).

### *Hyalomma (Euhyalomma) dromedarii* Koch, 1844 (Figs. 1–7)

**Type Specimens.** The original description is based on male and female (unquantified) from Asia Minor and Egypt (Koch 1844). According to Feldman-Muhsam (1954), only a partly destroyed male and female remain in Koch's type collection in the NHMB. Moritz and Fischer (1981) reported that they were unable to locate the type specimens of *H. dromedarii* (three males and two females; ZMB 1076 and ZMB 1077). D.A.A. also could not find any type specimens of *H. dromedarii* in the NHMB, including those mentioned by Feldman-Muhsam. Apparently, they have now completely disintegrated or been lost.

### Synonyms

(Camicas et al. 1998 with corrections)

*Ixodes camelinus* Fischer von Waldheim, 1823  
*Ixodes arenicola* Eichwald, 1830  
*Ixodes trilineatus* Lucas, 1836  
*Ixodes cinctus* Lucas, 1840 *nec* Fabricius, 1805

*Hyalomma aegyptium* var *dromedarii* Koch, 1844 *sensu* Neumann, 1901 (*pro parte*)

*Hyalomma aegyptium dromedarii* Koch, 1844 *sensu* Neumann, 1911

*Hyalomma aegyptium margaropoides* Senevet, 1922

*Hyalomma dromedarii dromedarii* Koch, 1844 *sensu* Schulze and Schlottke, 1930

*Hyalomma dromedarii canariense* Schulze and Schlottke, 1930

*Hyalomma yakimovi* Olenov, 1931

*Hyalomma yakimovi persiacum* Olenov, 1931

*Hyalomma delpyi* Schulze and Gossel in Schulze, 1936

D.A.A. has studied the type specimen of *H. yakimovi* (male, lectotype, Middle Asia, Kushka, cow, 16 July 1930, V. Popov leg., 5056) deposited in the collection of ZIN RAS and confirmed its synonymy. Filippova and Panova (1996) designated a lectotype.

We discovered two males, two females, and one nymph identified as *H. delpyi* (one male, Varamine, Kamel; one male, one female, one nymph, Iran, Varamine, Rind; one female, Teheran, Kammel, Delpy leg.) in the collection of Schulze in the USNTC. Varamin (Iran) is a type locality for *H. delpyi* (Schulze 1936). It is possible that all these specimens originate from the original type series. Their synonymy has been confirmed by D.A.A.

Various descriptions and illustrations of the adults of *H. dromedarii* have been published, and we consider that the most useful of these are to be found in Pomerantzev (1950), Feldman-Muhsam (1954), Hoogstraal (1956), and Hoogstraal et al. (1981). The larva and nymph were described and illustrated by Delpy (1937a), Camicas (1970), and Apanaskevich (2002).

### Description

**Male.** *Conscutum* (Fig. 1A and B): length 3.70–5.78 ( $4.98 \pm 0.43$ ,  $n = 100$ ), width 2.47–4.03 ( $3.38 \pm 0.31$ ,  $n = 100$ ), ratio length:width 1.30–1.60 ( $1.48 \pm 0.05$ ,  $n = 100$ ); yellow- to red-brown in color; pale marbling absent; broadly oval in shape; widest near mid-length; slight narrowing in region of spiracular plates; cervical and lateral grooves very deep, up to one half to two thirds of length of conscutum; marginal grooves short, furrow-like, extending anteriorly for posterior one-fourths of conscutum; posteromedian groove reaches parma; paramedian grooves well defined; caudal field well defined, laterally demarcated by moderate ridges; large punctations sparse, mainly on caudal and lateral fields, small punctations vary in density—usually very sparse, mainly on caudal and lateral fields; parma generally present, narrow, subtriangular; four distinct festoons. *Genital structures* (Fig. 2A) as illustrated. *Anal shields* (Fig. 2B): three pairs; adanal plates long, lateral margin markedly convex, anteriomedian margin concave, median projection prominent, posteriomedian margin deeply concave, posterior margin rounded; subanal plates vary in shape and size, usually very large and transversally aligned. Sclerotized plaques present ventrally on median (as tiny sclerite) and paramedian festoons. *Spiracular plate* (Fig. 2C): dorsal prolonga-

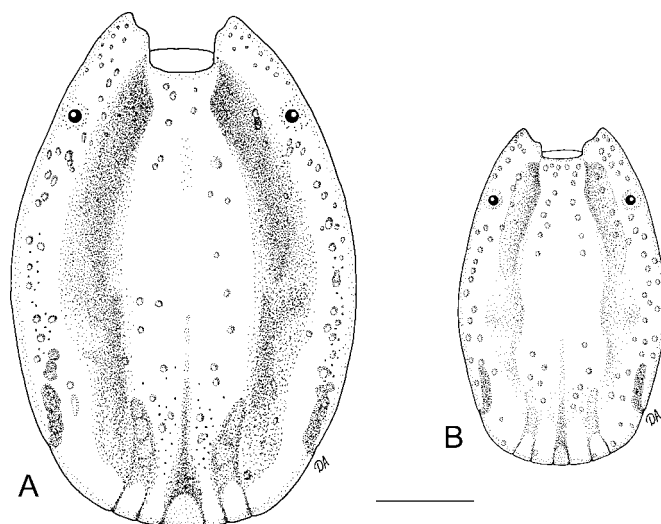


Fig. 1. *Hyalomma dromedarii*, male. (A and B) Conscutum showing variations. Scale bar = 1 mm. All setae are omitted.

tion long, narrow, and clearly distinct from body of plate; perforated portion of prolongation gently curved throughout its length. Circumspiracular setae sparse. *Basis capituli* (Fig. 2D and E) without lateral projections; dorsal posterior margin angular, deeply concave; cornua modest. Palpi (Fig. 2 F): segment I with more than five ventromedian setae. *Hypostome* (Fig. 2G): club-shaped; denticulate portion slightly longer than denticle-free portion (small scale-like projections posterior to last large denticle are not considered denticles). *Coxae* (Fig. 2H): posteromedian and posterolateral spurs of coxa I long, subequal in length or posterolateral spur longer than posteromedian spur, juxtaposed, tapering to apices; coxae II–IV each with distinct, broadly triangular posterolateral spur, with rounded apex; coxae II–IV each with modest, broadly arcuate, posteromedian spur. Coloration of legs similar to that of male (Fig. 3B).

**Female.** *Scutum* (Fig. 4): length 1.85–2.60 ( $2.29 \pm 0.17$ ,  $n = 100$ ), width 1.75–2.44 ( $2.20 \pm 0.14$ ,  $n = 100$ ), ratio length:width 0.97–1.13 ( $1.04 \pm 0.03$ ,  $n = 100$ ); yellow- to red-brown in color; pale marbling absent; nearly as broad as long; posterolateral angles distinct; cervical and lateral grooves deep, extending to posterior margin of scutum; large, deep punctations sparse, evenly distributed over scutum. *Genital structures* (Fig. 5A): genital aperture narrow, triangular in shape (V-shaped); vestibular portion of vagina strongly bulging; preatrial fold of genital aperture flat (Fig. 5B). *Spiracular plates* (Fig. 5C): perforated portion of dorsal projection slightly curved and relatively narrow. Circumspiracular setae sparse. *Basis capituli* (Fig. 5D and E): dorsally lateral projections broad and short, absent ventrally; dorsal posterior margin slightly concave; dorsal cornua inconspicuous. *Palpi* (Fig. 5

F): segment I with more than five ventromedian setae. *Hypostome* (Fig. 5G): club-shaped; denticulate portion slightly longer than denticle-free portion. *Coxae* (Fig. 5H): posteromedian and posterolateral spurs of coxa I long, subequal in length or posterolateral spur longer than posteromedian spur, tapering to apices, juxtaposed, posteromedian spur broad with blunt apex; coxae II–IV each with distinct, broadly triangular posterolateral spur, with rounded apex; coxae II–IV each with modest, broadly arcuate, posteromedian spur. Coloration of legs similar to that of male (Fig. 3B).

