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Redescription of Adults and First Description of the Larva of Haemaphysalis (Rhipistoma) adleri Feldman-Muhsam, 1951 (Acari: Ixodidae), Parasite of Carnivorans in Western Asia

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Redescription of Adults and First Description of the Larva of *Haemaphysalis* (*Rhipistoma*) *adleri* Feldman-Muhsam, 1951 (Acari: Ixodidae), Parasite of Carnivorans in Western Asia

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ABSTRACT

The adult ticks of *Haemaphysalis* (*Rhipistoma*) *adleri* Feldman-Muhsam, 1951 (Acari: Ixodidae) are redescribed and the larva of this species is described for the first time here. The adults of *H. adleri* that we studied were collected from various canid, felid and hyaenid carnivorans (Carnivora: Canidae, Felidae, Hyaenidae) as well as a hedgehog (Erinaceomorpha: Erinaceidae) in Iraq, Israel and West Bank. The males, females and larvae of *H. adleri* can be differentiated from *Haemaphysalis* (*Rhipistoma*) species occurring in the Palearctic portion of West Asia and Egypt as well those in the *H. asiatica* subgroup by the length of idiosomal setae, development and size of spurs on palpi, dental formula on the hypostome and spur size on coxae. A lectotype of *H. adleri* has been designated and the geographic distribution and host of this tick species are discussed.

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INTRODUCTION

TICKS

Ticks are blood-sucking arachnids from the subclass Acari and the order Ixodida (Durden & Beati, 2014). They are temporary, obligate ectoparasites meaning that their life-cycle is dependent on the presence and exploitation of a suitable host. They have three main body regions which are the capitulum (gnathosoma) that includes the mouthparts (chelicerae and hypostome) as well as sensory palpi, the body (idiosoma) that contains all of the internal organs, and the legs that facilitate movement and contain sensory organs (Haller's organ) (Sonenshine & Roe, 2014). The order Ixodida is subdivided into three families: Ixodidae, Argasidae, and Nuttalliellidae (Sonenshine & Roe, 2014). The families can be differentiated from one another by a number of morphological characteristics. The most prominent differences being the fact that ticks in the Ixodidae family are known as hard ticks because they have a sclerotized scutum

(shield) on their dorsal surface, the Argasidae ticks are known as soft ticks because they do not have a scutum, and finally the Nuttalliellidae ticks that share several characteristics of both Argasidae ticks and Ixodidae ticks, but can be differentiated from them due to things like their ball and socket leg joints which are unique to the family (Sonenshine & Roe, 2014).

Hard ticks exhibit hemimetabolous development with four distinct life stages: egg, larva, nymph, adult; progressing in that order (Sonenshine & Roe, 2014). During their development, hard ticks will exhibit one of three types of life cycles. These are known as the one-host, two-host, or three-host life cycles. The one-host life cycle suggests that development from larva to adult occurs on a singular host without the larva or nymph dropping off the host; the two-host life cycle means that the larvae stay and molt into nymphs on one host before leaving that host and molting to become adults that attack their own hosts. The most common life cycle is the three-host cycle, which describes larvae that feed on a host, drop off, then molt to a nymph. The nymphs then find another host to feed on and after that, they once again drop off the host and molt to the adults. Finally, the adults attack their host and feed on it. In all life cycles each stage feeds only once for about a week, engorged females drop off their hosts, lay eggs and die (Apanaskevich & Oliver, 2014).

Ticks exhibit varying degrees of host-seeking behavior with different strategies to do so. These strategies can be divided into two main groups of behavior. One being nidicolous ticks (it is common for them to live in things like burrows and nests and wait for their desired host) and the other being non-nidicolous ticks (“questing” ticks that actively search for their desired host) (Apanaskevich & Oliver, 2014). They can also have

varying degrees of host specificity. Most of the ticks that exhibit host specificity, feed only on a specific group of vertebrates, while those that do not exhibit host specificity are opportunistic parasites and feed on several different hosts indiscriminately (Sonenshine & Roe, 2014). Hard ticks feed on terrestrial vertebrates such as mammals, birds, reptiles and even amphibians (Sonenshine & Roe, 2014).

Ticks can be found nearly all across the world and they are avid transmitters of disease. Because of this, ticks are the most prominent arthropod in terms of the transmission of a large spectrum of pathogens causing various infectious diseases in vertebrate hosts (Sonenshine & Roe, 2014). They are also responsible for a substantial amount of money lost worldwide (estimated to be in the billions of dollars each year) due to things like treatment and vaccinations for the various diseases that they cause (Sonenshine & Roe, 2014).

THE GENUS *HAEMAPHYSALIS* KOCH

The content of this paper focuses on one of the tick species from the genus *Haemaphysalis* Koch, 1844 (Acari: Ixodidae) that occurs in West Asia (Palearctic Zoogeographic Region).

Haemaphysalis has more than 170 species and is second in the number of described species of ixodid ticks (Guglielmone et al., 2020). Species of *Haemaphysalis* are three-host life cycle ticks that primarily parasitise mammals and birds (Guglielmone et al., 2014).

There are a total of 11 species of *Haemaphysalis* recorded in the Palearctic part of Western Asia and Egypt: *H*. (*Allophysalis*) *pospelovashtromae* Hoogstraal, 1966, *H*.

(*Allophyslais*) *kopetdaghica* Hoogstraal, 1965, *H*. (*Aboimisalis*) *punctata* Canestrini & Fanzago, 1878, *H*. (*Herpetobia*) *sulcata* Canestrini & Fanzago, 1877, *H*. (*Haemaphysalis*) *concinna* Koch, 1844, *H*. (*Segalia*) *parva* (Neumann, 1897), *H*. (*Rhipistoma*) *caucasica* Olenev, 1928, *H*. (*Rhipistoma*) *erinacei* Pavesi, 1844, *H*. (*Rhipistoma*) *leachi* (Audouin, 1826), *H*. (*Rhipistoma*) *indica* Warburton, 1910 and *H*. (*Rhipistoma*) *adleri* Feldman-Muhsam, 1951 (Camicas et al., 1998; Guglielmone et al., 2023). A former species of *Haemaphysalis*, *Alloceraea inermis* (Birula, 1895) is also found in this region (Filippova, 1997).

The subgenus *Rhipistoma* Koch, 1844 is composed of 43 species from the Afrotropical, Palearctic and Oriental zoogeographic regions; these species parasitize carnivorans, rodents, hyraxes, hares, hedgehogs and other smaller mammals (Hoogstraal & Kim, 1985; Camicas et al., 1998; Guglielmone et al., 2014, 2020; Apanaskevich & Goodman, 2020; Apanaskevich & Tomlinson, 2020; Apanaskevich, 2023).

