

Article

The Iranian *Hyalomma* (Acari: Ixodidae) with a key to the identification of male species

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Abstract

The taxonomic status of ticks in the genus *Hyalomma*, as prominent vectors of domestic animal and human pathogen agents as well as hematophagous parasites of all terrestrial animals has a problematic history due to variability. The present paper is based on our observations on the Iranian *Hyalomma* species during 2009 to 2013. In this study, for nine *Hyalomma* species including *H. aegyptium*, *H. anatolicum*, *H. asiaticum*, *H. detritum*, *H. dromedarii*, *H. excavatum*, *H. marginatum*, *H. rufipes* and *H. schulzei*, morphologic characteristics and some notes on their variability, biology and distribution are presented. In this paper, diagnoses, host information, distribution data, illustrations of adult males and a taxonomic key to the native *Hyalomma* species of Iran are provided to facilitate their identification.

Key words: *Hyalomma*, identification key, Iran, taxonomy, morphological characteristc

Introduction

Hard ticks (Acari: Ixodidae) are prominent vectors of pathogens of domestic animal and human as well as hematophagous parasites of almost all terrestrial mammals, birds, and reptiles (Hoogstraal & Aeschlimann 1982). The genus *Hyalomma* (Koch, 1844) includes many economically important species. The distribution of *Hyalomma* is limited to the Old World (Sonenshine *et al.* 2002). The taxonomy and diagnosis of *Hyalomma* has been confused due to its morphological variability (Delpy 1946; Feldman-Muhsam 1954; Bakheit *et al.* 2012). C.L. Koch (1844) established the genus with 16 species (two of which were later shown to be *Amblyomma* spp.). However Neumann (1899, 1911) later reduced the number of species to one, with four subspecies and three uncertain

species. Neumann believed that all *Hyalomma* associated with domestic mammals belonged to a “catch-all” species *H. aegyptium* (*Acarus aegyptius* Linnaeus, 1758). Neumann (1899) thought *H. aegyptium* (sensu Neumann) to be a highly morphologically variable species and its variability relating to size, lighter or darker color of body, legs, epimers, patches of abdominal blends, the shape of the dorsal shield of the female, abundance and depth of punctuations and the relative length of palpi. Neumann stated that these changes are variable based on the location of collection (i.e. country), hosts and different tick populations (Neumann 1899). He believed that variation in the characters found in his observations were not stable enough to consider them as separate species. However, a few parasitologists (e.g., R. Koch, 1905) criticized Neumann (Delpy 1946). Neumann’s opinion was generally accepted until 1920s.

In early twentieth century, British scientists in Africa, according to nomenclature suggested by pioneer researchers, G.H.F. Nuttall and C. Warburton at Cambridge university, constructed a group of *Hyalomma* names that are synonymized nowadays (Camicas *et al.* 1998). During 1918–1950, Schulze and his students followed Koch’s methodology and described 80 species, subspecies, forms and races in the genus *Hyalomma* (Schulze 1919a; Chodziesner 1924; Schulze 1930; Schulze & Schlottke 1930; Schulze 1936; Kratz 1940). Schulze’s first dichotomous taxonomical key to identify *Hyalomma* species is a combination of Koch’s and Neumann’s nomenclatures (Schulze 1919a). The terminology proposed by Schulze (whose full scientific name has up to five names, for example *Hyalomma hyalomma impressum balcanicum brunripes*) was quite literary and, in most cases, the diagnoses are confused and highly variable. Chodziesner (1924) stated that high variability occurring in *Hyalomma* is due to the fact that they are a recent phylogenetically evolved group. Delpy (1936, 1946, 1949a, b) revised the genus *Hyalomma* with regard to its morphological variation. He collected female specimens from many parts of Asia, Africa and Europe and reared progeny from single females. Therefore, he could define the variability of a single species among each female progeny (Delpy 1936a, 1946, 1949a,b). Subsequently, Adler and Feldman-Muhsam (1946, 1948), by using Delpy’s method, constructed a key to *Hyalomma* and defined the taxonomic status of some doubtful taxa (Adler & Feldman-Muhsam 1946, 1948). Hoogstraal (1956) synonymized many former so-called species names in *Hyalomma* and criticized the nomenclatures proposed by Neumann and Schulze (Hoogstraal 1956). Interestingly, on the problem synonymy in the genus *Hyalomma*, Camicas *et al.* (1998) presented 32 and 23 synonyms for *H. anatolicum* and *H. marginatum*, respectively.

Currently, the genus *Hyalomma* comprises three taxonomic subgenera: *Hyalomma* (type subgenus: *H. dromedarii*), *Hyalommina* (type subgenus: *H. rhipicephaloides*) and *Hyalommasta* (type subgenus: *H. aegyptium*) (Kaiser & Hoogstraal 1964). However, Filippova (1984) considers just two subgenera: *Hyalommasta* (type species: *H. aegyptium*) and *Euhyalomma* (type species: *H. dromedarii*).

In Iran, initial taxonomy of *Hyalomma* was based on the works of Delpy (Delpy 1936b,a; Delpy 1937b; Delpy 1937a, 1946, 1949a,b). Later, several major faunal and taxonomic studies on *Hyalomma* were conducted by Pervomaisky (1948), Abbasian-Lintzen (1960, 1961), Mazlum (1968, 1971), Hoogstraal and Valdez (1980), Tavakoli (1997), Abdigoudarzi (2003), Rahbari *et al.* (2007), Nabian *et al.* (2009), Hosseini *et al.* (2011), Hosseini and Tavakoli (2012), Hosseini-Chegeni and Dalimi (2012), and Tavakoli *et al.* (2012). None of these studies provide keys to identify the species of

Hyalomma found in Iran, with the exception of a few studies conducted by Mazlum (1968), Abdigoudarzi (2003) and three unpublished keys (S. Rahbari, N. Piazak and Abdigoudarzi's personal communication). Moreover, for most species, no information is available on their disease relationships, faunal associations and ecological features. Since animal husbandry is a considerable economic profession in Iran, especially among villagers, determination of tick borne diseases, e.g., theileriosis, and their tick vectors, has great importance for veterinarian scientists. In addition, diagnosis of *Hyalomma* ticks is similarly critical in order to monitor human pathogen agents, e.g., Crimean-Congo hemorrhagic fever virus and *Anaplasma* spp.

The present study mainly reviews taxonomic status, distribution, host and disease relationship in nine *Hyalomma* species: *H. aegyptium*, *H. anatolicum*, *H. asiaticum*, *H. detritum*, *H. dromedarii*, *H. excavatum*, *H. marginatum*, *H. rufipes* and *H. schulzei*. Finally a taxonomic key is constructed to the native *Hyalomma* species of Iran. This study deals with male *Hyalomma* species since diagnosis of the female, especially engorged individuals, due to variability in taxonomic characters that may overlap in different species and absence of distinctive characters, is difficult. Although the females in a few species including *H. aegyptium* and *H. dromedarii* are easily recognized through coxa I and genital aperture. We also believe that the taxonomic characteristics of *Hyalomma* species are geographically variable and may be partly different from country to country.

Material and Methods

Studied area

Tick specimens were collected from ten geographical locations (province) in the Iranian territory as follows: north (Golestan), northwest (Azarbayjan-e-Sharqi), northeast to east (Khorasan-e-Razavi and Khorasan-e-Joonobi), southeast (Sistan va Baluchistan), south (Kerman and Hormozgan), southwest to west (Khuzestan and Lorestan), and central (Yazd) (Fig. 1).

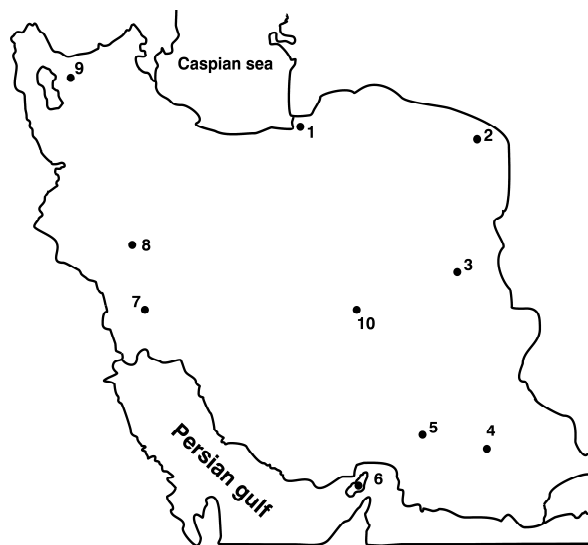


Figure 1. Numbers 1–10 indicating different locations (province) of tick collection. 1. Golestan; 2. Khorasan-e-Razavi (Saraks); 3. Khorasan-e-Joonobi (Ghaen); 4. Sistan va Baluchistan (Iranshahr and Bampoor); 5. Kerman (Manoujan); 6. Hormozgan (Qeshm island); 7. Khuzestan; 8. Lorestan; 9. Azarbayjan-e-Sharqi; 10. Yazd.