**Nymph.** *Scutum* (Fig. 6A): length 525–738 ( $635 \pm 47.26$ ,  $n = 70$ ), width 541–884 ( $679 \pm 68.48$ ,  $n = 69$ ), ratio length:width 0.83–1.05 ( $0.94 \pm 0.06$ ,  $n = 69$ ), distance between posterior margin of eyes and posterior margin of scutum 179–279 ( $222 \pm 18.88$ ,  $n = 70$ ), width:length of posterior portion of scutum 2.57–4.00 ( $3.06 \pm 0.27$ ,  $n = 69$ ); posterior margin of scutum broadly rounded; moderate posterolateral depressions on either side of scutal extremity. *Setae of alloscutum* (Fig. 6B): narrowing to rounded apex, without dentation. *Spiracular plates* (Fig. 6C): asymmetrically oval; dorsal prolongation distinct, short, broad, blunt at apex; submarginal row of perforations complete. *Basis capituli* (Fig. 6D and E): length 388–479 ( $446 \pm 18.74$ ,  $n = 50$ ); width 328–410 ( $363 \pm 17.73$ ,  $n = 68$ ), ratio length:width 1.05–1.40 ( $1.23 \pm 0.06$ ,  $n = 49$ ), subhexagonal dorsally. *Palpi* (segment II) (Fig. 6D and E): length 177–239 ( $211 \pm 11.77$ ,  $n = 70$ ), width 52–74 ( $65 \pm 5.37$ ,  $n = 70$ ), ratio length:width 2.82–4.11 ( $3.28 \pm 0.32$ ,  $n = 70$ ); palpal segment II proximally narrow, gradually expanding distally. *Hypostome* (Fig. 6E): length 171–244 ( $219 \pm 12.38$ ,  $n = 46$ ), width 56–84 ( $69 \pm 8.34$ ,  $n = 51$ ), ratio length:width 2.18–3.96 ( $3.26 \pm 0.45$ ,  $n = 46$ ); median file with six or seven large denticles; transition of denticulate portion to denticle-free portion abrupt; denticulate portion

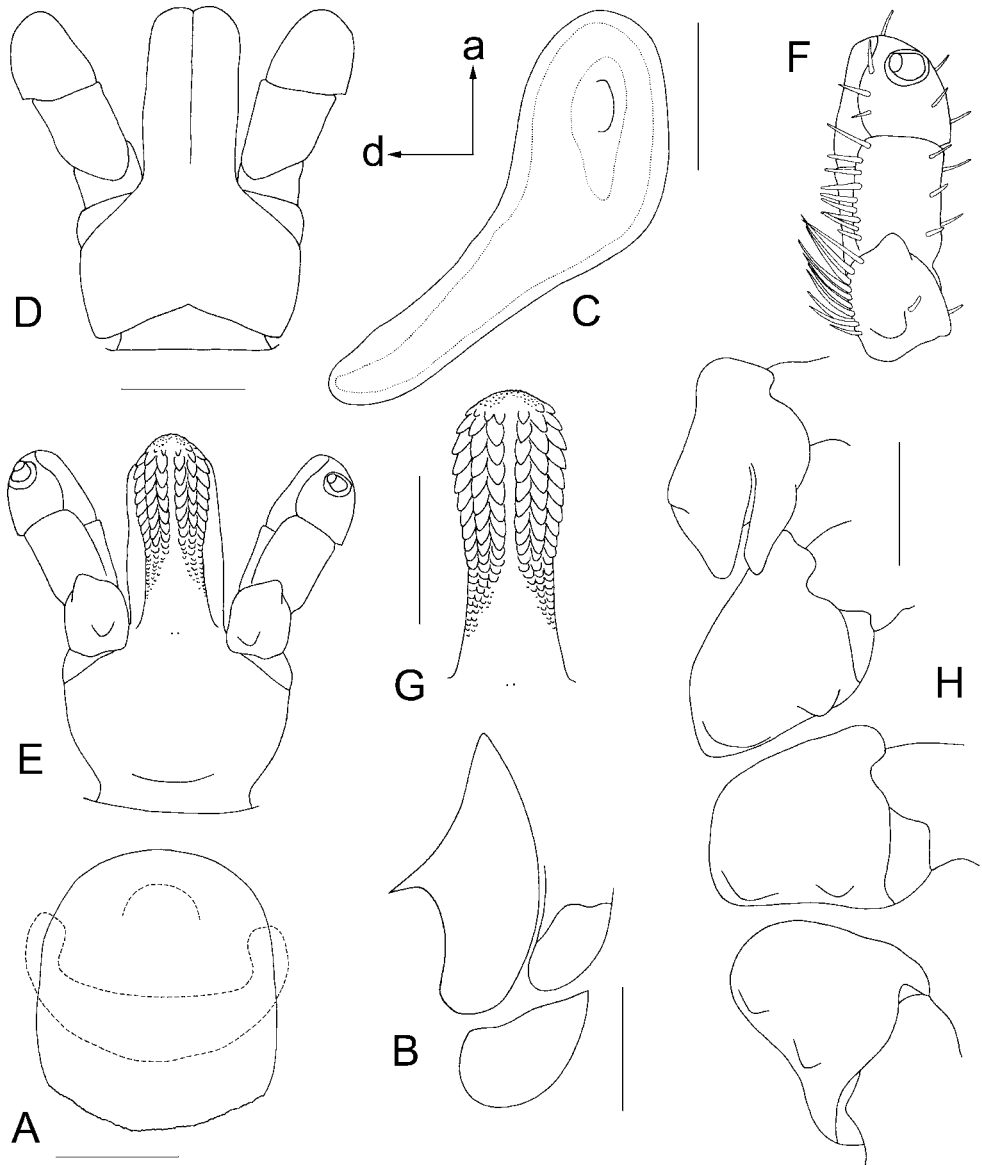


Fig. 2. *Hyalomma dromedarii*, male. (A) Genital structures. (B) Anal plates. (C) Spiracular plate (a, anterior; d, dorsal). (D) Gnathosoma dorsally. (E) Gnathosoma ventrally. (F) Palp ventrally. (G) Hypostome. (H) Coxae. Scale bars: A = 200  $\mu\text{m}$ ; B, D, E, and H = 500  $\mu\text{m}$ ; C, F, and G = 400  $\mu\text{m}$ . All setae are omitted except drawing F where only setae of palpal segment IV are omitted.

nearly as long as denticle-free portion. *Coxae* (Fig. 6 F): coxa I with long, narrow, subtriangular spurs nearly equal in length; coxae II–IV each with moderate lateral spur, spurs conspicuously decrease in size from coxae II to IV; coxal pore absent.

**Larva.** *Scutum* (Fig. 7A): length 220–270 ( $247 \pm 10.60$ ,  $n = 258$ ), width 344–450 ( $392 \pm 16.26$ ,  $n = 281$ ), ratio length:width 0.53–0.68 ( $0.63 \pm 0.02$ ,  $n = 258$ ), distance from posterior margin of eyes to posterior margin of scutum 40–70 ( $56 \pm 6.15$ ,  $n = 258$ ), ratio width:length of posterior portion 5.79–9.87 ( $7.06 \pm 0.70$ ,  $n = 258$ ). Portion of scutum posterior to eyes only

one fifth to one-fourth of scutal length; posterior margin of scutum broadly rounded; posterolateral depressions slight or indistinct. *Basis capituli* (Figs. 7B and C): width 146–188 ( $168 \pm 6.57$ ,  $n = 281$ ); subhexagonal dorsally; apex of dorsolateral projections directed laterally; dorsolateral projections distinct and acute from ventral aspect. *Palpi* (segments II and III) (Fig. 7B and C): length 102–129 ( $115 \pm 4.38$ ,  $n = 280$ ), width 36–53 ( $41 \pm 2.09$ ,  $n = 280$ ), ratio length:width 2.37–3.08 ( $2.78 \pm 0.12$ ,  $n = 280$ ). *Hypostome* (Fig. 7C): length 82–106 ( $94 \pm 4.59$ ,  $n = 256$ ), width 22–29 ( $25 \pm 1.38$ ,  $n = 270$ ), ratio length:width 3.15–4.45 ( $3.80 \pm$



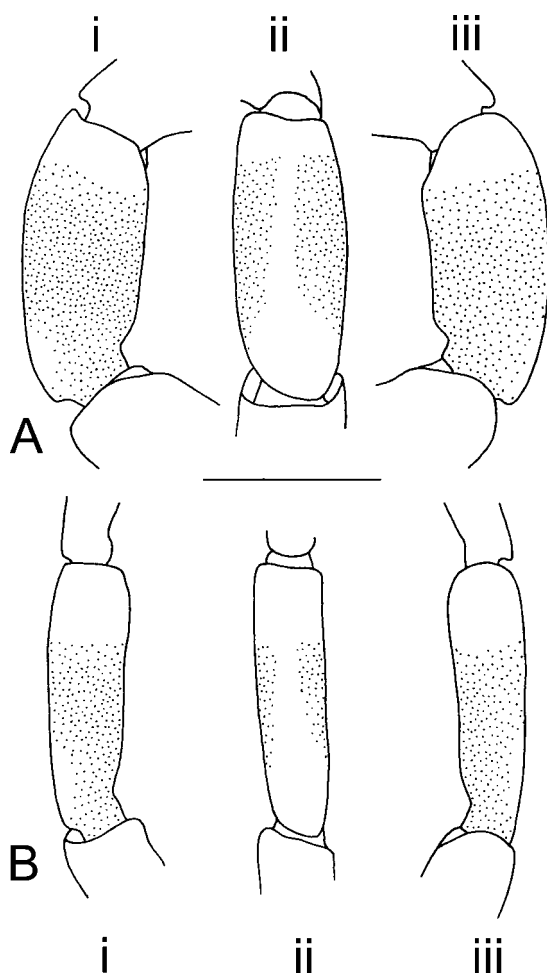


Fig. 3. *Hyalomma dromedarii*, genus IV. (A) Male (i, lateral view; ii, dorsal view; iii, medial view). (B) Female (i, lateral view; ii, dorsal view; iii, medial view). Scale bar = 1 mm. All setae are omitted.