The five valid species of *Rhipistoma* recorded from the Palearctic part of Western Asia and Egypt are classified among five groups of species. *Haemaphysalis indica* belongs to the *H. canestrinii* group of species. All species within this group, including *H. indica*, are Oriental ticks (Camicas et al., 1998). Records of this species in Iran could be based on erroneous identifications (Guglielmone et al., 2023) hence its presence in the discussed region is doubtful. *Haemaphysalis leachi* is a species from the *H. leachi* group. All species of this group, including *H. leachi*, are Afrotropical, i.e. distributed in sub-Saharan Africa. *Haemaphysalis leachi* is the only species that has limited distribution in the Palearctic region in Egypt (Apanaskevich et al., 2007; Guglielmone et al., 2023). *Haemaphysalis erinacei* is a sole representative of the *H. erinacei* group. This species is

broadly distributed in Southern Europe, North Africa, Western and Central Asia (Filippova, 1997; Guglielmone et al., 2023). Finally, *H. adleri* and *H. caucasica* belong to the same *H. asiatica* group, but are within different subgroups; *H. adleri* is within the *H. asiatica* subgroup whereas *H. caucasica* is in the *H. caucasica* subgroup (Camicas et al., 1998). Two species of the *H. caucasica* subgroup are Palearctic in their distribution, with *H. caucasica* being primarily found in the Caucasus region, Iran and some parts of Central Asia (Filippova, 1997; Guglielmone et al., 2023). The *H. asiatica* subgroup consists of 7 species that are widely separated geographically. Four of these species, *H. eupleres* Hoogstraal, Kohls & Trapido, 1965, *H. fossae* Hoogstraal, 1953, *H. galidiae* Apanaskevich & Goodman, 2020 and *H. obtusa* Dönitz, 1910, occur exclusively in Madagascar; two species, *H. asiatica* (Supino, 1897) and *H. dentipalpis* Warburton & Nuttall, 1909, are exclusively Oriental; and one species, *H. adleri* occurs in the Palearctic region (Camicas et al., 1998; Apanaskevich, 2023; Guglielmone et al., 2023).

GOAL

The proper identification of ticks is crucial for understanding their systematics, ecology, distribution, host-parasite association and pathogen transmission. *Haemaphysalis adleri* is a tick species that is still poorly defined morphologically, which prevents the correct identification of it. Only males and females of this species have been previously described and illustrated from four males and one female collected from jackals (Carnivora: Canidae) in the Central Region of Israel (Feldman-Muhsam, 1951). The larval and nymph stages remained unknown although supposed nymphs of this species were collected (Theodor & Costa, 1967). Essentially the only available

description of adults is that in the original paper. In that work the descriptions lack important morphological details and the illustrations are schematic. Both of these make identification of this species based on adults challenging. Besides this work, there are only a few references where geographical records and hosts of this species are mentioned (Hubbard, 1955; Hoogstraal & Kaiser, 1958; Feldman-Muhsam & Saturen, 1961; Theodor & Costa, 1967; Hoogstraal & Kim, 1985; Keysary et al., 2011; Shubber et al., 2014; Ereqat et al., 2016). Because each stage of a tick's life cycle (larva, nymph and adult) can contribute to the maintenance and spread of pathogens and diseases, the detailed redescription and proper illustrations of adults of *H. adleri* as well as the first description of the immature stages would allow for the correct identification of *H. adleri* at these stages and can then be used by medical entomologists and parasitologists in their studies.

Here, we redescribe the male and female of *H. adleri* in greater detail and describe its larval stage for the first time. Data on geographic distribution and hosts of this tick species are also analyzed and discussed.

MATERIALS AND METHODS

Field-collected and laboratory-reared ticks were available for study. Specimens deposited in the United States National Tick Collection (USNTC) (James H. Oliver, Jr. Institute for Coastal Plain Science, Georgia Southern University, Statesboro, Georgia, USA) were examined. Specimens that are stored in the Israel Arachnid National History Collection (IANHC) (the Hebrew University of Jerusalem, Israel) were examined by

Dmitry Apanaskevich. For comparative purposes, specimens of other *Haemaphysalis* species that are discussed in the discussion section were examined in the USNTC.

Adult ticks and larvae were examined using a stereoscopic microscope (Olympus SZX16, Olympus Corporation, Tokyo, Japan), a compound microscope (Olympus BX53, Olympus Corporation, Tokyo, Japan) and a scanning electron microscope (JEOL JSM6610LV, JEOL Ltd., Tokyo, Japan). Some morphological structures were illustrated using a digital camera and drawing tube attachments to the microscope. Larvae were mounted on slides in Hoyer's Medium and larvae viewed and pictured under the scanning electron microscope were dried and coated with gold. Measurements of adults are in millimeters whereas those of larvae are in micrometers. Measurements are given as the range followed by the mean ± standard deviation and the number of specimens measured (n) in parentheses.

RESULTS

Family Ixodidae Murray, 1877

Genus *Haemaphysalis* Koch, 1844

Subgenus *Rhipistoma* Koch, 1844

Haemaphysalis adleri Feldman-Muhsam, 1951

Type-host: *Canis aureus* Linnaeus (Carnivora: Canidae).

Other hosts: *Canis lupus* Linnaeus (Carnivora: Canidae), *Felis catus* Linnaeus, *Felis chaus* Schreber, *Felis silvestris* Schreber (Carnivora: Felidae), *Hyaena hyaena* (Linnaeus) (Carnivora: Hyaenidae), “hedgehog” (Erinaceomorpha: Erinaceidae).

Type-locality: Israel: Central District: Ness-Ziona.

Other localities: Iraq: Baghdad Governorate: Baghdad; Saladin Governorate: Samarra, Tharthar. Israel: Central District: Petah Tikva; Haifa District: Yagur; Jerusalem District: Jerusalem; Northern District: ‘En Harod, Har Ziv’on, Mishmar Ha’Emeq; Southern District: Negev, Shoval. West Bank: Jenin Governorate: Jenin.

Type-material: Lectotype: 1 female, from *C. aureus*, Ness-Ziona (~31°56'N, 34°48'E), Central District, Israel, 22.xii.1950, I. Saturen. Paralectotypes: 1 male, with the same collection data as for the lectotype; 2 males, from the same host and locality, 21.xi.1950, I. Saturen. Lectotype is designated here based on the original label (“Type”). All type specimens are in the IANHC and were examined by us.