Tick specimens

Since *Hyalomma* spp. generally parasitizes common domestic animals (except *H. aegyptium* as reptile parasite, especially land tortoise) thus, most specimens were collected from cattle, sheep, goat and camel by bended-head forceps. Tick specimens were kept in ethanol 70%, cold box or lively transported to the Acarology Laboratory of Lorestan Agricultural and Natural Resources Research Center as well as Department of Medical Entomology and Vector Control, Faculty of Public Health, Tehran University of Medical Science. The ticks *H. aegyptium*, *H. anatolicum*, *H. asiaticum* and *H. marginatum* relatively collected from entire Iran while *H. detritum*, *H. dromedarii* and *H. schulzei* only collected in some regions of Iran (i.e. patchily distributed) including Sistan va Baluchistan and Khorasan-e-Razavi province (*H. dromedarii* and *H. schulzei*), Khuzestan (*H. detritum*). Two species *H. rufipes* and *H. excavatum* were rarely collected in Iran. For instance, the former species were collected only in Lorestan and Hormozgan provinces.

Determination

Ticks were examined under a light stereomicroscope (STEMI SR-ZEISS® Germany) through related taxonomic keys including Delpy (1946), Pomerantzev (1950), Kaiser and Hoogstraal (1964), Estrada-Peña *et al.* (2004). The specimens of debatable species e.g., *H. anatolicum*, *H. asiaticum* and *H. excavatum* were compared with type species (identified by Hoogstraal & Kaiser 1967, Hoogstraal & Kaiser 1958 and Hoogstraal & Kaiser 1968) housed in Razi Vaccine and Serum Research Institute, Department of Parasitology, Reference Laboratory for Ticks and Tick Borne Diseases, Karaj, Iran. The representative specimens of each species were photographed then drawn by using a drawing tube connected to stereomicroscope and software Corel Draw Graphics Suite® (version X6). The common names related to each taxon were derived from the names authored by Hoogstraal (Robbins & Carpenter 2011). Finally, a taxonomical key was constructed for the native *Hyalomma* species of Iran.

Results and discussion

I. *Hyalomma aegyptium* (Linnaeus, 1758) Koch, 1844

Common name: Tortoise *Hyalomma*

Taxonomic status

In 1758, Linnaeus described *H. aegyptium* as *Acarus aegyptius* in *Systema Naturae* (Camicas *et al.* 1998). Afterwards, C.L. Koch (1844) described an external parasite from land tortoise namely *H. syriacum*. Neumann (1911) lumped all *Hyalomma* species present on domestic animals under the name *H. aegyptium* (Neumann 1911). Delpy (1949a) recognized that the most mooted name of *H. aegyptium* is related to the unique parasite of tortoises. Therefore, the name *H. syriacum* (= *H. aegyptium*) may be considered as its synonym. According to international rules of nomenclature, *H. aegyptium* is considered as the type species of the genus *Hyalomma*. However, Russian School suggested that *H. dromedarii* be considered as the type species of the genus (Kaiser & Hoogstraal 1964). They believed that *H. aegyptium* is a single species of subgenus *Hyalommasta* erected by Schulze (1930). When it compared to other species of *Hyalomma*, it is easily identified because male and female *H. aegyptium* have an

internal spur on coxa I which is a unique diagnostic character among *Hyalomma* species (Figs. 2-II, 13-III).

Distribution

Its distribution appears to be expanded all over Iran especially where its specific host, land tortoise genus *Testudo*, is established (Abbasian-Lintzen 1960; Nabian & Mirsalimi 2002; Rahbari *et al.* 2007; Tavassoli *et al.* 2007).

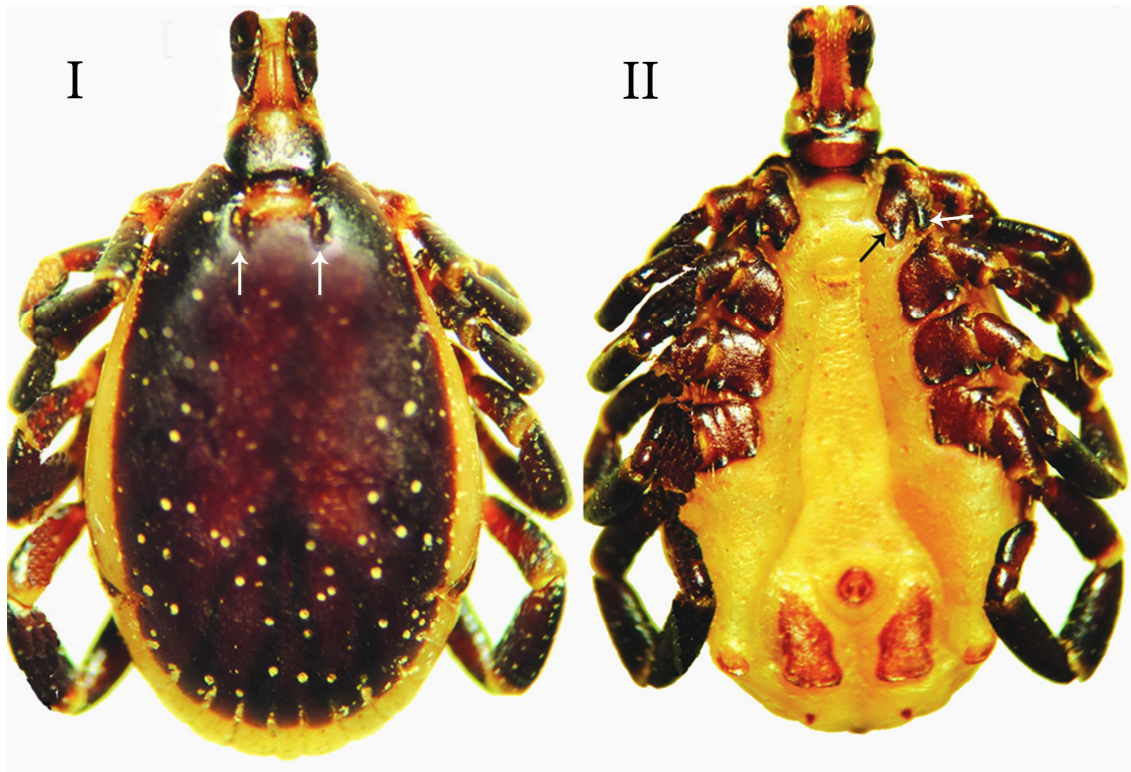


Figure 2. *Hyalomma aegyptium* (male). I. Dorsal view, white arrows indicating cervical groove; II. Ventral view, black and white arrows representing internal and external spurs on coxa I, respectively.

Host

The common preferred hosts for *H. aegyptium* are land tortoises and rarely may be seen on lizards (Abbasian-Lintzen 1960). However Abusalimov (1958) reported 35 adults of *H. aegyptium* collected on pigs sent from Rasht (Guilan province, north of Iran) to meat packing plant in Baku (Abusalimov 1958).

Diseases

The role of Iranian *H. aegyptium* as a vector of diseases has not been fully understood yet. However, according to the literature, the species is a vector of *Haemogregarina mauritanica*, *H. stepanovi* and *Coelomoplasma hyalommae* as well as *Anaplasma phagocytophilum*, *Ehrlichia canis* and *Coxiella burnetii* (Hoogstraal 1956; Paštiu *et al.* 2012).

II. *Hyalomma anatolicum* Koch, 1844

Common name: Small Anatolian *Hyalomma*

Taxonomic status

C.L. Koch described this species in 1844. However, Russian and eastern researchers did not agree on this and placed it as subspecies, *H. anatolicum anatolicum* (Pomerantzev 1950; Feldman-Muhsam 1962; Kaiser & Hoogstraal 1964). Delpy (1952) wrongly used *H. excavatum* instead of *H. anatolicum*. The name *H. savignyi* (Gervais and sensu Schulze) was synonymized with *H. excavatum* (sensu Delpy) by Delpy (1949b) after examining Adler and Feldman-Muhsam's materials, and by Feldman-Muhsam (1954) after examining Koch's type materials. Finally, the name *H. anatolicum anatolicum* (Koch 1844) was replaced with *H. excavatum* (sensu Delpy) (Hoogstraal & Kaiser 1959). To date, thirty-two synonyms were presented for *H. anatolicum* (Camicas *et al.* 1998). Morphological variation in different populations of this species is an important source of misidentification that makes difficult to differentiate it with closely related taxa, *H. excavatum*, *H. asiaticum* and *H. marginatum*. Most taxonomic characteristics suggested to differentiate of species in Iranian male specimens include cervical groove, basis capituli and lateral grooves on scutum (Figs. 3-I; 14-IV-VI), which the latter was statistically emphasized as a valuable quantitative character (Hosseini *et al.* 2011; Tavakoli *et al.* 2012). The distribution of this species is wider than another *Hyalomma*. Thus, variation in taxonomic characters may be common than the locally distributed *Hyalomma* species. Traditionally, *H. anatolicum* and two closely related species *H. excavatum* and *H. asiaticum* are recognized as *H. excavatum* group among Iranian researchers. Some populations of *H. anatolicum* and *H. asiaticum* could be partly distinguished through their Haller's organ (Fig. 4-I-II) (Hosseini-Chegani & Dalimi 2012). Pigmentation (color) of parma as a suitable taxonomic character for the differentiation of *H. anatolicum* and *H. marginatum* is nearly variable in different populations that may be seen as pale, semi-pale, semi-dark and dark (Fig. 3-II-V) (Tavakoli *et al.* 2012).

Distribution

Hyalomma anatolicum is the most widespread species in Iran. This species was collected from all zoogeographic situations including xeric, temperate (less common) and mountainous conditions even island (e.g., Qeshm island, south of Iran). However, previous studies emphasized that the species is most widely distributed in xeric or semi-desert area (Abbasian-Lintzen 1960; Mazlum 1971; Nabian *et al.* 2009).