0.24,  $n = 255$ ); median file with four or five large denticles; transition of denticulate portion to denticle-free portion abrupt; denticulate portion approximately one half of hypostome length. *Coxae* (Fig. 7D): coxa I with large, prominent triangular spur tapering at apex directed posteriorly or medially; coxae II and III each with moderate spur—broadly arcuate on coxae II and triangular on coxae III. *Genu I*: length 134–176 ( $157 \pm 7.21$ ,  $n = 276$ ), width 41–62 ( $48 \pm 2.71$ ,  $n = 153$ ), ratio length:width 2.86–3.75 ( $3.30 \pm 0.15$ ,  $n = 153$ ).

### Variability

The adults of most populations of *H. dromedarii* from Afghanistan, Pakistan, and India that have been examined are often extremely small (Fig. 1B). They are half or even less the normal size of *H. dromedarii*. Because of their small size, some diagnostic characters may not be evident. However, the characters that do

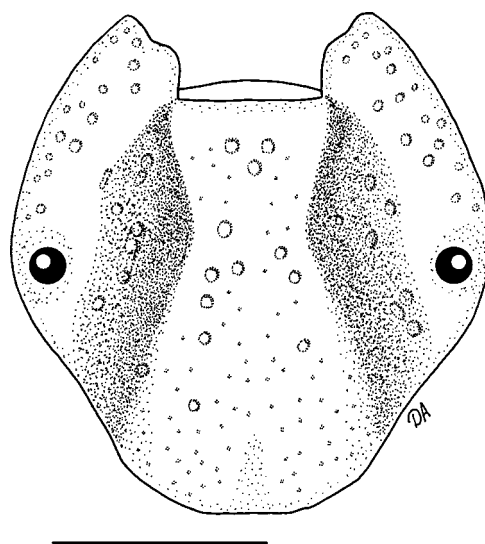


Fig. 4. *Hyalomma dromedarii*, female, scutum. Scale bar = 1 mm. All setae are omitted.

remain constant in these dwarf specimens are as follows: males—deep and long cervical grooves, postero-median groove reaches parma, adanal shields curved medially; females—narrow V-shaped genital operculum with flat preatrial fold.

Other variations of diagnostic characters on normal-sized ticks are as follows: punctations of male's conscutum—large punctations are always sparse, but the density of small or medium punctations can vary, from almost absent to relatively dense, especially on caudal field; adanal shields of male—the curvature can vary from distinct to slight, but in all cases curvature is obvious; subanal plates of male—extremely variable in size and shape from very large plates with rounded posterior margin, which are generally the case for normally developed males, to tiny triangular plates. Sometimes the plates appear to be divided in two. The size of the subanal plates is probably related to the total size of the specimen. Perforated portion of dorsal prolongation of spiracular plates of male: can sometimes be broader than usual. Coloration of legs: rarely the dorsal stripe on the leg segments is invisible either because of the size of an adult or because of the conditions of storage.

### Related Species

Males of *H. dromedarii* can be distinguished from those of other species of the *H. asiaticum* group by a combination of the following characters: broadly oval shape of conscutum; deep and long cervical grooves; short marginal grooves; posteromedian groove reaching parma; large punctations sparse; smaller punctations normally sparse or absent; distinct, narrow, sub-triangular parma; adanal shields distinctly curved medially; subanal shields usually large to very large; dorsal prolongation of spiracular plates long; perforated portion of spiracular plate usually relatively nar-