Other Material: Sixty-seven males, thirty-seven females and 157 larvae examined. Iraq: Baghdad Governorate: Baghdad (~33°18'N, 44°21'E): 2 males and 1 female, from *F. chaus*, 24.i.1954, USNMENT 01784348; Saladin Governorate: Samarra (~34°11'N, 43°52'E): 1 male, from *H. hyaena*, 7.iii.1966, J. Robson, USNMENT 01784351; Tharthar (~33°58'N, 43°10'E): 5 males and 4 females, from *F. chaus*, 6.xii.1994, USNMENT 01784349 (2 males and 2 females); same locality: 5 males and 3 females, from *F. chaus*, 20.xi.1994, USNMENT 01784355 (2 males and 2 females); Israel: Central District: Petah Tikva (~32°5'N, 34°53'E): 1 male, from hedgehog, 11.v.1955, IANHC; Haifa District: Yagur (~32°44'N, 35°4'E): 1 male and 2 females, from domestic cat, 2.i.1968, M. Costa (MC), USNMENT 01784350; same locality: 1 female and 157 larvae, larvae reared in

laboratory from female collected on domestic cat, 28.i.1968, MC, USNMENT 01784352; Jerusalem District: Jerusalem (~31°46'N, 35°13'E): 10 males and 8 females, from *C. aureus*, 7.xii.1966, IANHC; same locality: 4 males and 1 female, from domestic cat, 15.xii.2020, USNMENT 01784354; Northern District: ‘En Harod (~32°32' N, 35°22'E): 11 males and 1 female, from *C. aureus*, IANHC; same locality: 15 males and 2 females, from *F. chaus*, 10.ii.1970, IANHC; Har Ziv’on (~32°1' N, 35°22'E): 1 male and 2 females, from domestic cat, 6.viii.2008, USNMENT 01784353; Mishmar Ha’Emeq (~32°36'N, 35°8'E): 4 males and 12 females, from *F. chaus*, 9.ii.1957, IANHC; Southern District: Shoval (~31°24'N, 34°44'E): 2 males, from *C. lupus*, xii.1971, IANHC; West Bank: Jenin Governorate: Jenin (~32°27'N, 35°17'E): 4 males, from *C. aureus*, 11.ii.1956, IANHC. All specimens with the USNMENT numbers are deposited in the USNTC; those labeled with IANHC are at IANHC.

Etymology: The species is named after Russia-borne British-Israeli parasitologist Saul Adler (1895-1966).

REDESCRIPTION OF MALE

Male [Based on 70 specimens; Figs. 1, 2.] Conscutum (Fig. 1A–C) length from scapular apices to posterior margin 2.13–2.33 (2.20 ± 0.07; n = 13), width 1.05–1.17 (1.13 ± 0.03; n = 13), ratio 1.84–2.07 (1.95 ± 0.08; n = 13), narrowly suboval, widest posterior to mid-length, color yellowish brown; scapulae short, blunt; cervical grooves faint, very shallow; lateral grooves deep, extending from anterior 1/4 of conscutal length to first festoon, enclosing first festoon; eleven distinct festoons; punctations distinct, dense, uniform in distribution, moderately large and deep, slightly sloping punctations

bearing setae and smaller and shallower punctations; setae numerous, long (*c.*0.10) and clearly distinct (Fig. 1A–C). Genital apron medial to coxae II, with numerous moderately long denticles on posterior margin (Fig. 2A); postgenital sclerite (Fig. 1D) broad, nearly as broad as long, subtriangular with slightly concave anterior margin. Spiracular plates (Fig. 2B) length 0.21–0.30 (0.24 ± 0.02; n = 13), width 0.21–0.26 (0.24 ± 0.01; n = 13), ratio 0.83–1.19 (0.99 ± 0.10; n = 13); ratio length of spiracular plate to length of festoon I 1.24–1.75 (1.38 ± 0.14; n = 13), angularly suboval, with short broad dorsal prolongation.

Gnathosoma (Fig. 2C–E) length from palpal apices to cornual apices dorsally 0.44–0.50 (0.47 ± 0.02; n = 13), width of gnathosoma between lateral projection of palpal segments II dorsally 0.65–0.70 (0.67 ± 0.02; n = 13), ratio 0.67–0.74 (0.70 ± 0.02; n =13). Dorsal basis capituli (Fig. 2C) length 0.22–0.26 (0.24 ± 0.01; n = 13), width 0.30–0.34 (0.31 ± 0.01; n = 13), ratio width to length 1.21–1.38 (1.31 ± 0.05; n = 13); subrectangular with slightly converging lateral margins, posterior margin convex; cornua very long, with narrowly rounded apex, directed posteriorly or slightly posteromedially, ratio total length of basis capituli, including cornua, to cornual length 2.46–3.11 (2.77 ± 0.16; n = 13). Ventral basis capituli (Fig. 2D) subrectangular. Palpi (Fig. 2C–E) short, length dorsally (segments II–III) 0.27–0.30 (0.28 ± 0.01; n = 13), width 0.29–0.34 (0.32 ± 0.01; n = 13), ratio 0.83–0.99 (0.90 ± 0.05; n = 13); broadly salient, ratio combined palpal breadth to basis capituli breadth 2.00–2.23 (2.15 ± 0.07; n = 13); segment I indistinct; dorsomedial margin of segment II gradually widening anteriorly at its mid-length; two closely spaced posterodorsal spurs of segment II directed slightly posteromedially, with narrowly rounded apex; internal spur short, external spur long, external spur nearly twice as long as internal spur; ventrally posterolateral margin of segment II nearly straight;

posteroventral spur of segment II long, with narrowly rounded apex, directed slightly posteromedially; segment III dorsally subtriangular; long ventral spur of segment III nearly twice as long as broad, with narrowly rounded apex. Hypostome (Fig. 2D) short, broadly rounded at apex; dental formula 4/4 throughout hypostomal length, with approximately 7 to 8 denticles in file.

Legs moderately long, slender. Coxae (Fig. 2F): coxa I with moderately long spur, with broadly rounded apex, directed posteriorly; coxae II–IV each with relatively long and moderately broad spur, with narrowly to broadly rounded apex, spur on coxae II and III directed slightly posterolaterally, spur on coxa IV directed slightly posteriorly. Trochanter I (Fig. 2G) with long dorsal spur, with pointed apex; trochanters I–IV (Fig. 2F) without spurs ventrally.

REDESCRIPTION OF FEMALE

Female [Based on 38 specimens; Figs. 3, 4.] Idiosoma (Fig. 3A) of unengorged specimen narrowly suboval, widest approximately at mid-length. Scutum (Fig. 3A–D) length 1.17–1.30 (1.24 ± 0.04; n = 10), width 0.85–0.97 (0.90 ± 0.03; n = 10), ratio 1.32–1.46 (1.38 ± 0.04; n = 10); narrowly suboval, diverging in anterior 1/4 and gradually converging to broadly rounded and slightly angular posterior margin; cervical grooves distinct, narrow and relatively shallow, extending to posterior third of scutal length; punctations distinct, dense, uniform in distribution, moderately large and deep, slightly sloping punctations bearing setae and smaller and shallower punctations; setae (Fig. 3A–D) numerous, long (*c.*0.10), distributed as figured. Setae of alloscutum (Fig. 3A, D) numerous, evenly distributed, shorter than scutal setae (length of setae in center of

alloscutum *c*.0.04). Genital aperture (Fig. 4A) medial to coxae II, broadly U-shaped with broadly rounded posterior margin, lateral margins straightly convergent, genital sclerites indistinct. Spiracular plates (Fig. 4B) length 0.24–0.31 (0.28 ± 0.02; n = 10), width 0.27–0.33 (0.30 ± 0.02; n = 10), ratio 0.86–1.00 (0.93 ± 0.04; n = 10), subcircular, with very short broad dorsal prolongation.