Host

This species, with no doubt, is a parasite of many terrestrial small and large animals including domestic and wild mammals. In our country, cattle, sheep and goat serve as the most common domestic hosts for *H. anatolicum*. In, one year, these hosts were parasitized with different infestation rates depending on season and geographic location (Tavakoli 1997). In cold season, engorged larvae and young adults overwinter in wall cracks and other shelters (Delpy 1952). This species occasionally parasitized human, especially in immature stages.

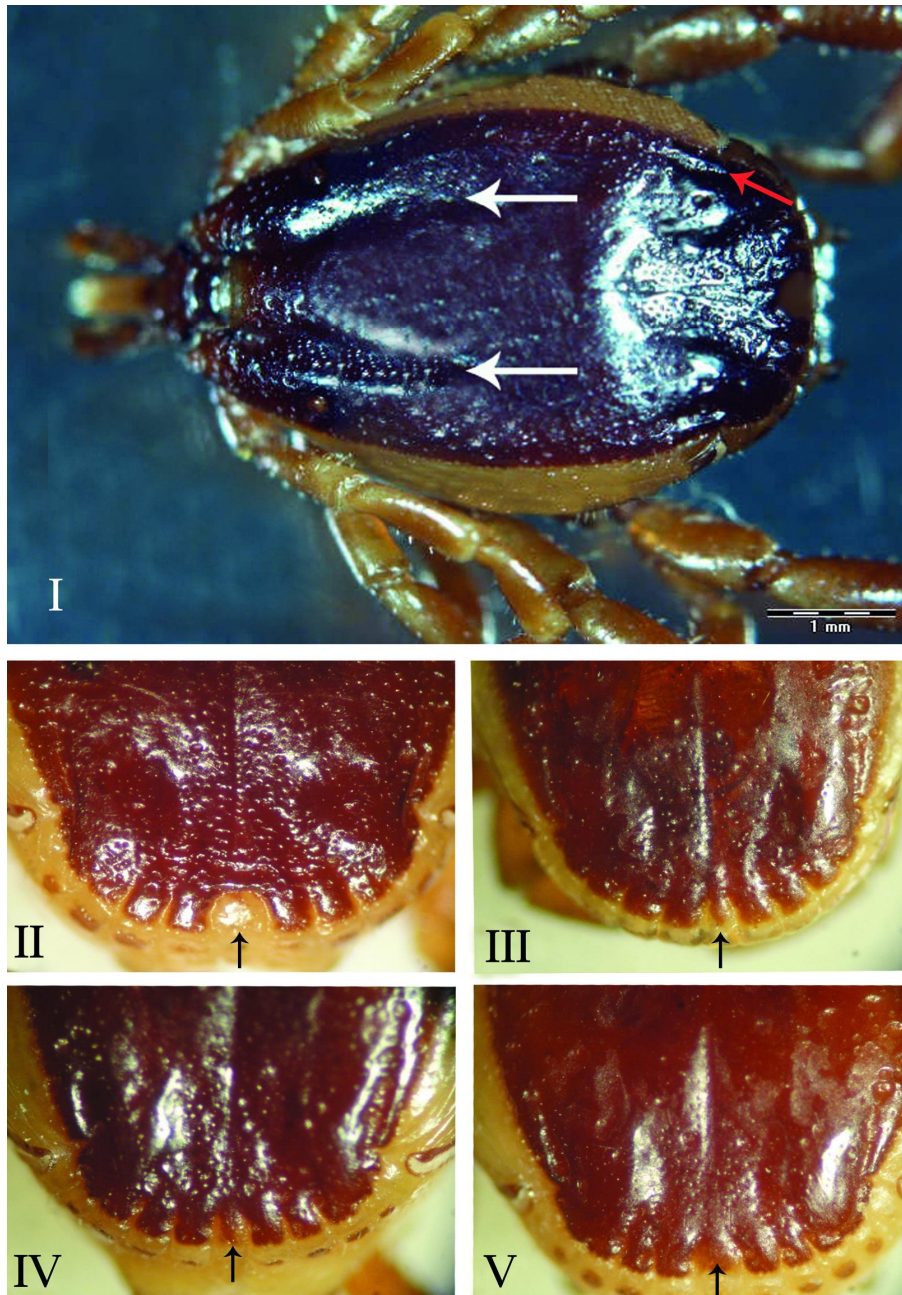


Figure 3. *Hyalomma anatolicum* (male). I. Dorsal view, white and red arrows indicating cervical grooves and lateral groove, respectively; variation in the color of parma: II. Pale; III. Semi-pale; IV. Semi-dark; V. Dark, (black arrows indicating parma position).

Diseases

Hyalomma anatolicum is considered as a main vector of ovine and caprine malignant thileriosis (OCMT) and tropical thileriosis whose causative agents are *Theileria lestoquardi* and *T. annulata*, respectively (Delpy 1952; Rak 1976). Also, the virus of human fatal Crimean Congo hemorrhagic fever (CCHF) has been frequently detected from *H. anatolicum* (Telmadarrai *et al.* 2008; Salim-abadi *et al.* 2011). Few unknown arboviruses Thogoto and one isolate of Wad Medani which may be fatal in

humans were reported for *H. anatolicum* (Hoogstraal 1985; Sureau & Klein 1980). *H. excavatum* sensu Delpy (syn. *H. anatolicum*) was reported as a vector of *Ehrlichia bovis*, agent of bovine Ehrlichiosis, and presumably *Coxiella burnetii*, agent of Q fever and *Eperythrozoon wenyoni*, agent of Eperythrozoonosis in cattle (Rafyi & Rak 1985).

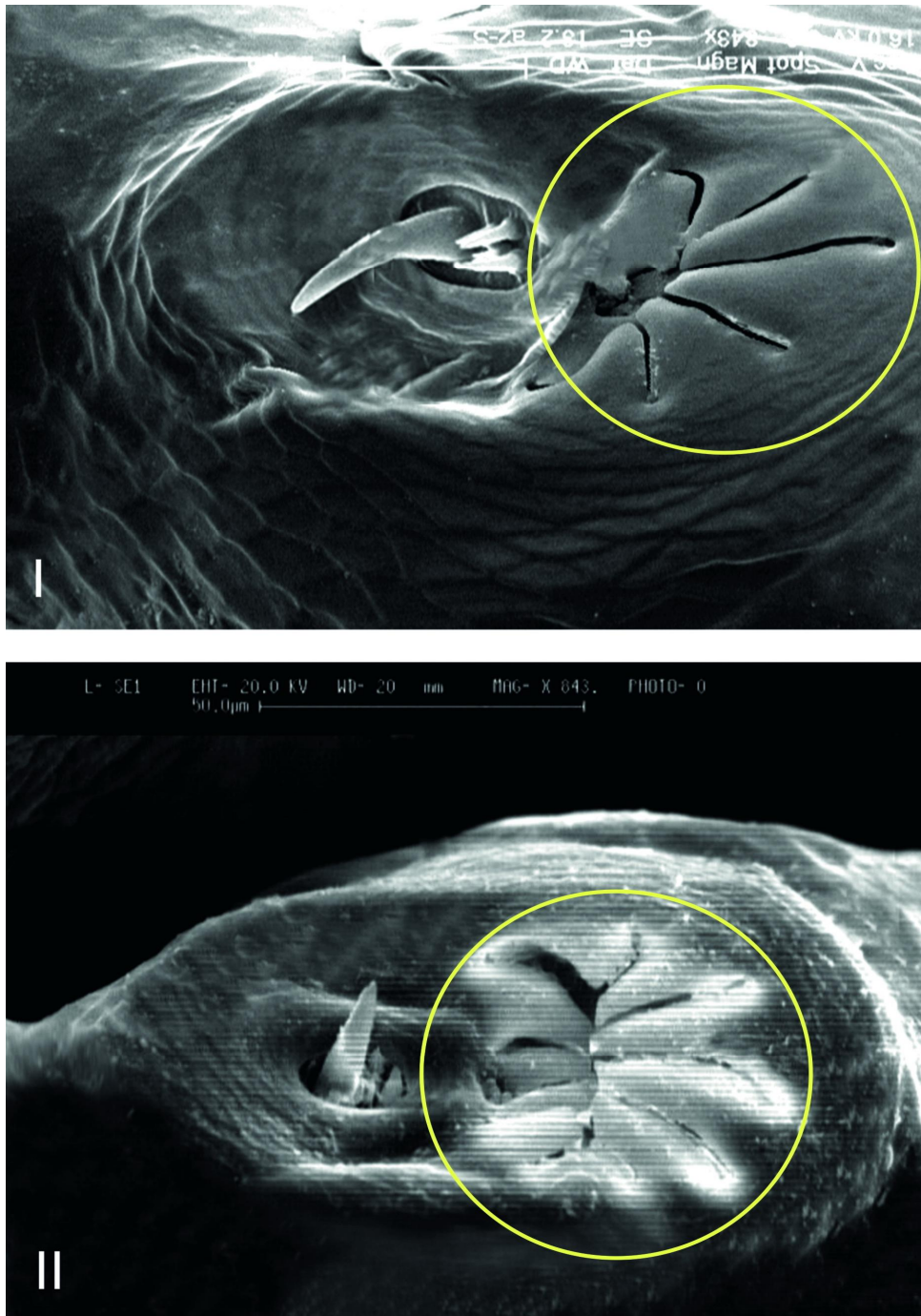


Figure 4. Scanning electron micrograph of Haller's organ in two closely related species. I. *H. anatolicum*; II. *H. asiaticum*; variation at capsular pattern of organ shown by yellow circles; Mag., 843X.