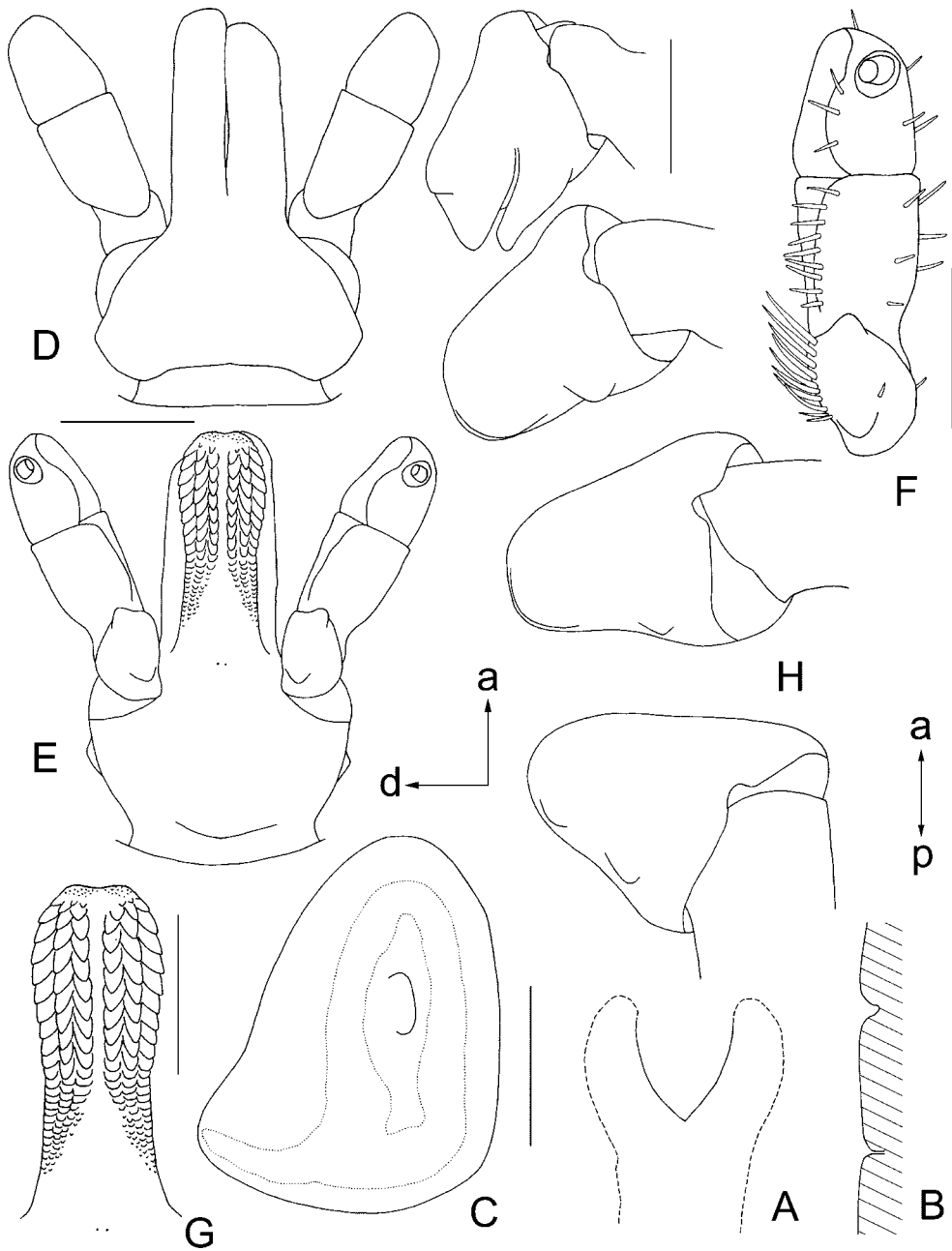


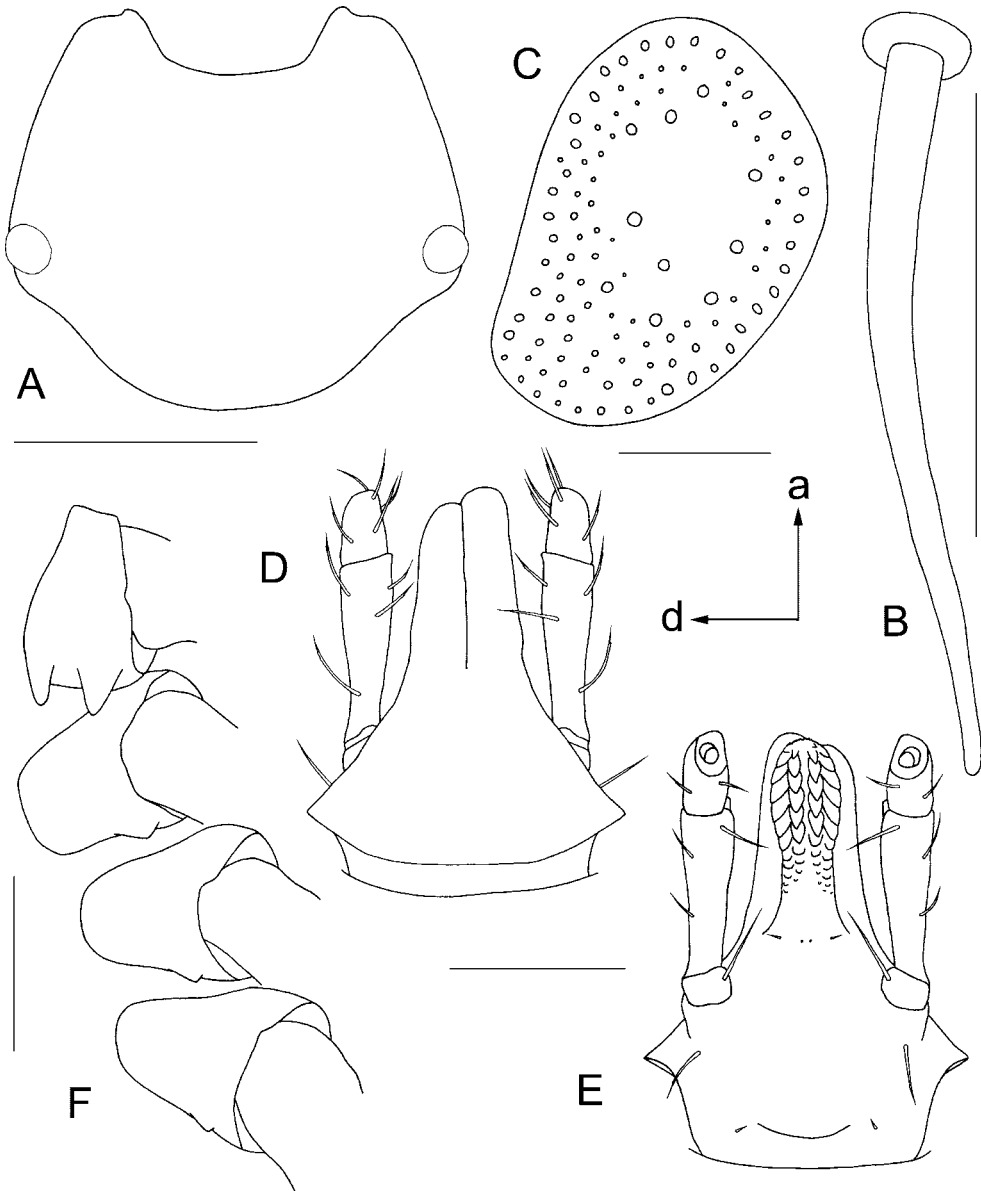
Fig. 5. *Hyalomma dromedarii*, female. (A) Genital structures. (B) Longitudinal section through preatrial fold of genital aperture schematically (a, anterior; p, posterior). (C) Spiracular plate (a, anterior; d, dorsal). (D) Gnathosoma dorsally. (E) Gnathosoma ventrally. (F) Palp ventrally. (G) Hypostome. (H) Coxae. Scale bars: A = 200  $\mu\text{m}$ ; C, F, and G = 400  $\mu\text{m}$ ; E, D, and H = 500  $\mu\text{m}$ . All setae are omitted except drawing F where only setae of palpal segment IV are omitted.

row; dorsal posterior border of basis capituli angular and deeply concave; dorsal ivory-colored strip on leg segments.

Females of *H. dromedarii* can be distinguished from those of other species of the *H. asiaticum* group by a combination of the following characters: deep cervical grooves; sparse large punctations; small punctations usually very sparse or absent; narrow V-shaped genital

operculum; vestibular part of vagina strongly bulging; preatrial fold of genital operculum flat or very slightly convex; posteromedian spur of coxa I broad and with blunt apex; dorsal ivory-colored strip on leg segments.

Because of insufficient data on the immature stages of *H. asiaticum*, *H. impeltatum*, and *H. erythraeum*, the following diagnosis is given only in relation to those of



**Fig. 6.** *Hyalomma dromedarii*, nymph. (A) Scutum. (B) Seta of alloscutum. (C) Spiracular plate (a, anterior; d, dorsal). (D) Gnathosoma dorsally. (E) Gnathosoma ventrally. (F) Coxae. A = 400  $\mu$ m; B and C = 50  $\mu$ m; D–F = 200  $\mu$ m. All setae are omitted except drawing E where only setae of palpal segment IV are omitted.

*H. schulzei*, which seems to be the most closely related species.

Nymphs of *H. dromedarii* can be distinguished from those of *H. schulzei* and possibly other species of the *H. asiaticum* group by a combination of the following characters: posterior margin of scutum broadly rounded with moderate posterolateral depressions on either side of its extremity; spiracular plates with relatively large, wide, blunt dorsal prolongation; submarginal row of perforations on spiracular plate complete; absence of coxal pore; measurements and their ratios (see description).

Larvae of *H. dromedarii* can be distinguished from those of *H. schulzei* by a combination of the following characters: portion of scutum posterior to eyes one-fifth to one-fourth of scutal length; apex of spur on coxae I directed posteriorly or medially; narrower palpi and hypostome; shorter legs.

#### Hosts

*Hyalomma dromedarii* can behave as a three-, two-, or one-host species (Hoogstraal 1956, Berdyev 1980).

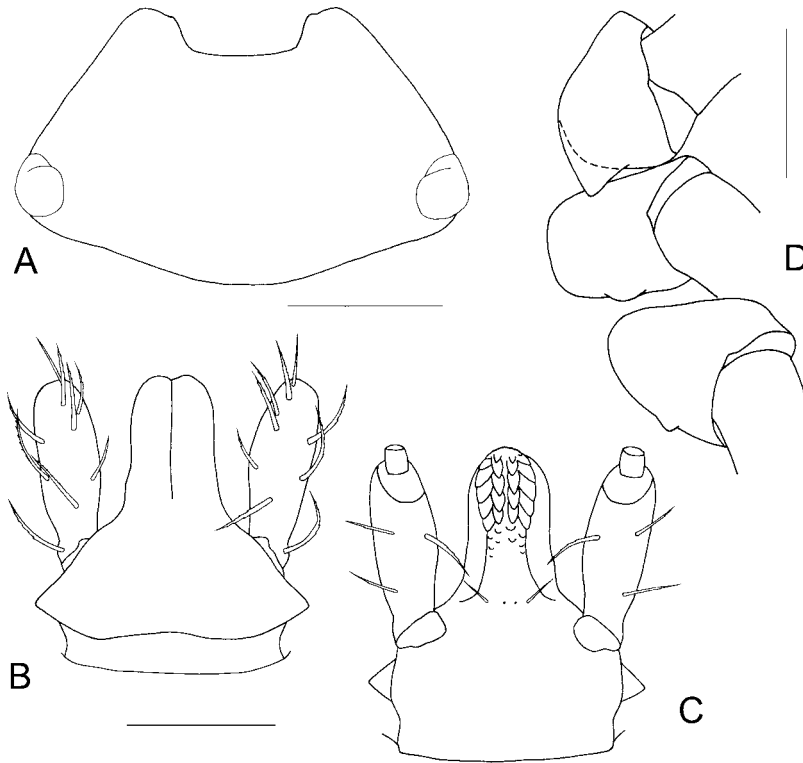


Fig. 7. *Hyalomma dromedarii*, larva. (A) Scutum. (B) Gnathosoma dorsally. (C) Gnathosoma ventrally. (D) Coxae. Scale bars: A = 150  $\mu$ m; B–D = 100  $\mu$ m. All setae are omitted except drawings B and C where only setae of palpal segment IV are omitted.

It is believed that the two-host life cycle is the most common for this species (Hoogstraal et al. 1981).

Camels are the principal hosts of the adults. Adults also parasitize other domestic ungulates, such as cattle, sheep, buffaloes, horses, donkeys, and goats (Pomerantzev 1950, Hoogstraal 1956, Hoogstraal et al. 1981, our data). In the USNTC collection, there are *H. dromedarii* adults collected from Arabian oryx, *Oryx leucoryx* (Pallas). There are also occasional records of adults from dogs, hyena, *Hyaena hyaena* (Linnaeus), ostrich, *Struthio camelus* Linnaeus, a lizard, and humans (Hoogstraal et al. 1981, our data).