Gnathosoma (Fig. 4C–E) length from palpal apices to cornual apices dorsally 0.55–0.63 (0.59 ± 0.03; n = 10), width of gnathosoma between lateral projection of palpal segments II dorsally 0.78–0.87 (0.81 ± 0.03; n = 10), ratio 0.69–0.76 (0.73 ± 0.03; n = 10). Dorsal basis capituli (Fig. 4C) length 0.21–0.26 (0.24 ± 0.01; n = 10), width 0.43–0.48 (0.46 ± 0.02; n = 10), ratio width to length 1.79–2.16 (1.94 ± 0.12; n = 10); subrectangular, with slightly converging lateral margins; posterior margin slightly sinuous; cornua moderately long, with broadly rounded apex, ratio total length of basis capituli, including cornua, to cornual length 5.60–8.67 (6.97 ± 0.89; n = 10); porose areas suboval, with no clear circumscribed borders, poorly indented, greatest dimension slightly inclined posterolaterally, separated by distance nearly 1.5 times their width. Ventral basis capituli (Fig. 4D) subrectangular. Palpi (Fig. 4C–E) short, length dorsally (segments II–III) 0.37–0.40 (0.38 ± 0.01; n = 10), width 0.37–0.43 (0.39 ± 0.02; n = 10), ratio 0.94–1.00 (0.98 ± 0.02; n = 10); broadly salient, ratio combined palpal breadth to basis capituli breadth 1.71–1.88 (1.76 ± 0.05; n = 10); segment I indistinct; dorsomedial margin of segment II gradually widening anteriorly at its mid-length; two closely spaced posterodorsal spurs of segment II; internal spur, short, directed posteriorly or slightly posteromedially, with narrowly rounded apex; external spur moderately long, directed slightly posteromedially, with broadly rounded apex; external spur nearly twice as long as

internal spur; posteroventral spur of segment II poorly distinct, very short, with broadly rounded apex, directed slightly posteromedially; segment III dorsally subtriangular; long ventral spur of segment III nearly twice as long as broad, with narrowly rounded apex. Hypostome (Fig. 4D) short, broadly rounded at apex; dental formula 4/4 throughout hypostomal length, with approximately 10 denticles in file.

Legs moderately long, slender. Coxae (Fig. 4F): coxa I with moderately long spur, with broadly rounded apex, directed slightly posterolaterally; coxae II–IV each with relatively long and moderately broad spur, with narrowly to broadly rounded apex, directed posteriorly. Trochanter I (Fig. 4G) with long dorsal spur, with narrowly rounded to pointed apex; trochanters I–IV (Fig. 4F) without spurs ventrally.

LARVA DESCRIPTION

Larva [Based on 157 specimens; Fig. 5] Idiosoma: length 490–540 (513 ± 13; n = 12), width 430–450 (437 ± 8; n = 12), ratio 1.13–1.21 (1.17 ± 0.02; n = 12); broadly suboval, widest near mid-length. Scutum (Fig. 5A): length from scapular apices to posterior margin 215–225 (221 ± 3; n = 12), maximal width 285–305 (296 ± 7; n = 12), ratio 0.72–0.78 (0.75 ± 0.02; n = 12); pentagonal, posterior margin broadly rounded, posterolateral marginal depressions very slight; cervical grooves as faint, shallow depressions. Setae 3 pairs, Sc_2 24–30 (27 ± 2; n = 12), Sc_3 21–26 (24 ± 2; n = 12). Dorsal setae of alloscutum 10 pairs; 2 pairs of central dorsals, Cd_1 22–28 (25 ± 2; n = 12), Cd_2 19–25 (22 ± 2; n = 12); 8 pairs of marginal dorsals, Md_1 27–30 (29 ± 1; n = 12), Md_8 21–25 (23 ± 1; n = 12). Ventral setae 13 pairs plus 1 pair on anal valves; 3 pairs of sternals, St_1 39–45 (43 ± 2; n = 12); 2 pairs of preanals, Pa_1 22–27 (25 ± 2; n = 12), Pa_2

22–27 (25 ± 1; n = 12); 4 pairs of premarginals, Pm_1 31–36 (33 ± 2; n = 12); 4 pairs of marginal ventrals, Mv_1 27–34 (30 ± 2; n = 12), Mv_4 25–32 (29 ± 2; n = 12).

Gnathosoma (Fig. 5B–D): length from palpal apices to posterior margin of basis capituli dorsally 120–128 (124 ± 2; n = 12), width of gnathosoma between lateral projection of palpal segments II dorsally 201–209 (204 ± 2; n = 12), ratio 0.59–0.62 (0.61 ± 0.01; n = 12). Basis capituli dorsally subrectangular; cornua indistinct; ventrally rectangular; small triangular auriculae ventrally; 1 pair of posthypostomal setae. Palpi (Fig. 5B–D): short, length 104–113 (109 ± 2; n = 12), width 70–78 (73 ± 2; n = 12), ratio 1.38–1.57 (1.49 ± 0.06; n = 12); broadly salient, ratio combined palpal width to basis capituli width 1.59–1.71 (1.64 ± 0.04; n = 12); segment I indistinct; suture between palpal segments II and III indistinct; lateral margin of palpal segments II and III nearly straight; posterodorsal spur on palpal segment II indistinct as very slight broadly rounded convexity; posteroventral spur on palpal segment II very small, triangular, often indiscernible; palpal segment III sharply pointed at anterior apex; posteroventral spur of palpal segment III very small, fold-like, poorly discernible; segment I without setae, segments II and III combined with 8 dorsal and 4 ventral setae. Hypostome (Fig. 5C): length from apex to level of posthypostomal setae 63–73 (67 ± 3; n = 12), width 30–33 (31 ± 1; n = 12), ratio 2.00–2.42 (2.15 ± 0.12; n = 12); blunt at apex; dental formula 2/2; denticles in files of 5 or 6; denticulated portion distinctly longer than half of hypostomal length.

Coxae (Fig. 5E): spur of coxa I moderate, triangular; spur of coxa II broad, fold-like, spur on coxa III indistinct. Genu I length 105–113 (108 ± 2; n = 12). Tarsus I length 158–173 (167 ± 4; n = 12); tarsus III length 144–153 (148 ± 2; n = 12).