III. *Hyalomma asiaticum* Schulze & Schlottke, 1930

Common name: Asiatic *Hyalomma*

Taxonomic status

Hyalomma asiaticum was described by Schulze in 1930 and is one of the most problematic “species” in the genus *Hyalomma*. Russian taxonomists suggested three subspecies including *H. a. asiaticum*, *H. a. caucasicum* and *H. a. kozlovi* based on a few unreliable characters (Serdyukova 1956; Pomerantzev 1950; Filippova *et al.* 1995).

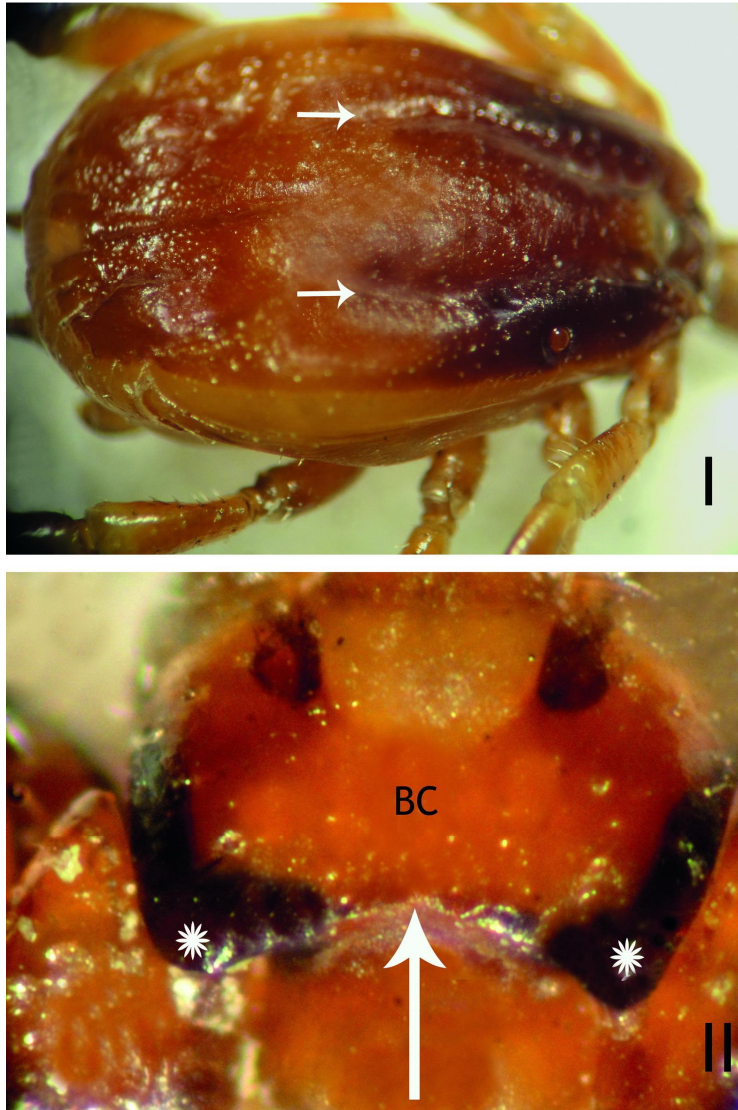


Figure 5. *Hyalomma asiaticum* (male). I. Dorsal view, white arrows indicating cervical grooves position; II. Dorsal view, asterix and white arrow indicating cornua and dorsal posterior margin of the basis capituli, basis capituli (BC).

Filippova *et al.* (1995) stated that all characters in all subspecies are overlapped. Delpy (1949b) did not accept *H. asiaticum* as a valid species. Delpy and eastern researchers have generally synonymized *H. asiaticum* with *H. dromedarii* (Delpy 1949a; Kaiser & Hoogstraal 1963). Apanaskevich and Horak (2010) studied different

populations of *H. asiaticum* from several locations and suggested *H. (Euhyalomma) asiaticum* is a valid name. Based on the criteria introduced by Pomerantzev (1950), Kaiser and Hoogstraal (1963), Mazlum (1968), Apanaskevich and Horak (2010) as well as our observation, *H. asiaticum* can be distinguished from other closely related species, for instance *H. anatolicum*, by presenting long and very deep cervical grooves, and the dorsal posterior margin of the basis capituli that is concave and angular (Figs. 5-I-II; 14-III-V). In *H. asiaticum*, subanal shields are situated on median axis of the adanal shields. However, in *H. dromedarii*, subanal shields are situated externally to the median axis of adanal shields. Nevertheless, it needs to be mentioned that further taxonomic studies, e.g., molecular approaches should be conducted to decide the species status of *H. asiaticum* and to compare closely related taxa such as *H. anatolicum*.

Distribution

According to Mazlum (1968, 1971), *H. asiaticum* is widely distributed in Iran, except for the coastal Caspian sea. However, Nabian *et al.* (2009) claim that *H. asiaticum* was found in all zoogeographic zones in Iran.

Host

Sheep, goat, cattle, camel, horse as well as wild goat and sheep, pigs, and gazelles may be parasitized by *H. asiaticum* (Mazlum 1971; Hoogstraal & Valdez 1980).

Diseases

Experiments showed that *H. asiaticum* can transmit the protozoan agent of bovine theileriosis, *Theileria annulata*, in Iran. However, its role in nature is neglected (Mazlum 1968). Likewise, two strains of Wanowrie virus were subsequently isolated from *H. asiaticum* specimens collected in Iran (Sureau & Klein 1980). This species may also be a prominent vector of CCHF virus (unpublished data).

IV. *Hyalomma detritum* Schulze, 1919

Common name: Shiny *Hyalomma*

Taxonomic status

Schulze (1919a) described this species with a subspecies named *H. d. albipictum*. In 1930, a taxonomic key was compiled for the identification of six problematic geographical races/subspecies related to *H. detritum* based on a few variable morphological characters. Then, he described two closely related species *H. detritum* and *H. scupense* based on two unreliable characters including leg size and width of dorsal projection in the spiracular plate (Schulze 1919a, b). Although some authors have accepted the questionable description of Schulze (Pomerantzev 1950; Camicas *et al.* 1998; Guglielmone *et al.* 2010). Recently, *H. detritum* was redescribed as a junior synonym of *H. scupense* and two name indicated one species (Apanaskevich *et al.* 2010). In the present study (to avoid confuse), we use *H. detritum* (var. *scupense*) according to Delpy (1946). The best character for the diagnosis of *H. detritum* is the glossy scutum that could be seen in most specimens, and the posteromedian groove reaching parma, but lateral grooves are variable (Figs. 6-I; 12-I). Adler & Feldman-Muhsam (1948) stated that the yellow longitudinal band on the legs of *H. detritum* is a constant feature for the identification of the species.

Distribution

This species has an unequal distribution in Iran and rarely could it be collected in routine tick collections (Abbasian-Lintzen 1960; Mazlum 1971). In the present study, more specimens were collected in Khuzestan province whereas Mazlum (1971) states that *H. detritum* is a most frequent species in the coastal Caspian sea.