*Hyalomma dromedarii* is the only species of the genus in which the immature stages can use both small and large mammals as hosts. Both nymphs and larvae can use the same species of large ungulates (especially camels) as the adults. However, the immature stages can also parasitize rodents, leporids, and hedgehogs, as well as birds and a reptile. These include lesser Egyptian gerbil, *Gerbillus gerbillus* (Olivier), greater Egyptian gerbil, *Gerbillus pyramidum* Geoffroy, Cheesman's gerbil, *Gerbillus cheesmani* Thomas, four-spotted gerbil, *Gerbillus quadrimaculatus* Lataste, Sundevall's jird, *Meriones crassus* Sundevall, Shaw's jird, *Meriones shawi* (Duvernoy), fat sand rat, *Psammomys obesus* Cretzschmar, lesser Egyptian jerboa, *Jaculus jaculus* (Linnaeus), house rat, *Rattus rattus* (Linnaeus), Cape hare, *Lepus capensis* Linnaeus, desert hedgehog, *Hemiechinus aethiopicus* (Ehren-

berg), long-eared hedgehog, *Hemiechinus auritus* (Gmelin), common quail, *Coturnix coturnix* L., Egyptian plover, *Pluvianus aegyptius* L., common kestrel, *Falco tinnunculus* L., and fringe-fingered lizard, *Acanthodactylus boskianus* (Daudin) (Hoogstraal 1956, Hoogstraal et al. 1964, our data). There is also a male *H. dromedarii* in the USNTC reared from a nymph collected from a red fox, *Vulpes vulpes* L.

### Geographic Distribution

*Hyalomma dromedarii* is widely distributed in North Africa, northern West, Central, and East Africa, Arabia, Asia Minor, the Middle East, Central and South Asia. Asia: Afghanistan, Azerbaijan (probably introduced), Bahrain, China, India, Iran, Iraq, Israel, Jordan, Kuwait, Kyrgyzstan, Lebanon, Oman, Pakistan, Palestinian territories, Qatar, Saudi Arabia, Syria, Tajikistan, Turkey, Turkmenistan, United Arab Emirates, Uzbekistan and Yemen. Africa: Algeria, Burkina Faso, Chad, Djibouti, Egypt, Eritrea, Ethiopia, Kenya, Libya, Mali, Mauritania, Morocco, Namibia (introduced), Niger, Nigeria, Senegal, Somalia, Spain (Canary Islands), Sudan, Tunisia, and Uganda (Pomerantzev 1950, Hoogstraal 1956, Theiler 1962, Hoogstraal et al. 1981, Kolonin 1983, Matthyse and Colbo 1987, Teng and Jiang 1991, our data).



## Disease Relationships

A number of viruses have been isolated from *H. dromedarii*, namely Crimean-Congo hemorrhagic fever virus, Kadam virus, Dera Ghazi Khan virus, and Dhori virus. *H. dromedarii* is also a vector of *Coxiella burnetii*, *Theileria camelensis*, and *Theileria annulata* (Hoogstraal et al. 1981).

### *Hyalomma (Euhyalomma) schulzei* Olenev, 1931 (Figs. 8–14)

**Type Specimens.** The original description is based on four males and one female from five localities in Iran (Olenev 1931). Lectotype: male, Eastern Khorasan, Seistan, 14 May 1898, N. Zarudnyi leg., 3096. Paralectotypes: male, Tehran, Keiserling leg., 3095; male, Northern Persia, Shahroud, 27 May 1914, A.N. Portenko leg., 3097; male, Eastern Persia, Bandun, Neibandun, 23 May 1896, Zarudnyi leg., 3098; female, Eastern Khorasan, village Makhunik, 1 May 1898, N. Zarudnyi leg., 3096a. Lectotype and paralectotypes designated by Filippova and Panova (1996). All type specimens are deposited in the collection of the ZIN RAS.

Descriptions and illustrations of the adults are available in a number of publications, and we consider that the most useful of these are to be found in Olenev (1931), Delpy (1937b), Pomerantzev (1950), Hoogstraal (1956), and Hoogstraal et al. (1981). The larva and nymph were described and illustrated by Apanaskevich (2002).

## Description

**Male. Conscutum** (Fig. 8): length 4.56–8.06 ( $6.23 \pm 0.77$ ,  $n = 100$ ), width 2.74–4.90 ( $3.76 \pm 0.49$ ,  $n = 100$ ), ratio length: width 1.41–1.85 ( $1.66 \pm 0.08$ ,  $n = 100$ ); yellow- or red-brown in color; pale marbling absent; broadly oval in shape; widest near mid-length; slight narrowing in region of spiracular plates; cervical and lateral grooves very deep, up to two-thirds length of conscutum; marginal grooves very short, furrow-like, extending anteriorly to posterior one-fifths of conscutum; posteromedian groove separated from parma or median festoon by smooth region; paramedian grooves slanted, well defined; caudal field poorly defined, laterally demarcated by slight ridges; large punctations on caudal and lateral fields sparse, small punctations moderately dense; transverse ridges usually present on caudal field; broad, rectangular parma commonly present; four distinct festoons; posteromedial angle of paraparmal festoons protrudes beyond conscutal margin. **Genital structures** (Fig. 9A) as illustrated. **Anal shields** (Fig. 9B): three pairs; adanal plates long, broad, lateral margin slightly convex, anteromedian margin concave, median projection prominent, posteromedian margin concave, posterior margin convex; subanal plates usually moderate in size, asymmetrically oval. Sclerotized plaques present (as tiny sclerite) or absent ventrally on median festoon and present on paramedian festoons. **Spiracular plate** (Fig.

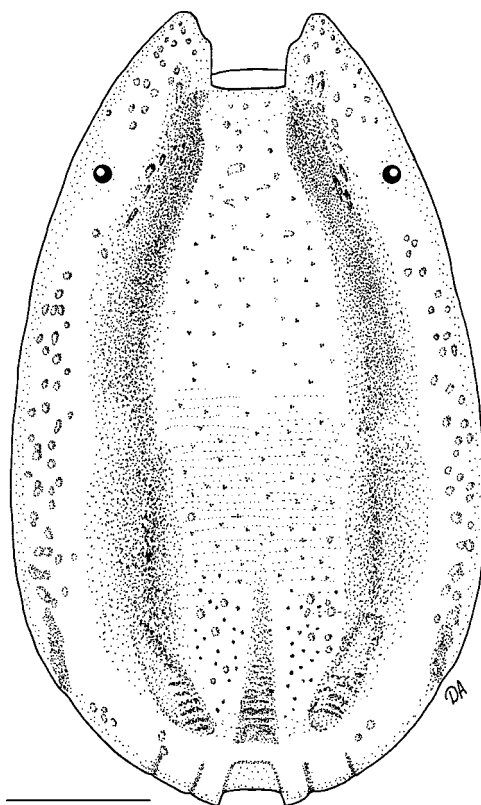


Fig. 8. *Hyalomma schulzei*, male, conscutum. Scale bar = 1 mm. All setae are omitted.

9C): dorsal prolongation short and not distinct from body of plate; perforated portion of prolongation straight, triangular. Circumspiracular setae sparse. **Basis capituli** (Fig. 9D and E): without lateral projections; dorsal posterior margin angular, deeply concave; cornua modest. **Palpi** (Fig. 9F): segment I with more than five ventromedian setae. **Hypostome** (Fig. 9G): club-shaped; denticulate portion slightly longer than denticle-free portion. **Coxae** (Fig. 9H): posteromedian and posterolateral spurs of coxa I long, subequal in length or posterolateral spur longer than posteromedian spur, juxtaposed, tapering to apices; coxae II–IV each with distinct, broadly arcuate posterolateral spur; coxae II and III each with moderate, very broadly arcuate, posteromedian spur; posteromedian spur on coxa IV distinct, triangular. Ivory-colored enamel band encircles distal portion of each segment of legs; complete or partially complete stripe present on dorsal aspect of leg segments (Fig. 10A).

**Female. Scutum** (Fig. 11): length 2.31–3.04 ( $2.74 \pm 0.15$ ,  $n = 87$ ), width 2.24–2.90 ( $2.57 \pm 0.12$ ,  $n = 87$ ), ratio length:width 0.93–1.19 ( $1.06 \pm 0.04$ ,  $n = 87$ ); yellow- or red-brown in color; pale marbling absent; slightly longer than broad; posterolateral angles prominent; cervical and lateral grooves very deep, extending to posterior margin of scutum; large and medium-sized, deep punctations sparse, evenly distributed over scutum. **Genital structures** (Fig. 12A):