DISCUSSION

The original description of *H. adleri* was based on 4 males and 1 female but the current whereabouts of the 4th male is unknown.

Based on several characteristics, males and females of *H. adleri* differ distinctly from all other *Haemaphysalis* species occurring in the same geographic region or those within the *H. asiatica* subgroup. the same area. Below we chose only to detail the most significant and distinct characteristics.

By having two posterodorsal spurs on palpal segment II in adults, *H. adleri* is closest to *H. asiatica* and *H. dentipalpis* from Southeast Asia and to *H. eupleres* from Madagascar (Uilenberg et al., 1979; Apanaskevich, 2023).

The male and female of *H. adleri* can readily be distinguished from those of *H. asiatica* and *H. dentipalpis* by considerably longer setae on conscutum and scutum: *c*.0.10 mm (*vs* very short setae in those species: *c*.0.02 mm) and 4/4 dental formula on hypostome (*vs* 6/6–8/8 in those species). The male and female of *H. adleri* can be distinguished from those of *H. eupleres* by the considerably longer setae on conscutum and scutum: *c*.0.10 mm (*vs* very short setae: *c*.0.01–0.02 mm in *H. eupleres*), lacking of posteromedial spur on palpal segment III dorsally (*vs* distinct posteromedial spur in *H. eupleres*) and longer posteroventral spur on palpal segment III (*vs* distinctly shorter spur in *H. eupleres*).

The male and female of *H. adleri* can easily be distinguished from those of *Rhipistoma* species occurring in the Palearctic portion of Western Asia and Egypt, such as *H. caucasica*, *H. erinacei*, *H. indica* and *H. leachi* (Hoogstraal, 1970; Filippova, 1997;

Apanaskevich et al., 2007) by the distinctly longer setae on conscutum and scutum: *c*.0.10 mm (*vs* considerably shorter setae: *c*.0.01–0.03 mm in those species) and presence of two posterodorsal spurs on palpal segment II (*vs* only one spur in those species).

The larva of *H. adleri* can be distinguished from those of *H. indica* and *H. leachi* by very short posteroventral spur on palpal segment II (*vs* very long spur in those species). The larva of *H. adleri* can be distinguished from that of *H. caucasica* by poorly distinct, broadly arcuate, ridge-like spurs on coxae II and III (*vs* distinct triangular spurs in *H. caucasica*). The larva of *H. adleri* can be distinguished from those of *H. erinacei* by shorter idiosomal setae: mean length of Md_1 29 (27–30) μm, mean length of Md_8 23 (21–25) μm, mean length of Mv_1 30 (27–34) μm, mean length of Mv_4 29 (25–32) μm (*vs* longer setae in *H. erinacei*: mean length of Md_1 38 (32–41) μm, mean length of Md_8 37 (31–42) μm, mean length of Mv_1 37 (31–42) μm, mean length of Mv_4 40 (36–44) μm) and shorter tarsi: mean length of tarsus I 169 (166–173) μm, mean length of tarsus III 147 (143–150) μm (*vs* longer tarsi in *H. erinacei*: mean length of tarsus I 201 (190–208) μm, mean length of tarsus III 179 (173–188 μm).

Collection data for *H. adleri* are listed in the material above. Based on studied material this species is distributed in Iraq (Baghdad and Saladin Governorates), Israel (Central, Jerusalem, Haifa, Northern and Southern Districts) and West Bank (Jenin Governorate) (Fig. 6). *Haemaphysalis adleri* was recorded from the same countries before (Feldman-Muhsam, 1951; Hubbard, 1955; Hoogstraal & Kaiser, 1958; Feldman-Muhsam & Saturen, 1961; Theodor & Costa, 1967; Keysary et al., 2011; Shubber et al., 2014; Ereqat et al., 2016). This species has also been recorded from Lebanon (Byblos District) and we consider this record possible (Morel, 2003).

Hoogstraal and Kim (1985) listed Oman as one of the countries where *H. adleri* is found, but those authors did not provide any factual data on specimens from Oman and we provisionally exclude this country from the distributional range of *H. adleri*. The majority of the studied adults of this species were collected from various carnivorans, such as the golden jackal, *C. aureus*, wolf, *C. lupus* (Carnivora: Canidae), domestic cat, *F. catus*, jungle cat, *F. chaus*, wildcat, *F. silvestris* (Carnivora: Felidae) and striped hyena, *H. hyaena* (Carnivora: Hyaenidae). A single male was collected from an unidentified hedgehog (Erinaceomorpha: Erinaceidae). Besides the above listed carnivoran hosts, adults of *H. adleri* were also found on the domestic dog, red fox, *Vulpes vulpes* (Linnaeus) (Carnivora: Canidae) and beech marten, *Martes foina* (Erxleben) (Carnivora: Mustelidae) (Theodor & Costa, 1967; Ereqat et al., 2016). Moreover, singular adult ticks were found on a domestic sheep (Artiodactyla: Bovidae) and a wild boar, *Sus scrofa* Linnaeus (Artiodactyla: Suidae) (Keysary et al., 2011; Ereqat et al., 2016) but these records require confirmation. Thus the major hosts of adult *H. adleri* are carnivorans of the families Canidae and Felidae.

Theodor and Costa (1967) recorded nymphs of *H. adleri* collected on the marbled polecat, *Vormela peregusna* (Güldenstädt) (Carnivora: Mustelidae) in Haifa District of Israel. We tentatively exclude this record since the nymph of *H. adleri* remains unknown and undescribed. Hosts of *H. adleri* larvae remain unknown.

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Fig. 1 *Haemaphysalis adleri* Feldman-Muhsam, 1951, scanning electron micrographs and digital photograph of male (A–C, Jerusalem, Jerusalem, Israel, USNMENT 01784354; D, Tharthar, Saladin, Iraq, USNMENT 01784355). A, Conscutum, dorsal view; B, Conscutum, dorsolateral view; C, Conscutum showing punctations and setae, dorsal posterolateral surface; D, postgenital sclerite. *Scale-bars*: A, B, 0.5 mm; C, 0.1 mm; D, 0.02 mm