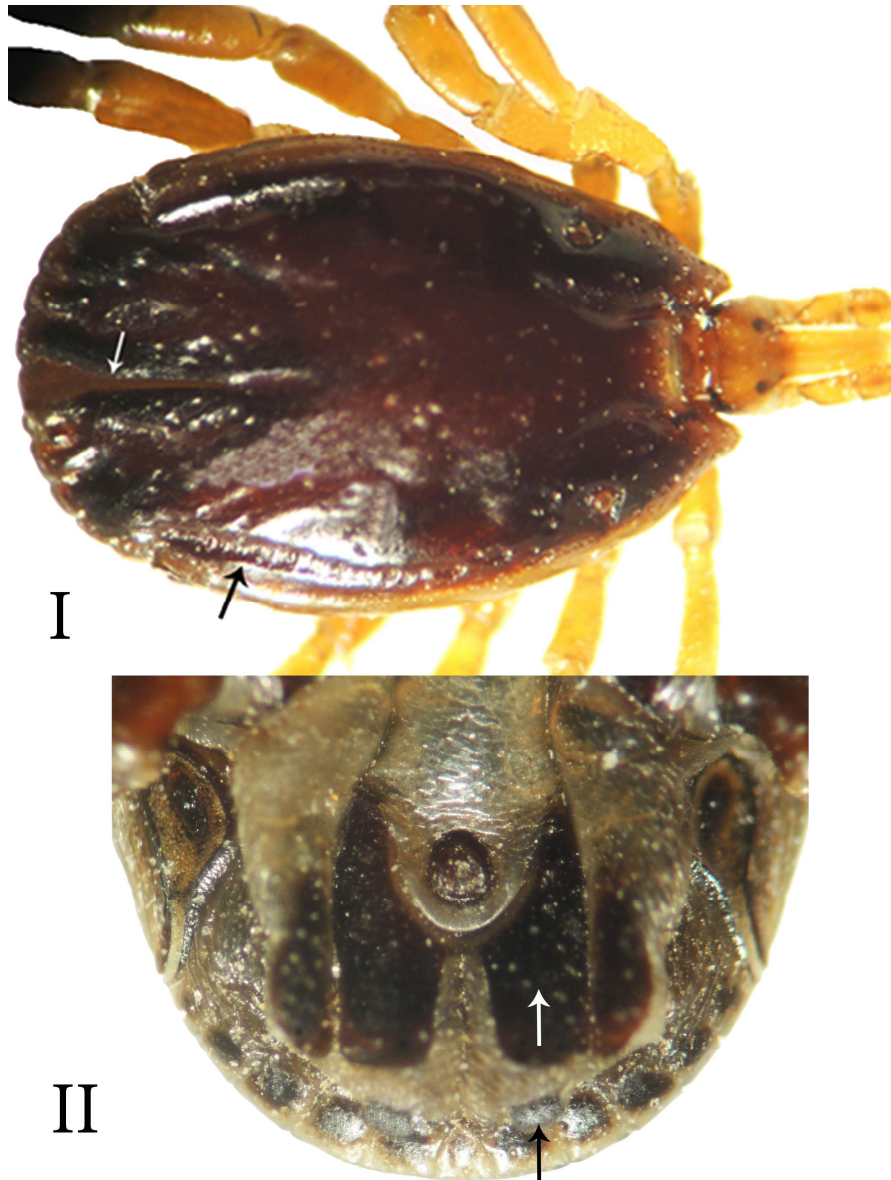


Figure 6. *Hyalomma detritum* (male). I. Dorsal view, white arrow showing posteromedian groove reaching parma, black arrow showing lateral groove position; II. Ventral view, black and white arrows indicating subanal and adanal shields, respectively situated in line with the longitudinal axis.

Host

Hyalomma detritum similar to other species of *Hyalomma* tends to feed on domestic ruminants especially cattle and bufflehead as well as sheep, camel, horse and ass (Abbasian-Lintzen 1960, 1961; Mazlum 1971).

Diseases

The role of *Hyalomma* ticks as a vector of bovine theileriosis, *T. annulata* (syn. *T. dispar*) was first discovered with *H. detritum* (syn. *H. mauritanicum*) (Sergent *et al.* 1928). Delpy (1952) also claimed the role of *H. detritum* in the transmission of bovine theileriosis in Iran.

V. *Hyalomma dromedarii* Koch, 1844

Common name: Camel *Hyalomma*

Taxonomic status

This species was described by Koch (1844) as a type species in the genus *Hyalomma*. It seems that there is no significant controversy in the taxonomic status of *H. dromedarii*, except for a few refusal of the nomenclatures suggested by Neumann School as *H. aegyptium* v. *dromedarii*, *H. (H.) a. dromedarii* and Schulze School as *H. d. dromedarii*, *H. d. canariense* and *H. delpyi* that all have been synonymized. Recently, *H. dromedarii*, together with other four related species, was placed in *H. asiaticum* species group (Apanaskevich & Horak 2010). Species characteristics are well defined. Thus, the diagnosis of *H. dromedarii* is not mostly difficult compared to another *Hyalomma* species. In ventral view, subanal shields are not situated below adanal shields. It means that subanal shields are outside the longitudinal axis of adanal shields (Figs. 7-II, 12-IV). Small morphological variations can sometimes be observed within unengorged specimens, like subanal shields may be closer to the longitudinal axis. Moreover, in dorsal view, the posteromedian groove reaches the parma.

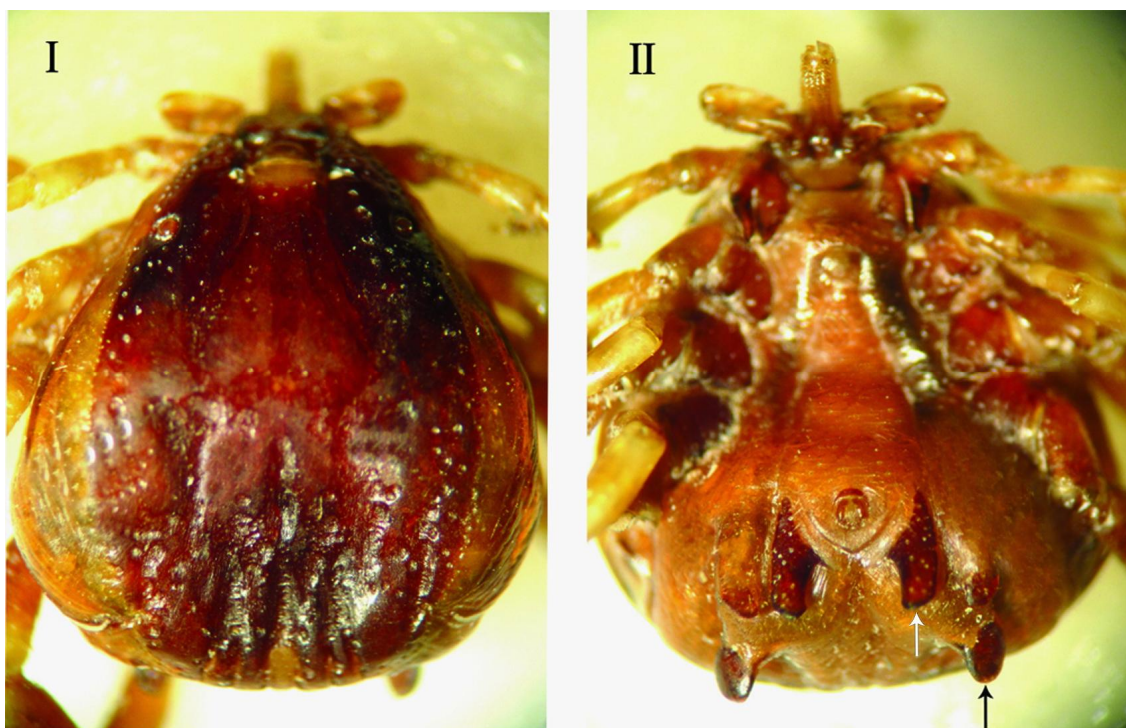


Figure 7. *Hyalomma dromedarii* (male). I. Dorsal view; II. Ventral view, black and white arrows indicating subanal and adanal shields, respectively situated in line with the longitudinal axis.

Distribution

The species is scattered almost all over Iran, especially in the areas where camels occur as large herds, e.g., southern, eastern and northeastern parts of Iran. Surprisingly, we found *H. dromedarii* engorging on many camels grazing around the Persian Gulf with relative humidity nearly up to 90%, although it seems that tick mobility decreased when they were removed from the host.

Host

Apparently, camel is the main host of *H. dromedarii* (and *H. schulzei*). Also, cattle or other livestock may be parasitized only as alternative host in camel farming areas (Delpy 1952).

Diseases

Delpy (1952) and Mazlum (1969) showed that *H. dromedarii* is a competent vector of *T. annulata*. Also, CCHF virus was detected from *H. dromedarii* collected in Iran (Telmadarraiy *et al.* 2008; Salim-abadi *et al.* 2011).

VI. *Hyalomma excavatum* Koch, 1844

Common name: Large Anatolian *Hyalomma*

Taxonomic status

Hyalomma excavatum is very similar to *H. anatolicum*. Mazlum (1971) states that the presence of *H. excavatum* is doubtful in Iran. However, this species was recorded in the checklist of Iranian *Hyalomma* (Nabian *et al.* 2009). Delpy (1949a), Hoogstraal (1956), Feldman-Muhsam (1962) and other western researchers incorrectly used the name *H. excavatum* instead of *H. a. anatolicum* (sensu Pomerantzev). Later, Hoogstraal changed his opinion in a critical review (Hoogstraal & Kaiser 1959). Pomerantzev (1950) refers to both *H. a. anatolicum* and *H. a. excavatum* as subspecies of polytypic species *H. anatolicum*. However, Pervomaisky (1954) (cited in Kaiser & Hoogstraal 1964) lumps two forms as a single species following the examination of morphological variability of ticks reared in laboratory. Doubtful status of this species would lead us to use new approaches, e.g., molecular systematics to clear specific or subspecific position of recently so-called *H. excavatum* (Apanaskevich & Horak 2005). A most debatable taxonomic character for the differentiation of *H. excavatum* from *H. anatolicum* is an anterior fusion between the pair of festoons next to the central one (paraparmal or paracentral) to form an arch shape (Figs. 8, 15-I). Other characters consist of caudal ridges distinctness, tick robustness and darkish color of the scutum (Hoogstraal & Kaiser 1959).

Distribution

Apparently, this species is distributed almost all over Iran except the Caspian sea area in the northern part of the country (Rahbari *et al.* 2007; Nabian *et al.* 2009). Overlap may occur between populations of the two closely related taxa *H. excavatum* and *H. anatolicum* (Hoogstraal & Kaiser 1959; Bakheit *et al.* 2012). To date, we observed only few specimens representative of *H. excavatum* in Iranian territory.



Figure 8. *Hyalomma excavatum* (male). Dorsal view, black arrows showing anterior fusion paraparmal festoons (arch), white arrow showing caudal ridges.

Host

According to Walker *et al.* (2007), adults of *H. excavatum* parasitize cattle, sheep, goat, camel, horse and ass. However, larvae and nymphs feed on hares, hedgehogs, and rodents. *H. excavatum* is a ditropic tick contrary to *H. anatolicum*, larvae and nymphs do not naturally feed on cattle and other large hosts.