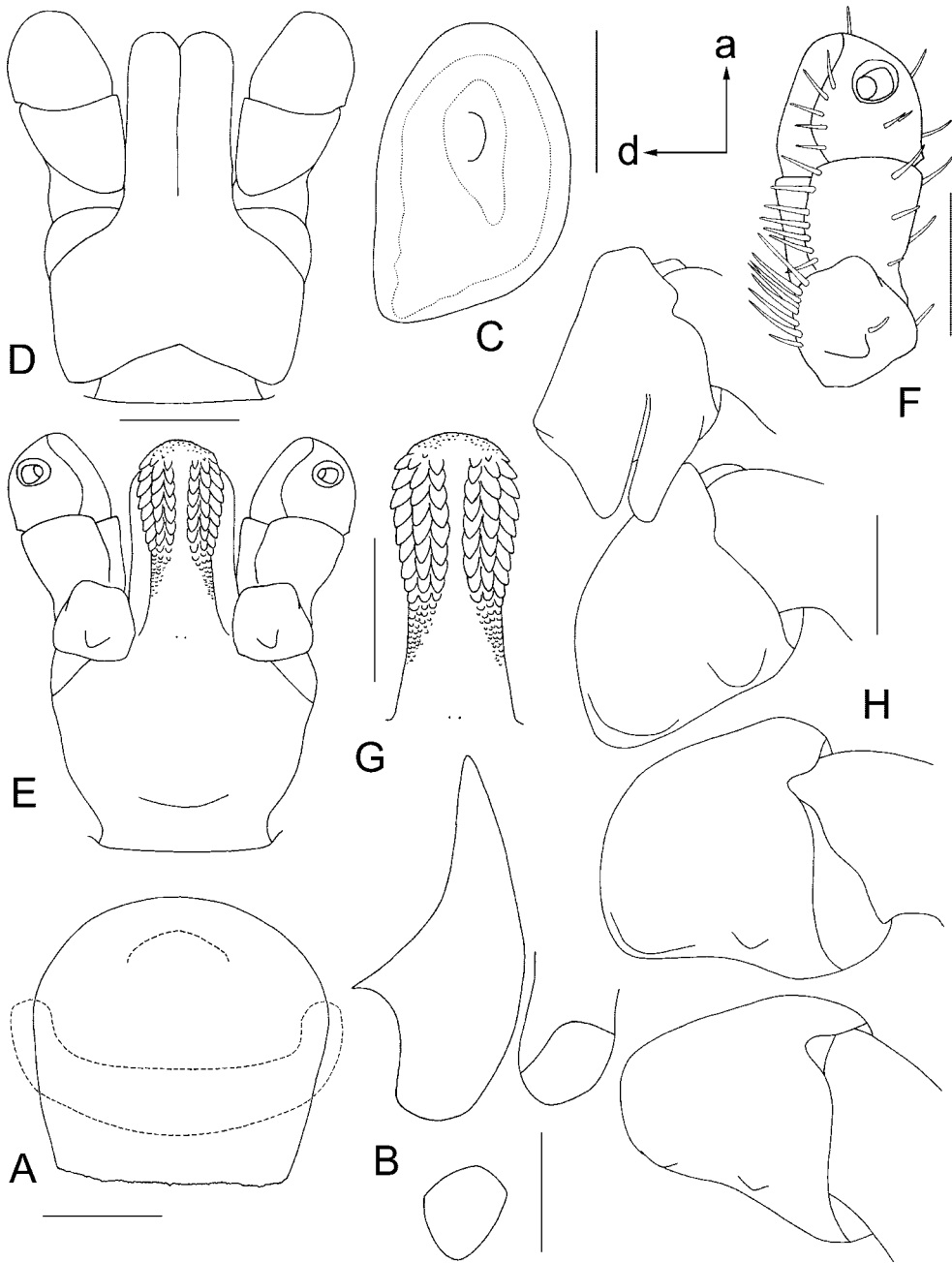


Fig. 9. *Hyalomma schulzei*, male. (A) Genital structures. (B) Anal plates. (C) Spiracular plate (a, anterior; d, dorsal). (D) Gnathosoma dorsally. (E) Gnathosoma ventrally. (F) Palp ventrally. (G) Hypostome. (H) Coxae. Scale bars: A = 200  $\mu$ m; B, D, E, and H = 500  $\mu$ m; C, F, and G = 400  $\mu$ m. All setae are omitted except drawing F where only setae of palpal segment IV are omitted.

genital aperture very broad, deep, broadly U-shaped with flat base; vestibular portion of vagina moderately bulging; preatrial fold of genital aperture flat or slightly convex (Fig. 12B). *Spiracular plates* (Fig. 12C): perforated portion of dorsal projection short, slightly curved and broad. Circumspiracular setae sparse. *Basis capituli* (Fig. 12D and E): dorsally

lateral projections short, absent ventrally; dorsal posterior margin straight or slightly concave; dorsal cornua inconspicuous. *Palpi* (Fig. 12F): segment I with more than five ventromedian setae. *Hypostome* (Fig. 12G): club-shaped; denticulate portion slightly longer than denticle-free portion. *Coxae* (Fig. 12H): posteromedian and posterolateral spurs

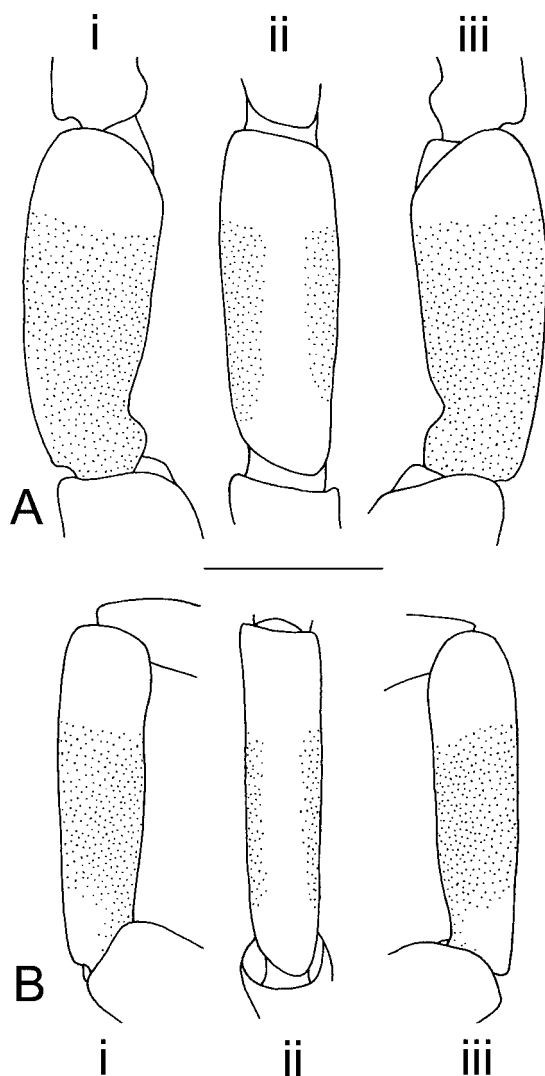


Fig. 10. *Hyalomma schulzei*, genu IV. (A) Male (i, lateral view; ii, dorsal view; iii, medial view). (B) Female (i, lateral view; ii, dorsal view; iii, medial view). Scale bar = 1 mm. All setae are omitted.

of coxa I long, subequal in length or posterolateral spur longer than posteromedian spur, tapering to apices, juxtaposed, posteromedian spur broad with blunt apex; coxae II–IV each with distinct, broadly triangular posterolateral spur, with rounded apex; coxae II–IV each with moderate, broadly arcuate, posteromedian spur. Coloration of legs similar to that of male (Fig. 10B).

**Nymph. Scutum** (Fig. 13A): length 525–687 ( $638 \pm 54.48$ ,  $n = 8$ ), width 600–662 ( $631 \pm 19.66$ ,  $n = 8$ ), ratio length:width 0.82–1.09 ( $1.01 \pm 0.08$ ,  $n = 8$ ), distance between posterior margin of eyes and posterior margin of scutum 150–238 ( $215 \pm 28.88$ ,  $n = 8$ ), width:length of posterior portion of scutum 2.60–4.25 ( $3.00 \pm 0.54$ ,  $n = 8$ ); posterior margin of scutum rounded; slight posterolateral depressions

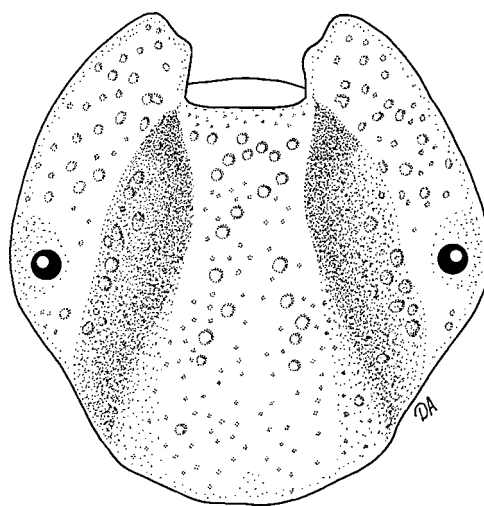


Fig. 11. *Hyalomma schulzei*, female, scutum. Scale bar = 1 mm. All setae are omitted.

on either side of scutal extremity. *Setae of alloscutum* (Fig. 13B): narrowing to rounded apex. *Spiracular plates* (Fig. 13C): egg-shaped; dorsal prolongation indistinct, short, blunt at apex; submarginal row of perforations incomplete. *Basis capituli* (Fig. 13D and E): length 396–456 ( $431 \pm 20.43$ ,  $n = 8$ ); width 350–399 ( $380 \pm 17.72$ ,  $n = 8$ ), ratio length:width 1.03–1.20 ( $1.13 \pm 0.05$ ,  $n = 8$ ); subhexagonal dorsally. *Palpi* (segment II) (Fig. 13D and E): length 165–208 ( $190 \pm 15.54$ ,  $n = 8$ ), width 60–74 ( $65 \pm 4.40$ ,  $n = 8$ ), ratio length:width 2.42–3.30 ( $2.94 \pm 0.33$ ,  $n = 8$ ); palpal segment II proximally narrow, gradually expanding distally. *Hypostome* (Fig. 13E): length 200–246 ( $221 \pm 13.09$ ,  $n = 8$ ), width 52–74 ( $67 \pm 7.30$ ,  $n = 8$ ), ratio length:width 2.92–3.85 ( $3.32 \pm 0.34$ ,  $n = 8$ ); median file with six or seven large denticles; transition of denticulate portion to denticle-free portion abrupt; denticulate portion nearly as long as denticle-free portion. *Coxae* (Fig. 13F): coxa I with long, narrow, subtriangular spurs nearly equal in length; coxae II–IV each with moderate lateral spur, spurs conspicuously decrease in size from coxae II to IV; coxal pore absent.