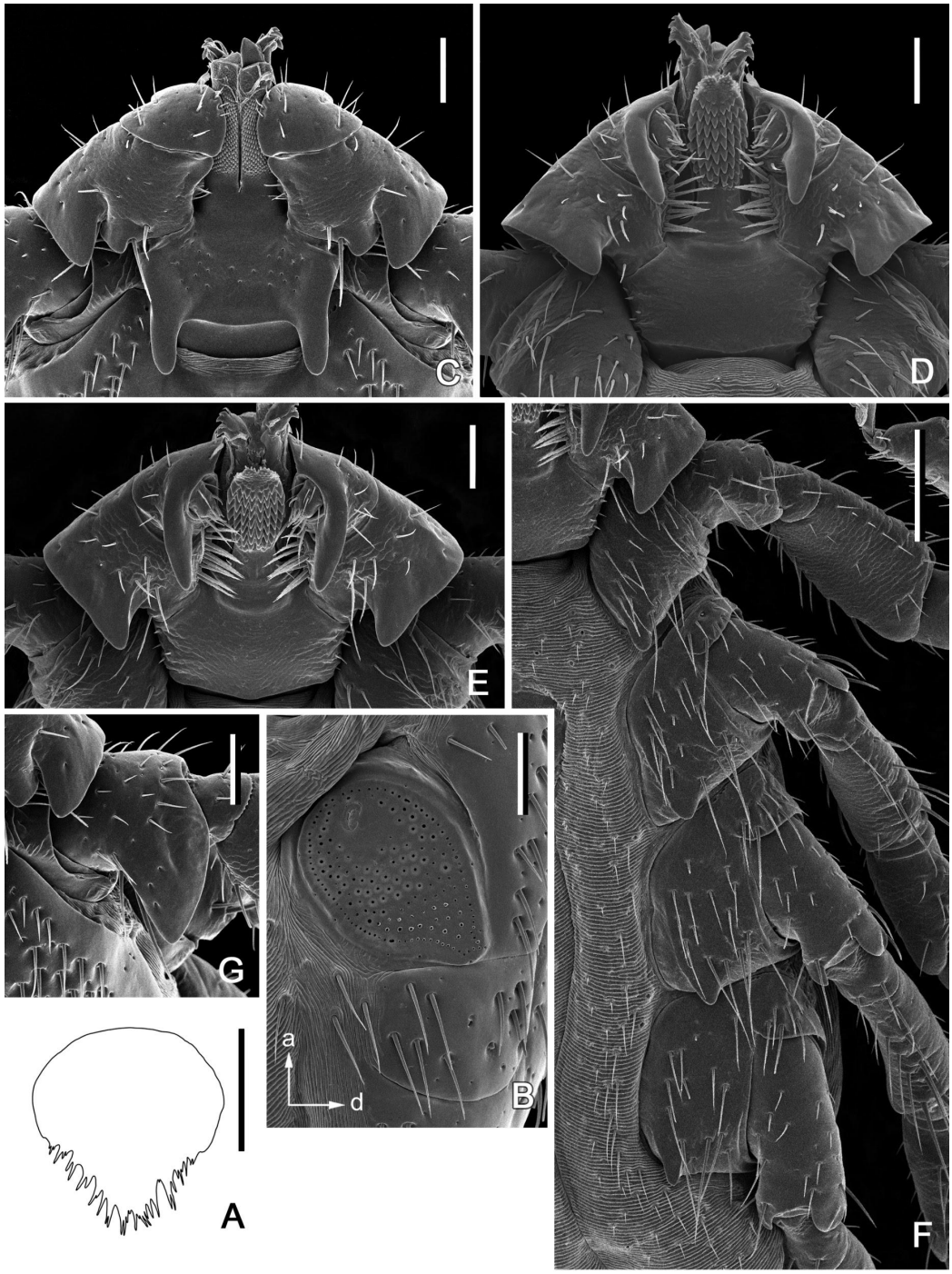

Fig. 2 *Haemaphysalis adleri* Feldman-Muhsam, 1951, line drawing and scanning electron micrographs of male (A, Tharthar, Saladin, Iraq, USNMENT 01784355; B–G, Jerusalem, Jerusalem, Israel, USNMENT 01784354). A, Apron; B, Spiracular plate (*arrows* indicate orientation of spiracular plate: a, anterior; d, dorsal) and festoon I; C, Gnathosoma, dorsal view; D, Gnathosoma, ventral view; E, Gnathosoma, anteroventral view; F, Coxae and trochanters; G, Trochanter I, dorsal view. *Scale-bars*: A, 0.125; B, C–E, G, 0.1 mm; F, 0.2 mm