Diseases

Although immature stages feed on rodents and small vertebrates except large animals, the ability of this tick to act as a vector of pathogens such as *Theileria*, is uncertain (Walker *et al.* 2007). *H. excavatum* has not been reported as an important vector of *Theileria*, but can transmit it under laboratory conditions (Walker *et al.* 2007). The relationship between *H. excavatum* and disease transmission in Iran is poorly known, mainly because its occurrence and correct identification are still in controversy among researchers.

VII. *Hyalomma marginatum* Koch, 1844

Common name: Mediterranean *Hyalomma*

Taxonomic status

The specific name “*marginatum*”, derived from “margin”, refers to the lateral grooves that run as lines of punctuations near the margin of scutum and may be seen as a marginal rim. *H. marginatum* was described by C.L. Koch in 1844. Then, it was considered as subspecies *H. m. marginatum* by Schulze & Schlottke (1930), and Hoogstraal & Valdez (1980).

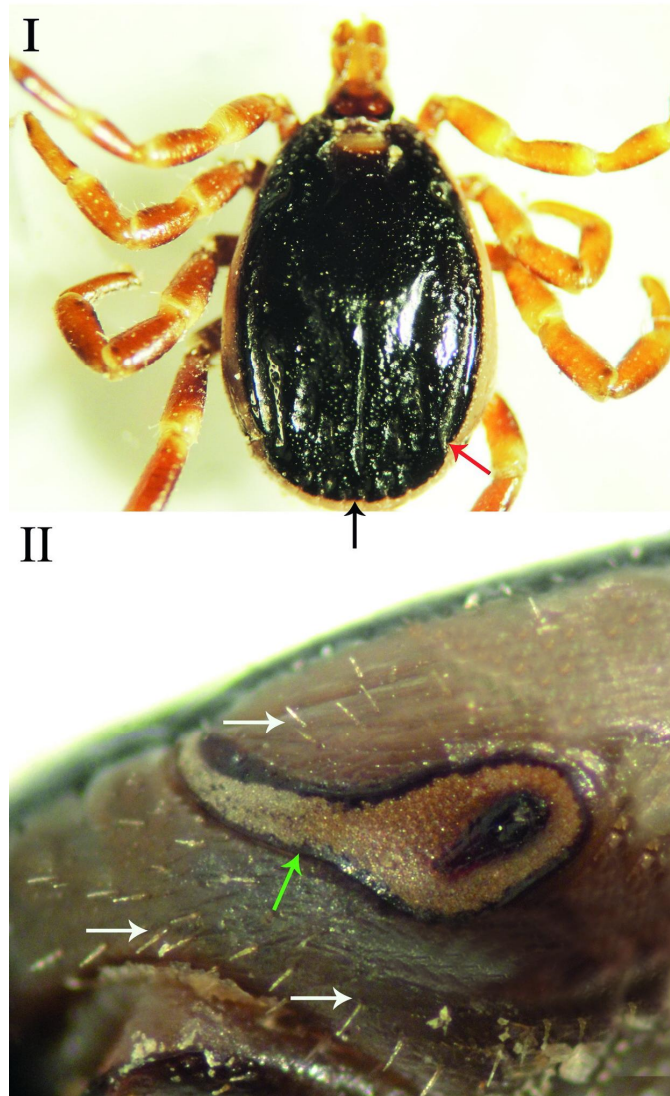


Figure 9. *Hyalomma marginatum* (male): I. Dorsal view, black and red arrows representing central festoon and lateral groove, respectively; II. Thickness of spiracular plate tail (green arrow) and circum-spiracular seta density (white arrows).

Delpy (1949a) suggested a different name *H. savignyi* (Gervais, 1844) and did not accept the name *H. m. marginatum* as a junior synonym for *H. savignyi*. Abbasian-Lintzen (1960) reported so-called *H. savignyi* (= *H. marginatum*) according to Delpy's nomenclature. In the Russian literature (Pomerantzev 1950) it was cited as *H. plumbeum plumbeum* that is now considered as an invalid name. Camicas *et al.* (1998) presented twenty-three synonyms for *H. marginatum*. The species was recently revised and *H. marginatum* was maintained as its original status (Apanaskevich & Horak 2008). *H. marginatum* is placed in *H. marginatum* species groups with three more similar taxa including *H. rufipes*, *H. turanicum* and *H. isaaci* (Apanaskevich & Horak 2008). The most important characters for the identification of the species are absence of parma, long lateral grooves, dense scutal punctuations (the scutal punctuations are dense and large in distal and scapular areas, but variable elsewhere and usually smaller, shallower and less dense centrally), thickness of spiracular plate tail, circum-spiracular seta

density, as well as lateral (marginal) groove observed although may sometimes be seen as a line of punctuation (Figs. 9-I-II, 15-IV-VI). However, accurate identification of the *marginatum* group species requires an expert taxonomist who is familiar with morphological variability occurring in the genus *Hyalomma*. Hosseini and Tavakoli (2012) reported an instability in shape of spiracular plate of the Iranian specimens of *H. marginatum*, where it is sometimes slightly similar to *H. rufipes*.

Distribution

Our observations and earlier extensive studies confirmed that *H. marginatum* is widely distributed in entire Iran and is possibly in the second place following *H. anatolicum* (Mazlum 1971; Nabian *et al.* 2009).

Host

The species *H. marginatum* parasitizes almost all domestic ruminants (similar to *H. anatolicum*). Although Abbasian-Lintzen (1960) and Mazlum (1971) argued whether cattle or sheep and goat serve as the preferred host of *H. marginatum*. We suggest seasonal condition and geographic location as two important factors that can affect tick's behavior in host selection.

Diseases

This species is a significant vector of Crimean Congo hemorrhagic fever virus in Europe, Africa and Asia including Iran and its neighboring countries (Hoogstraal 1979). Also *H. marginatum* could be a probable vector of OCMT in Iran (Mazlum 1970).

VIII. *Hyalomma rufipes* Koch, 1844

Common name: Hairy *Hyalomma*

Taxonomic status

Recently, the taxonomic rank of *H. marginatum rufipes*, traditionally accepted as subspecies, raised to species level as *H. rufipes* (Apanaskevich & Horak 2008). This species has been described by Koch (1844). Afterwards Hoogstraal and Kaiser (1960) considered it as a subspecies rank in a distinct group with closely related taxon *H. m. turanicum*. Hoogstraal wrote an unpublished taxonomic key for the identification of Iranian *marginatum* group ticks including *H. m. rufipes* specimens (Abdigoudarzi 2003). His key was constructed based on materials sent by the Razi Institute of Iran (M. Abdigoudarzi's-personal communication). Pomerantzev (1950) used the name *H. plumbeum impressum* for *H. rufipes* (Koch 1844). Delpy (1949a) divided the taxon *H. rufipes* into two subspecies *H. r. rufipes* and *H. r. glabrum*. Iranian researchers synonymized the names *H. rufipes*, *H. rufipes glabrum* and *H. rufipes turanicum* under the taxon *H. rufipes* (Hashemi-Fesharaki *et al.* 2002; Rahbari *et al.* 2007). Three characters are important for the identification of this species including, scutal punctuation, thinness of spiracular plate tail and denser state of circum-spiracular setae (Figs. 10-I-III, 15-III-V) (Hosseini & Tavakoli 2012). However, owing to morphological variation only an expert taxonomist can accurately identify variable specimens.