**Larva. Scutum** (Fig. 14A): length 232–268 ( $254 \pm 7.10$ ,  $n = 35$ ), width 396–439 ( $416 \pm 13.77$ ,  $n = 35$ ), ratio length:width 0.58–0.64 ( $0.61 \pm 0.01$ ,  $n = 35$ ), distance from posterior margin of eyes to posterior margin of scutum 46–58 ( $52 \pm 3.81$ ,  $n = 35$ ), width: length ratio of posterior portion 6.90–9.50 ( $8.11 \pm 0.68$ ,  $n = 35$ ). Portion of scutum posterior to eyes only one-fifths of scutal length; posterior margin of scutum broadly rounded; posterolateral depressions indistinct or absent. *Basis capituli* (Figs. 14B and C): width 148–178 ( $167 \pm 5.99$ ,  $n = 35$ ); subhexagonal dorsally; apex of dorsolateral projections directed laterally; dorsolateral projections distinct and acute from ventral aspect. *Palpi* (segments II and III) (Fig. 14B and C): length 108–126 ( $118 \pm 3.61$ ,  $n = 35$ ),

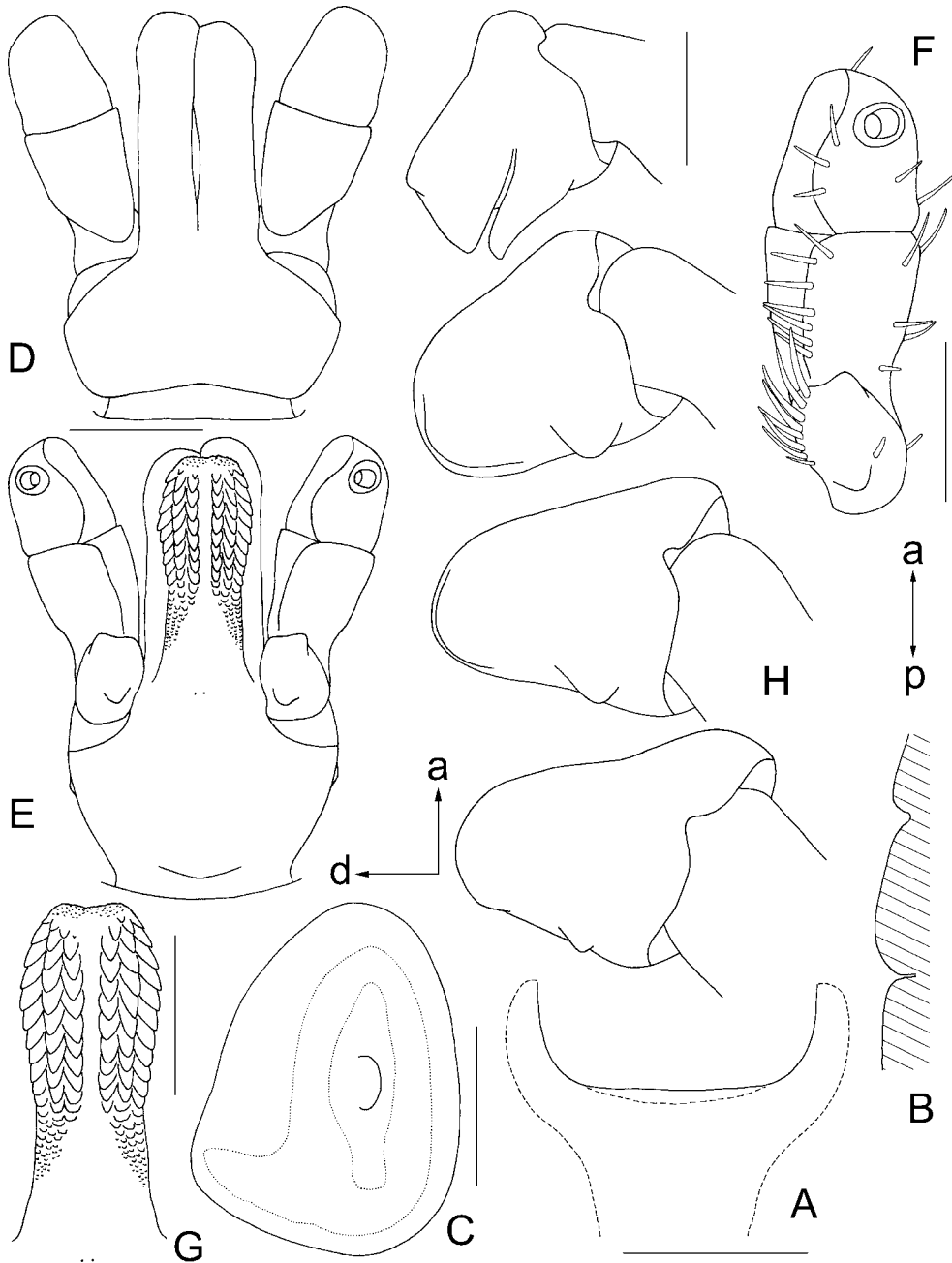


Fig. 12. *Hyalomma schulzei*, female. (A) Genital structures. (B) Longitudinal section through preatrial fold of genital aperture schematically (a, anterior; p, posterior). (C) Spiracular plate (a, anterior; d, dorsal). (D) Gnathosoma dorsally. (E) Gnathosoma ventrally. (F) Palp ventrally. (G) Hypostome. (H) Coxae. Scale bars: A = 200  $\mu\text{m}$ ; C, F, and G = 400  $\mu\text{m}$ ; E, D, and H = 500  $\mu\text{m}$ . All setae are omitted except drawing F where only setae of palpal segment IV are omitted.

width 43–48 ( $45 \pm 1.25$ ,  $n = 35$ ), ratio length:width 2.45–2.75 ( $2.60 \pm 0.06$ ,  $n = 35$ ). *Hypostome* (Fig. 14C): length 82–101 ( $93 \pm 3.42$ ,  $n = 35$ ), width 28–31 ( $29 \pm 1.02$ ,  $n = 35$ ), ratio length:width 2.82–3.40 ( $3.22 \pm 0.13$ ,  $n = 35$ ); median file with five large denticles; transition of denticulate portion to denticle-free portion abrupt; denticulate portion approxi-

mately one half of hypostome length. *Coxae* (Fig. 14D): coxa I with large, subtriangular spur tapering at apex, directed laterally; coxae II and III each with moderate spur—arcuate on coxae II and triangular on coxae III. *Genu I*: length 144–182 ( $169 \pm 7.26$ ,  $n = 35$ ), width 45–50 ( $48 \pm 1.85$ ,  $n = 13$ ), ratio length:width 3.20–3.75 ( $3.51 \pm 0.16$ ,  $n = 13$ ).