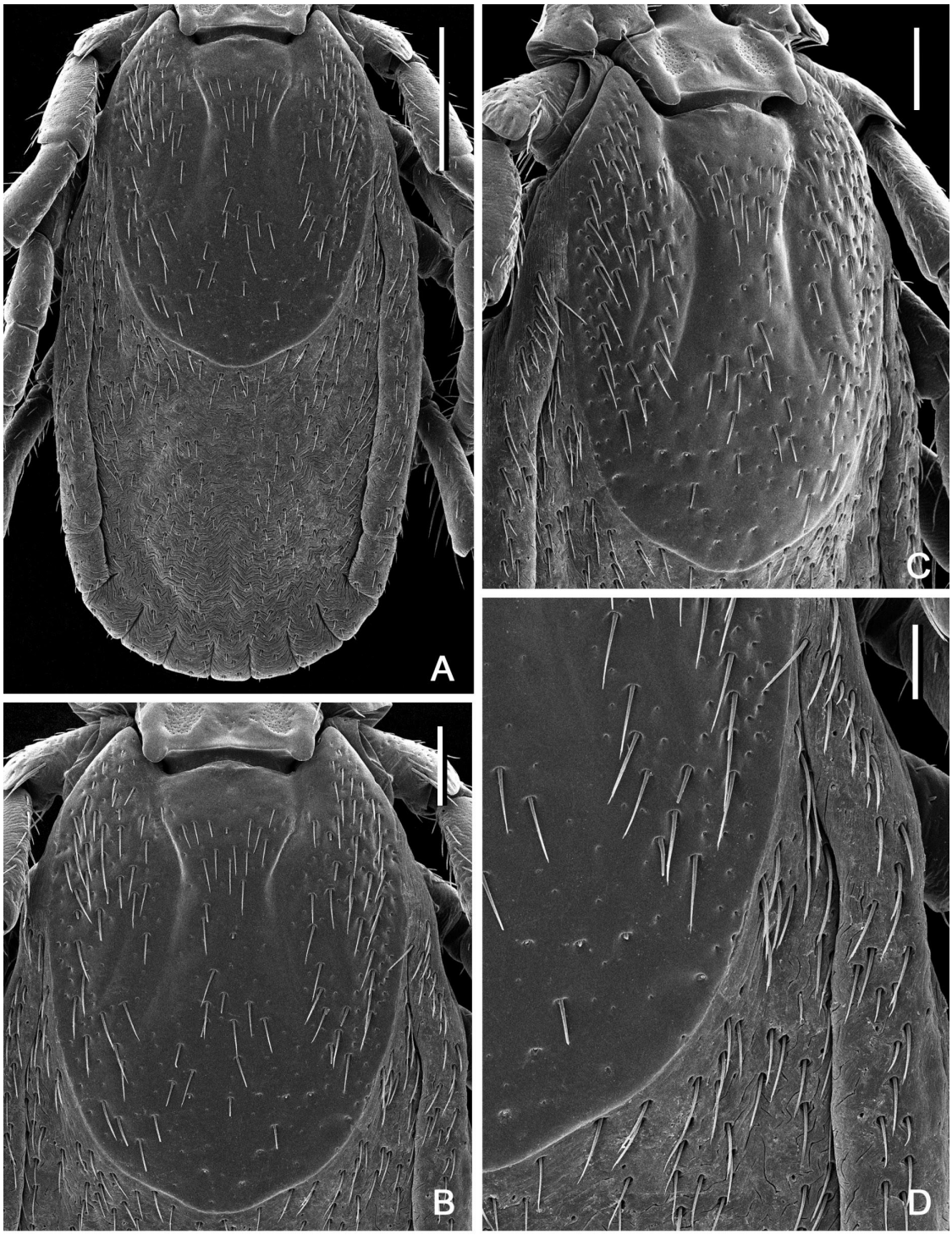

Fig. 3 *Haemaphysalis adleri* Feldman-Muhsam, 1951, scanning electron micrographs of female (Tharthar, Saladin, Iraq, USNMENT 01784355). A, Idiosoma, dorsal view; B, Scutum, dorsal view; C, Scutum, dorsolateral view; D, Idiosoma showing scutum and alloscutum with punctations and setae, dorsal centrolateral surface. *Scale-bars*: A, 0.5 mm; B, C, 0.2 mm; D, 0.1 mm

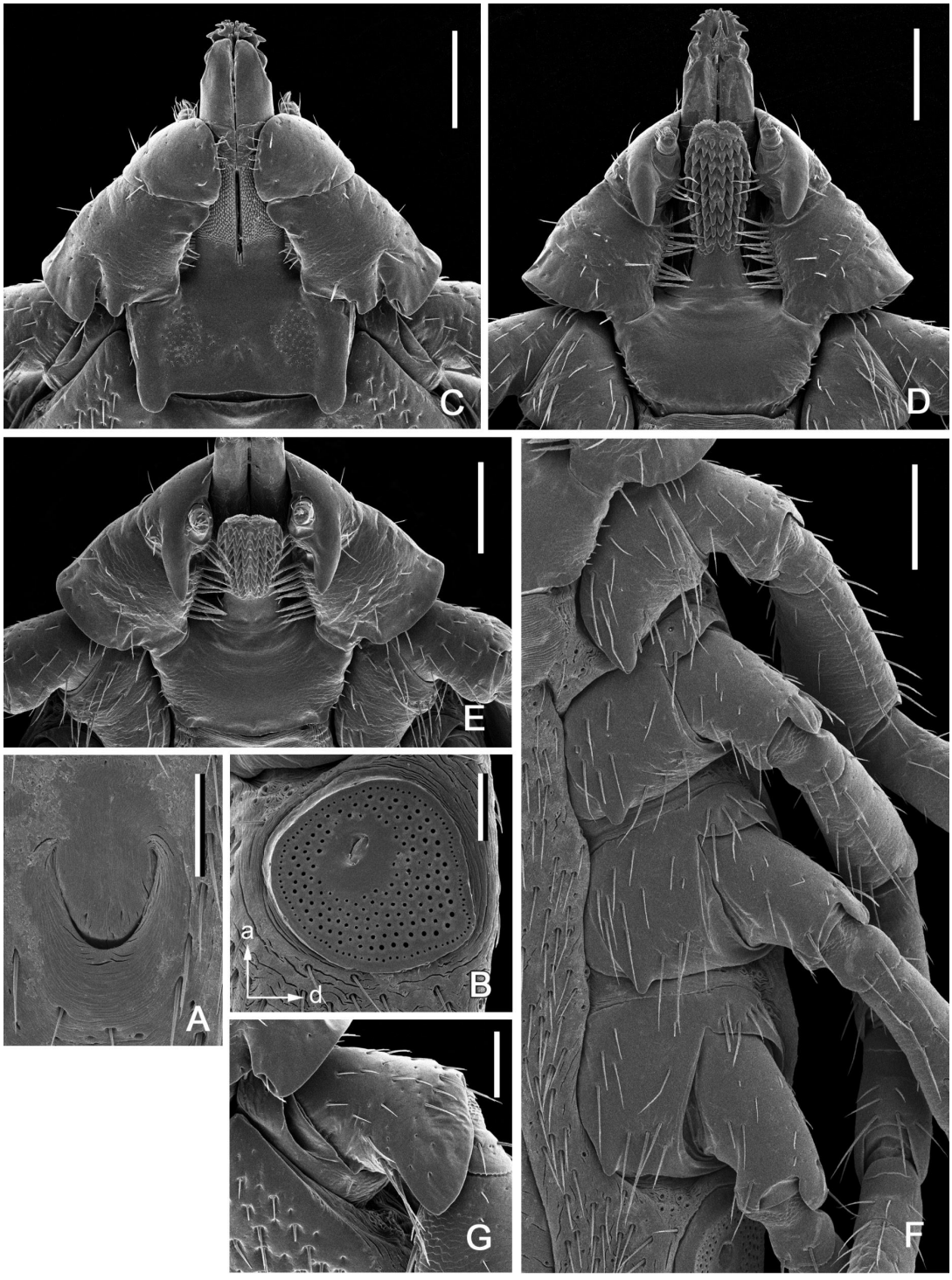

Fig. 4 *Haemaphysalis adleri* Feldman-Muhsam, 1951, scanning electron micrographs of female (Tharthar, Saladin, Iraq, USNMENT 01784355). A, Genital aperture; B, Spiracular plate (*arrows* indicate orientation of spiracular plate: a, anterior; d, dorsal); C, Gnathosoma, dorsal view; D, Gnathosoma, ventral view; E, Gnathosoma, anteroventral view; F, Coxae and trochanters; G, Trochanter I, dorsal view. *Scale-bars*: A, B, G, 0.1 mm; C–F, 0.2 mm