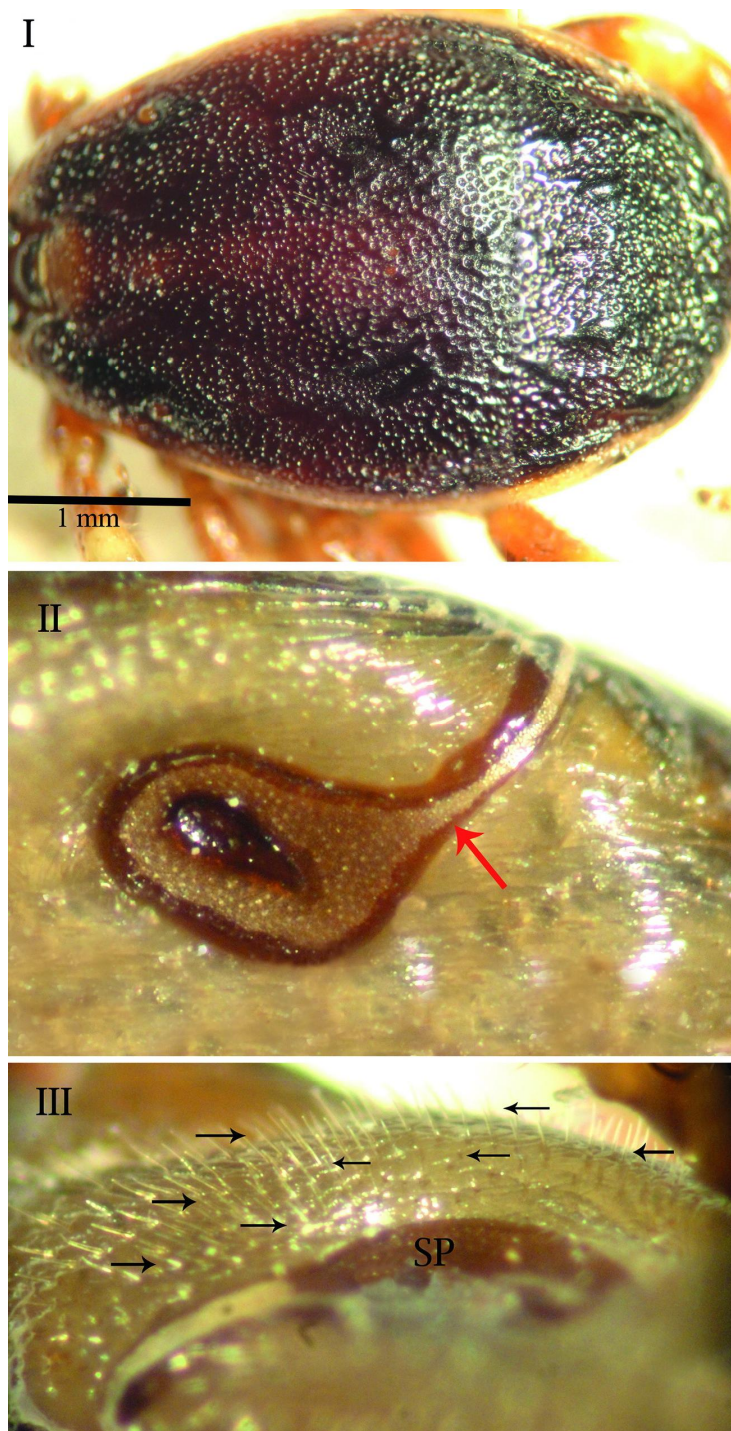


Figure 10. *Hyalomma rufipes* (male): I. Dorsal view; II. Thinness of spiracular plate tail (red arrow); III. Density of circum-spiracular setae (black arrows), SP: spiracular plate.

Distribution

In the current study *H. rufipes* was collected from western and southern parts of Iran. Although, further specimens need to be collected from other parts of Iran to confirm the establishment of this African-origin species in the Iranian territory.

Host

Domestic animals, especially cattle and sheep may be parasitized by adult *H. rufipes*. However, species can be dispersed via land migratory birds in their immature stages and causes the spread of pathogen agents to new areas (Hoogstraal 1972; Kaiser *et al.* 1974).

Diseases

Delpy (1952) reported *H. r. glabrum* (*sensu* Delpy, 1949) as a vector of the agent of tropical thileriosis *T. annulata* (Delpy 1952).

IX. *Hyalomma schulzei* Olenev, 1931

Common names: The Near Eastern Camel Hyalomma, Baluchistanian Camel Hyalomma, Iranian Camel Hyalomma or Large Camel tick (Abbasian-Lintzen 1961; Al-Asghar *et al.* 1985; Robbins & Carpenter 2011)



Figure 11. *Hyalomma schulzei* male: I. Dorsal view shown subrectangular parma (black arrow); II. Female-like spiracular plate.

Taxonomic status

According to Hoogstraal (1956), *H. schulzei* was originally described by Olenev (1931) based on males and some females of *H. dromedarii*, likely misidentified as *H. dromedarii*. No synonym has been suggested for *H. schulzei* most likely because that male of *H. schulzei* is unique among the males of *Hyalomma* species owing to its female-like spiracular plate (i.e., shortness mode of spiracular plate tail) (Figs. 11-II, 13-I). This is contrary to the male of most *Hyalomma* species where spiracular plate has comma shape form. The typical male specimens of *H. schulzei* are observed as the largest *Hyalomma* specimens.

Distribution

Nabian *et al.* (2009) reported the semi-desert area in central Iran as the geographical distribution of Iranian camel *Hyalomma* (Nabian *et al.* 2009). In the present study, several males of this species were collected from southeastern parts of Iran (Sistan va Baluchistan province). Generally, *H. schulzei* is a relatively rare species in Iran (Abbasian-Lintzen 1960).

Host

According to Abbasian-Lintzen, (1960, 1961) and Mazlum (1971), camels and cattle could be as the preferred hosts of *H. schulzei* (Abbasian-Lintzen 1960, 1961; Mazlum 1971).

Diseases

In the literature, there are no reports of *H. schulzei* as biological vector of pathogen agents.

Key to the identification of Iranian *Hyalomma* (male)

1. Posteromedian groove reaching parma (Figs. 6-I, 12-I).....2
- Posteromedian groove not reaching parma or not present (Figs. 3-II-V, 12-II).....3
2. Subanal shields situated in line with the longitudinal axis of adanal shields (Figs. 6-II, 12-III); scutal punctuations occupying less than 5 percent of the scutum that is often shiny (Fig. 6-I); lateral groove more than a half of the scutum length (in some variant populations less than a half) (Fig. 6-I); leg bands absent (Fig. 6-I).....*H. detritum*
- Subanal shields situated outside the longitudinal axis of adanal shields (Figs. 7-II, 12-IV); scutal punctuations occupying less than 5 percent of the scutum that is not shiny (Fig. 7-I); lateral groove less than a quarter of the scutum length; leg bands present.....*H. dromedarii*
3. Short spiracle plate tail (Figs. 11-II, 13-I) not reaching scutum; lateral groove less than a quarter of scutum length; parma usually subrectangular (Fig. 11-I).....
.....*H. schulzei*
- Long spiracle plate tail (Figs. 9-II, 10-II, 13-II) reaching scutum or adjacent to it; lateral groove less than a third of scutum length.....4
4. Internal and external spurs as well as fissure of coxa I short (Figs. 2-II, 13-III); all scutal grooves absent except small pit-like cervical groove (Fig. 2-I)....*H. aegyptium*
- Internal and external spurs as well as fissure of coxa I long (Fig. 13-IV); nearly all scutal grooves present.....5

5. Parma present¹ (Fig. 14-I) (i.e. size and shape of central festoon differ paraparmal festoons, its color is usually paler or semi-paler).....6
 - Parma absent (Figs. 9-I, 10-I, 14-II) (i.e. size, shape and color of central festoon are similar to those paraparmal festoons).....8
 6. Cervical grooves exceeding the scutum midlength and it appears deep (Figs. 5-I, 14-III); posterior margin of basis capituli concave (Figs. 5-II, 14-V).....*H. asiaticum*
 - Cervical grooves rarely reaching the scutum midlength and it appears as shallow (Figs. 3-I, 14-IV); posterior margin of basis capituli not concave (Fig. 14-VI).....7
 7. Arch (fusion paraparmal festoons) present (Figs. 8, 15-I).....*H. excavatum*
 - Arch (fusion paraparmal festoons) absent (Figs. 3-II-V, 15-II).....*H. anatolicum*
 8. Scutal punctuation large and compact (Fig. 15-III); circum-spiracular setae very dense (Fig. 10-III); the relative width of joint spiracle plate tail to its body is very narrow (Figs. 10-II, 15-V).....*H. rufipes*
 - Scutal punctuation small and not compact (Fig. 15-IV); circum-spiracular setae slightly dense (Fig. 9-II); the relative width of joint spiracle plate tail to its body is broad (Figs. 9-II, 15-VI).....*H. marginatum*

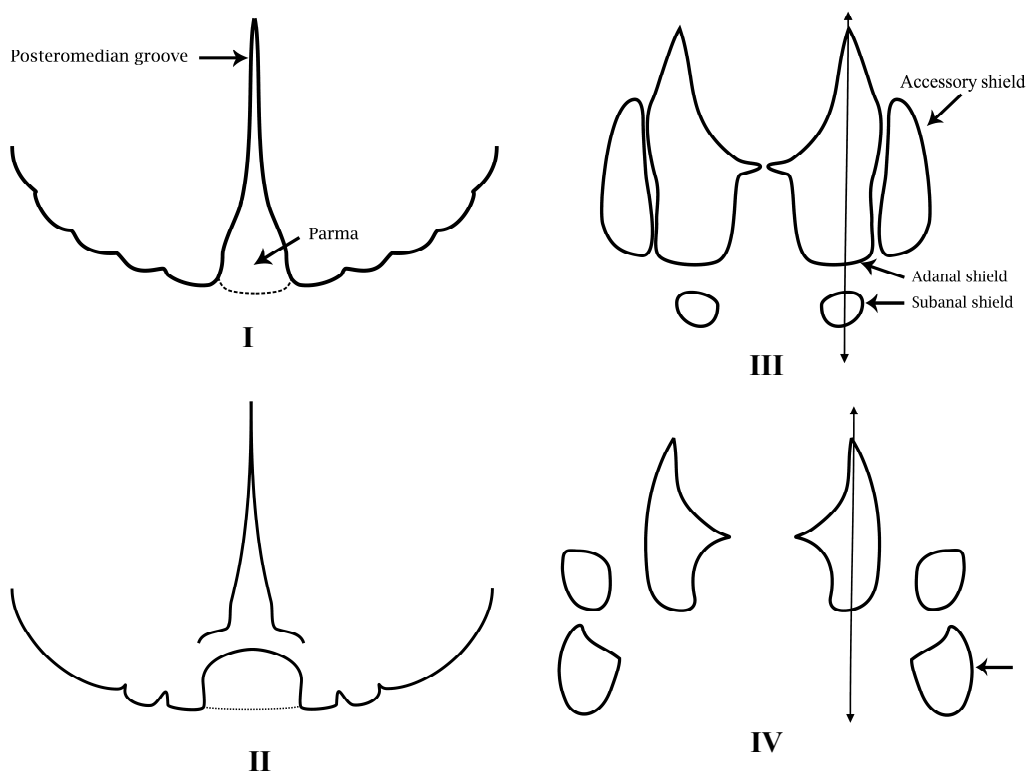


Figure 12. The situation of posteromedian groove to parma (I-II), and subanal shields with adanal shields (III-IV). I. Reaching to parma; II. Not reaching parma; III. In line with longitudinal axis; IV. Outside of longitudinal axis.