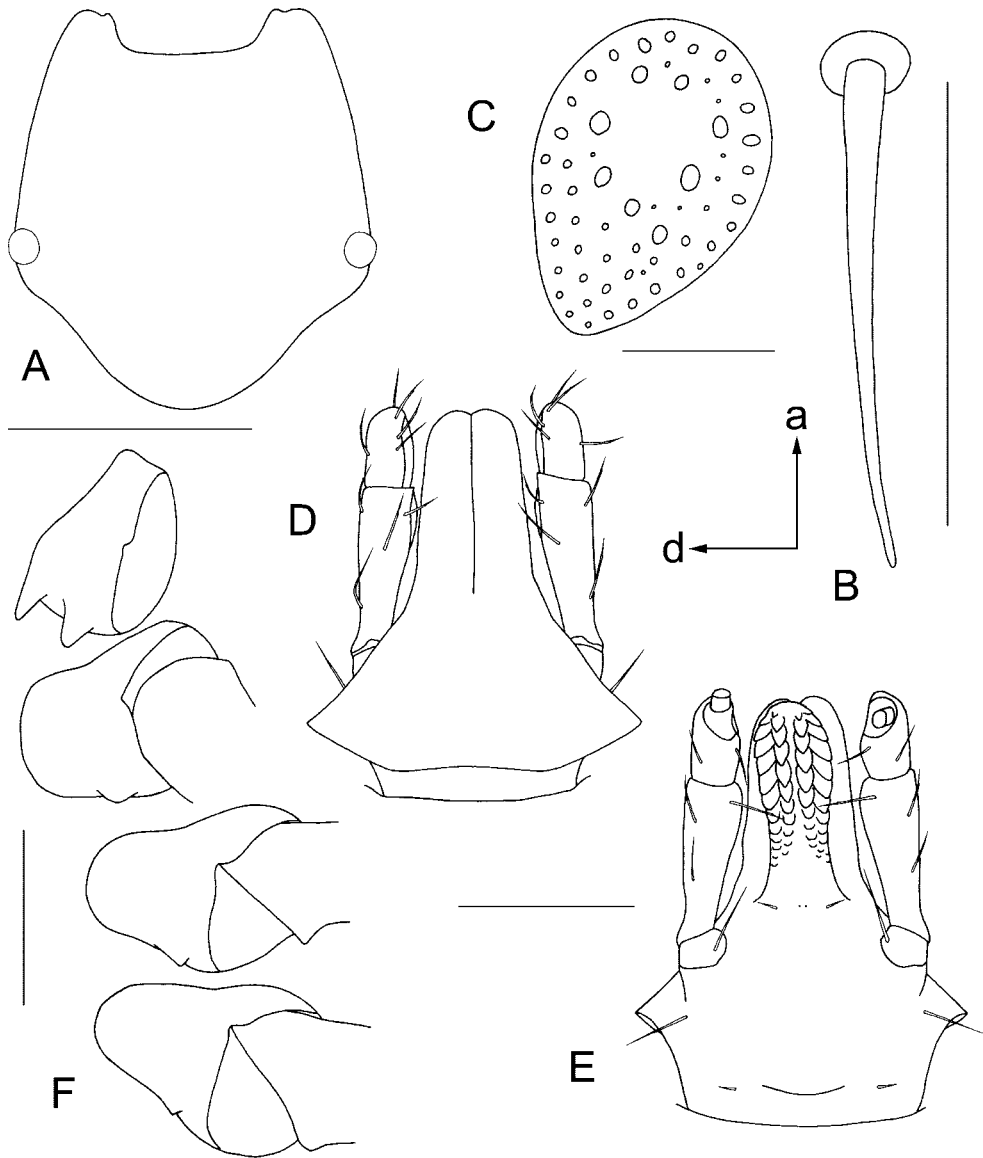


Fig. 13. *Hyalomma schulzei*, nymph. (A) Scutum. (B) Seta of alloscutum. (C) Spiracular plate (a, anterior; d, dorsal). (D) Gnathosoma dorsally. (E) Gnathosoma ventrally. (F) Coxae. Scale bars: A = 400  $\mu$ m; B and C = 50  $\mu$ m; D–F = 200  $\mu$ m. All setae are omitted except drawing E where only setae of palpal segment IV are omitted.

### Related Species

Males of *H. schulzei* can easily be distinguished from those of other species of the *H. asiaticum* group and other species of the genus *Hyalomma* by the very short dorsal prolongation of their spiracular plates. The other discriminating characters are very deep and long cervical grooves; very short marginal grooves; posteromedian groove does not reach the parma; sparse large punctations; small punctations moderately dense on central, caudal and lateral fields; transverse ridges on caudal field; wide and rectangular parma; paramedian festoons protruding beyond the posterior conscutal margin; posterome-

dian margin of adanal plates slightly concave; subanal shields moderate in size; dorsal aspect of basis capituli angular and deeply concave; dorsal ivory-colored strip on leg segments.

Females of *H. schulzei* can be distinguished from those of other species of the *H. asiaticum* group by a very wide, deep, U-shaped genital aperture; vestibular part of vagina moderately bulging; preatrial fold of genital aperture slightly convex. Additional characters are deep cervical grooves; sparse large and small punctations on scutum; posteromedian spur of coxa I broad with blunt apex, dorsal ivory-colored strip on leg segments.



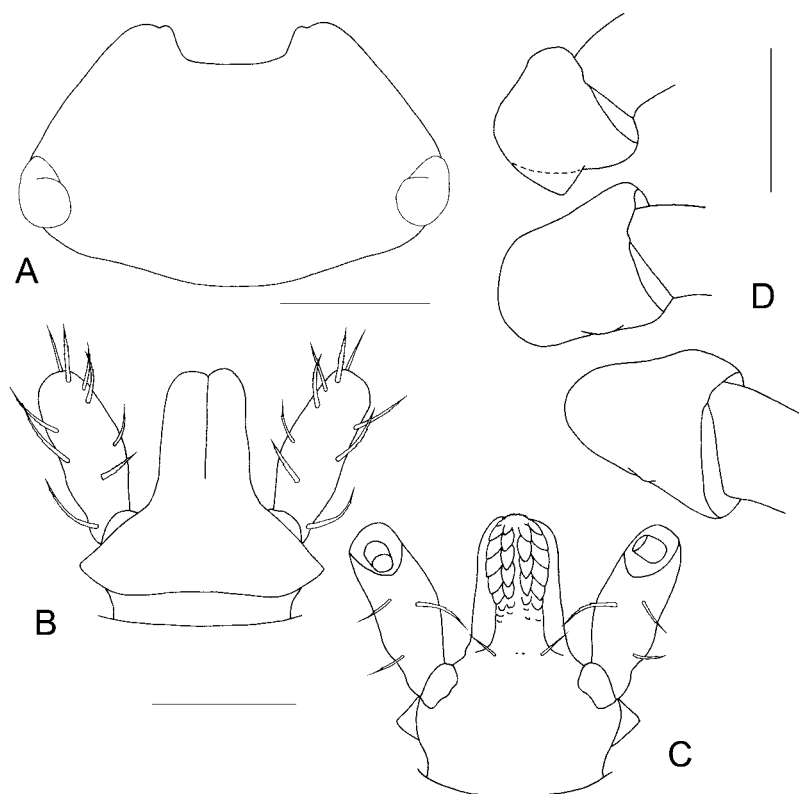


Fig. 14. *Hyalomma schulzei*, larva. (A) Scutum. (B) Gnathosoma dorsally. (C) Gnathosoma ventrally. (D) Coxae. Scale bars: A = 150  $\mu$ m; B-D = 100  $\mu$ m. All setae are omitted except drawings B and C where only setae of palpal segment IV are omitted.

Because of insufficient data on the immature stages of *H. asiaticum*, *H. impeltatum*, and *H. erythraeum*, the following diagnosis is given only in relation to those of *H. dromedarii*, which seems to be the most closely related species.

Nymphs of *H. schulzei* can be distinguished from those of *H. dromedarii* by a combination of the following characters: posterior margin of scutum more narrowly rounded with moderately distinct posterolateral depressions on either side of its extremity; spiracular plates with relatively short, narrowly blunt dorsal prolongation; submarginal row of perforations on spiracular plate incomplete; measurements and their ratios (see description).

Larvae of *H. schulzei* can be distinguished from those of *H. dromedarii* by a combination of the following characters: portion of scutum posterior to eyes only one fifth of scutal length; apex of spur on coxae I directed laterally; broader palpi and hypostome, longer legs.

#### Hosts

*Hyalomma schulzei* is a two-host species (Al-Asgah 1992).

The principal hosts for the adults are camels. Single records of adults are known from cattle and goats

(Pomerantzev 1950, Hoogstraal 1956, Hoogstraal et al. 1981, our data).

The nymphs of *H. schulzei* have been recorded from Cape hare, *L. capensis*, fat sand rat, *P. obesus*, Sundevall's jird, *M. crassus* and desert hedgehog, *H. aethiopicus* (Hoogstraal 1956, our data). Hoogstraal et al. (1981) listed burrowing rodents, hares, and hedgehogs as hosts of the immature stages of *H. schulzei*.

#### Geographic Distribution

*Hyalomma schulzei* is a fairly uncommon tick throughout most of its geographic range. The only locality where it has been found in very large numbers is southeastern Iran (Abbassian-Lintzen 1961).

Asia: Afghanistan, Iran, Iraq, Israel, Jordan, Kuwait, Pakistan, Saudi Arabia, Syria, and Turkmenistan. Africa: Egypt (Hoogstraal 1956, Kerbabaev 1960, Hoogstraal et al. 1981, Kolonin 1983, our data).

#### Disease Relationships

The relationships between *H. schulzei* and disease-causing agents have not been investigated.

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