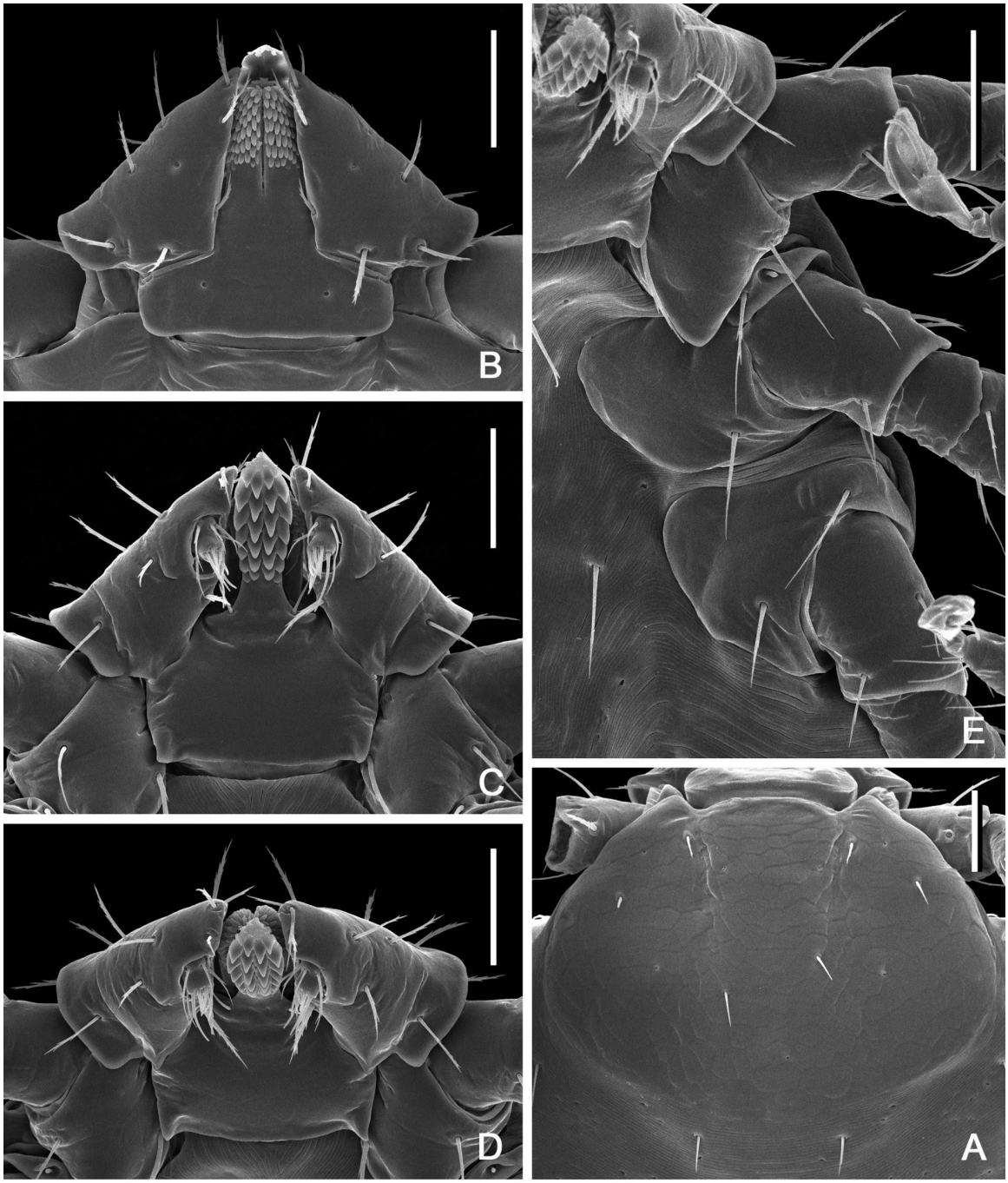

Fig. 5 *Haemaphysalis adleri* Feldman-Muhsam, 1951, scanning electron micrographs of larva (Yagur, Haifa, Israel, USNMENT 01784352). A, Scutum; B, Gnathosoma, dorsal view; C, Gnathosoma, ventral view; D, Gnathosoma, anteroventral view; E, Coxae and trochanters. *Scale-bars*: A–E, 0.05 mm

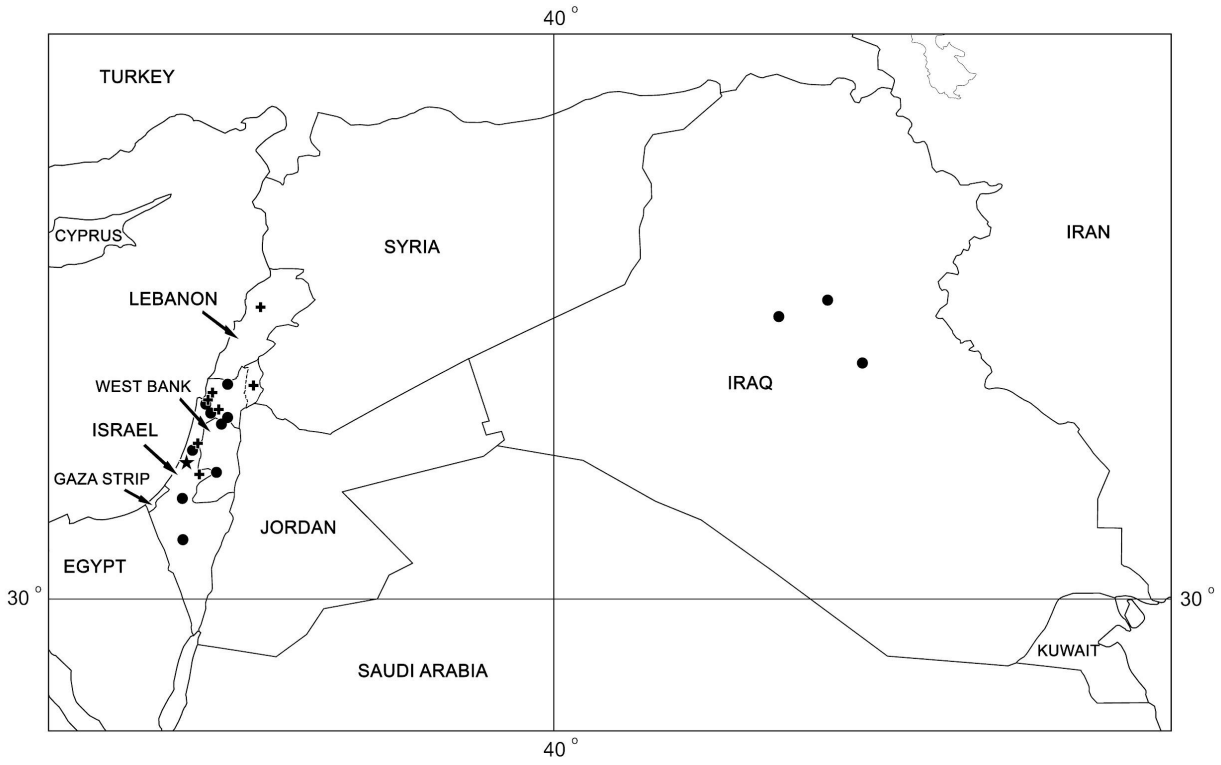

Fig. 6 Map showing the known geographical distribution of *Haemaphysalis adleri* Feldman-Muhsam, 1951. Filled star shows the type-locality, filled circles show confirmed localities and crosses show unconfirmed (based on literature) localities.