¹ Often parma having same color (rarely size and shape) of the adjacent festoon. Thus, it may seem that parma is absent. This variation is frequently observed in two closely related species *H. anatolicum* (Fig. 3-II-V) and *H. asiaticum*.

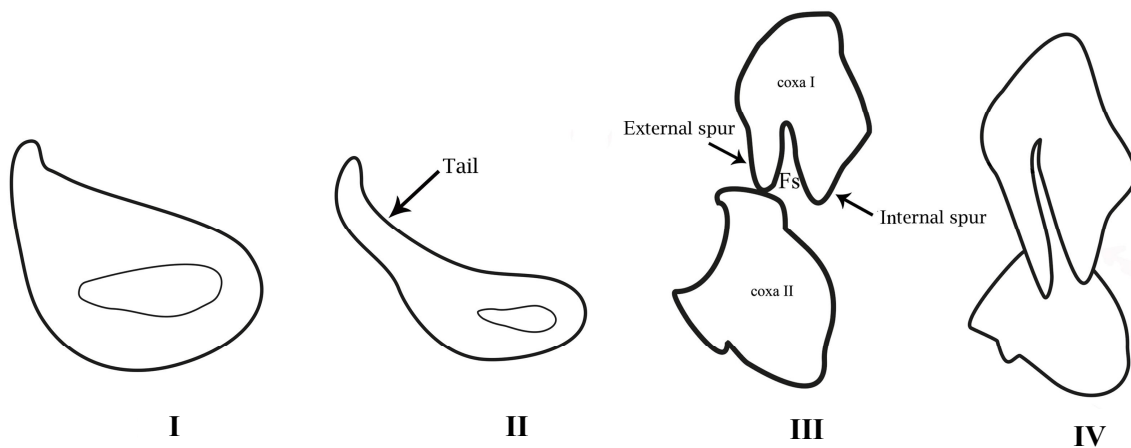


Figure 13. Spiracle plate tail (I-II), and Internal and external spurs as well as fissure on coxa I (Fs) (III-IV). I & III. Short; II & IV. Long.

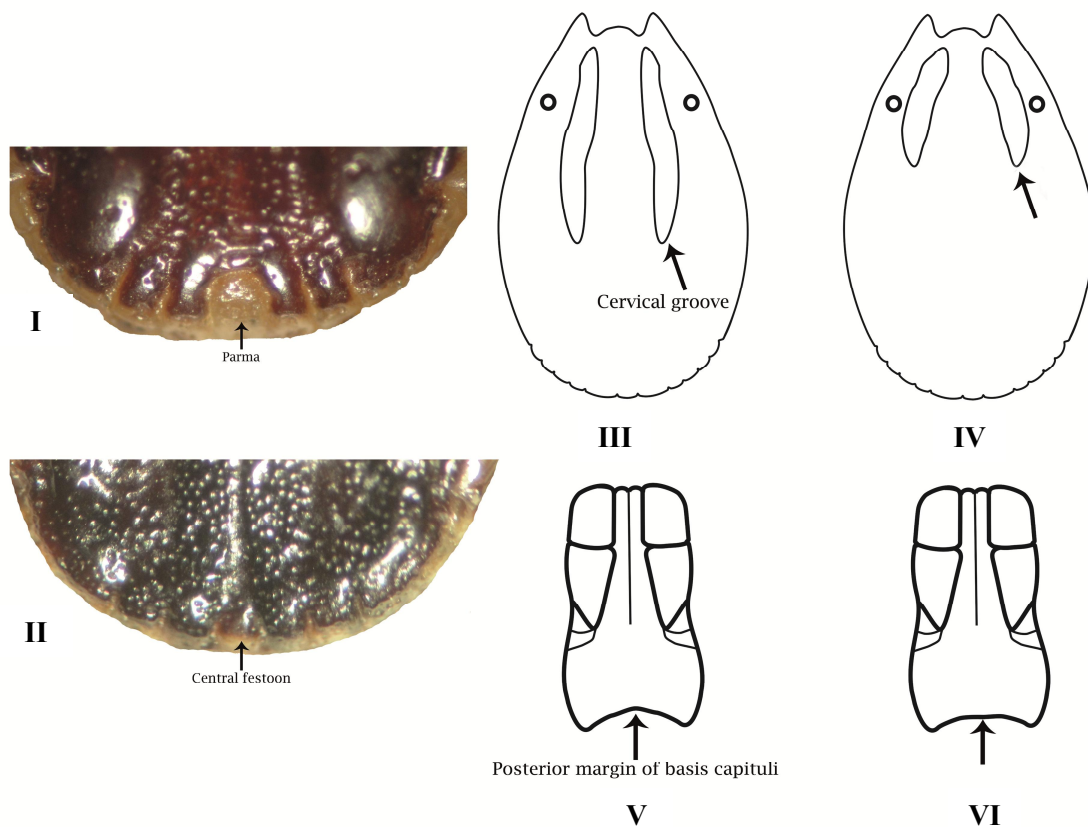


Figure 14. Parma and central festoon (I-II), position of cervical grooves related to scutum (III-IV), and posterior margin of basis capituli (V-VI). I. Parma present; II. Parma absent (it appears as central festoon); III. Exceeding scutum midlength and it appears deep (arrow); IV. Not reaching scutum midlength and it appears shallow (arrow); V. Concave; VI. Not concave

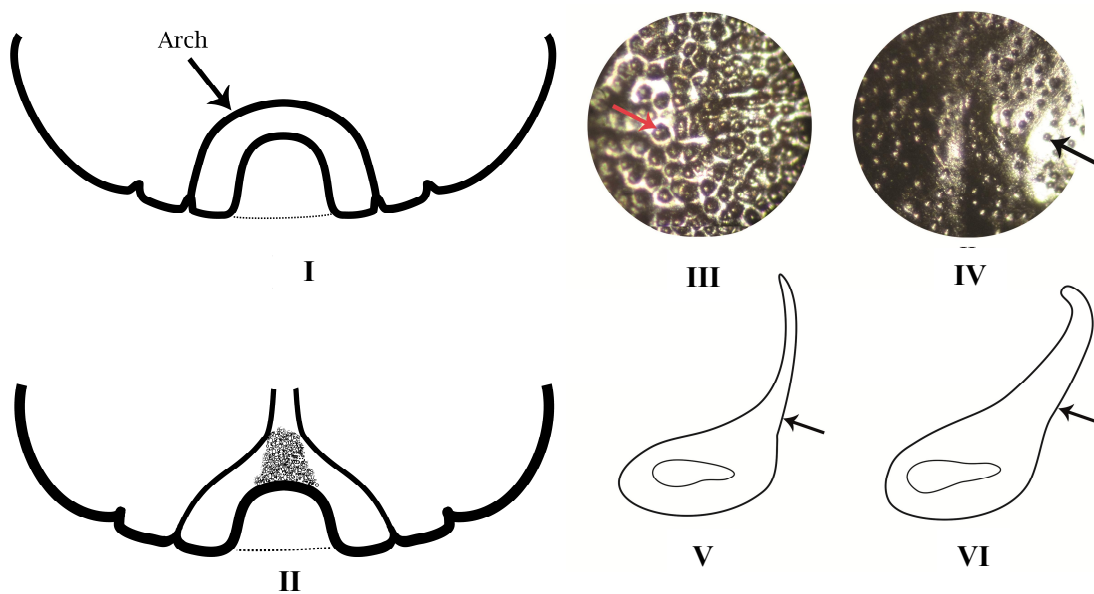


Figure 15. Arch (fusion paraparmal festoons) (I-II), scutal punctuation (III-IV), and spiracle plate tail (black arrows). I. Present; II. Absent; III. Large and compact (red arrow); IV. Small and sparse (black arrow); V. Very narrow; VI. Broad.

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گونه‌های جنس *Hyalomma* (Acari: Ixodidae) ایران و کلید شناسایی نرها

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چکیده

وضعیت رده‌بندی کنه‌های جنس *Hyalomma*، به عنوان ناقل‌های مهم عوامل بیماری‌زای حیوانات اهلی و انسان‌ها و انگل‌های خونخوار همه حیوانات خشکی‌زی به خاطر تغییرات ریخت‌شناسی، تاریخچه‌ی پر مسئله‌ای دارد. مقاله حاضر بر اساس مشاهدات نگارندگان در مورد گونه‌های *Hyalomma* ایران در طی سال‌های ۲۰۰۹ تا ۲۰۱۳ نوشته شده است. در این مطالعه برای نه گونه *H. detritum*، *H. asiaticum*، *H. anatolicum*، *H. aegyptium* شامل *H. schulzei* و *H. rufipes*، *H. marginatum*، *H. excavatum*، *dromedarii* ریخت‌شناسی به همراه چند یادداشت در زمینه ریخت‌شناسی، زیست‌شناسی و پراکندگی آنها ارائه می‌شود. در این مقاله صفات مشخصه، اطلاعات پراکندگی گونه‌ها، شکل‌های کنه‌های نر و کلید شناسایی گونه‌های *Hyalomma* بومی ایران برای تسهیل در شناسایی آنها ارائه می‌شود.

واژگان کلیدی: *Hyalomma*، کلید شناسایی، ایران، رده‌بندی، صفت ریخت‌شناسی.

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