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EPIDEMIOLOGICAL AND MORPHOLOGICAL STUDIES ON HYALOMMA SPECIES INFESTATING DROMEDARY CAMELS IN ASWAN GOVERNORATE, EGYPT

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Abstract

The study evaluated the hard ticks' prevalence parasitizing dromedary camels *(Camelus dromedaries)* in Aswan Governorate from July 2020 to August 2021. Of 1190 camels examined 1060 (89%) were infested. Factors were camel age, sex, infested site, and seasonal variations association with the tick distribution, as camels > 10 years were at higher risk rate of 97% (390/410).

The infestation rate was 90% (990/1100) in males and 77.8% (70/90) in females. Exposure to infestation was higher in summer 93.7% (458/489) than other seasons. The face, udder, testes, hind limbs, and tail were the most infested site 97.5% (1160/1190) for each, followed by forelimbs was 96.6% (1150/1190), chest was 94% (1120/1190), and abdomen was 92.4% (1100/1190). Statistical analysis of the possible associated risk factors, camel's age, gender, sampling season, and infested parts within animal body were all found to be significantly affected and related to hard tick distribution (P<0.05). Also, the identification and morphological characterization of the isolated hard ticks were performed using stereomicroscope.

Key words: Aswan Governorate, Egypt, Camels, hard tick, *Hyalomma* species.

Introduction

The Arabian one-humped camel (*Camelus dromedarius*) has a many of characteristic adaptive physical and functional abilities, making them a vital component of the desert and non-desert environments. In Egypt, camel construction is practiced on a small scale and the country burdens are met by importation, mainly from Sudan. Conversely, the financial impact of camel production is troubled by highly infectious and zoonotic diseases, inappropriate veterinary facilities and feed deficiency (Ahmed *et al*, 2020). Of particular apprehension, the hard ticks are damaging blood sucking ecto-parasites, establish in most if not all the countries of the world, but are of greater economic importance in the tropical and sub-Tropical districts (El-Tigani and Mohammed 2010). The significance of ticks is mainly owing to cause emerging and re-emerging diseases, which are important universal problems of great concern to humans as well as to animal health (Perveen *et al*, 2021a). Ticks are globally considered important arthropod vectors due to the wide variety of human and animal pathogens they can transmit (Perveen *et al*, 2020). In North Africa, ticks are one of the utmost damaging pest, and potent vectors for transmission of various bacterial, viral, rickettsial, as well as protozoan diseases of animals and man (Karesh *et al*, 2005), tick-borne protozoan diseases e.g. theileriosis and babesiosis), rickettsial diseases e.g. anaplasmosis, Rocky Mountain Spotted Fever and heart water or cowdriosis and others (Morsy *et al*, 2021), Bacterial diseases e.g. tularaemi, Spirochaetes e.g. Lyme disease "tick-borne disease affecting humans" and Relapsing fever), and Viral diseases e.g. Looping ill and African Swine Fever are the main health, and management problems of livestock (Wall and Shearer, 2001).

The main effect of tick infestation in one humped camel is mild to severe anemia, defeat appetite, leading to a fall in growth rate, and declined productivity (Mohsen *et al*, 2013). Moreover, ticks are responsible for deterioration of skin due to piercing, sucking blood, extreme pruritus, and infrequent mortalities in untreated and young animals (Constantin *et al*, 2012).

In Egypt, camels tick paralysis was reported only in Sudan by *Hyalomma* spp. adults, and/or *Rhi-picephalus* spp. adults or nymphs (Musa and Osman, 1990). But, Mosabah and Morsy (2012) in Egypt reported first zoonosis tick paralysis in four hospitalized children living in animals rearing farm in Giza Governorate. Saleh *et al.* (2016) added that when dealing with children from tick infested areas, tick paralysis must be considered in differential diagnosis of clinically confused diseases as poliomyelitis, myasthenia gravis; Guillain-Barre; paralytic rabies botulism; transverse myelitis and/or diphtheritic polyneuropathy.

Till now, only 27 *Hyalomma* species were described (Schulz *et al*, 2020). The most dominant ones were *H. dromedarii*, *H. impeltatum* Schulze et Schlottke, 1930, *H. excavatum, H. anatolicum* Koch, 1844, *H. truncatum* Koch, 1844, *H. marginatum, Hyalomma rufipes, H. turanicum* Hoogstraal et Kaiser, 1960, *H. schulzei* Olenev, 1931, and *H. impressum* (Abdel-Shafy *et al*, 2011). El Kady (1993) in Sinai reported *Hyalomma dromedarii, H. impeltatum, H. an. excavatum, H. an. anatolicum*, *H. marginatum* and *H. schulzei*. He added that *Babesia* sp. and *Theilera* sp. were recorded in tick guts and haemolymph in most species allover Sinai, *Trypanosoma* sp. was recorded in guts of ticks collected from Beer El Abd, Nakhel and Dahab, and *Anaplasma* sp. was in tick guts from Beer El Abd and Dahab, and in haemolymph of ticks collected in Nakhel and Dahab. Mazyad and Khalaf (2002) in North Sinai reported *Babesia ovis* and *Theileria ovis* in tick infested animals. They found *B. ovis* and *Th. ovis* were in 13 (2.7%), &14 (2.9%) sheep, 14 (7.0%), & 15 (7.5%) goats, 13 (9.6%), & 11 (8.1%) cattle, & 18 (9.5%), & 24 (12.6%) camels respectively. Identified adult ticks were *Rhipicephalus appendiculatus, R. bursa, R. turanicus* & *Haemaphysalis parva* on sheep, *Hyalomma an. excavatum* & *Haemaphysalis sulcata* on goats, *Hyalomma lusitanicum* on cattle and *Hyalomma dromedarii, H. impeltatum, H. marginitum* & *H. an. anatolicum* on camels. *B. ovis* and/or *Th. ovis* in gut and/or salivary glands in *R. appendiculatus* (20%), *R. bursa* (16.7%), *R. turanicus* (10%), *Haemaphysalis parva* (10%), *H. an. excavaium* (30%), *H. dromedarii* (18%), and *H. an. Anatolicum* (6.7%).

Loftis *et al.* (2006) in Egypt by PCR reported rickettsial pathogens in ticks; *Anaplasma marginale*, *Coxiella burnetii, Rickettsia aeschlimannii*, and four novel genotypes similar to “*Anaplasma platys*", *Ehrlichia canis, Ehrlichia* spp. on Asian ticks, and a *Rickettsiales endosymbiont* of *Ixodes ricinus*. Okely *et al.* (2021) studied the fauna of hard ticks on domestic animals in seven governorates of Egypt during 2018-2019. A total of 3265 individual tick specimens were collected and identified to the species level; they belong to 11 species within 3 genera (*Amblyomma*, *Hyalomma,* & *Rhipicephalus*). Tick infestation was highest in dromedary camels (70%), followed by dogs (52.5%), cattle (50%), buffaloes (38%), and horses (12%). Ten species were collected from dromedary camels, two from cattle, and a species from dogs, buffaloes, and horses.

This study aimed to investigate the prevalence and risk factors of ixodid tick infesting one-humped camels in Aswan Governorate, with an illustrative descriptive morphology of the recovered ones.

Materials and Methods

The present study was carried out at different main cities in Aswan Governorate (Aswan, Daraw, Kom-Ombo, Nasser, and Edfu), where the camels were managed and housed traditionally, during the period from July 2020 to August 2021. A total 1190 of camels of different ages (between 3 months to 15 year) were examined for tick infestations. Factors as animal age, sex, seasonal variations, infested site and location were registered.

Ticks were collected through weekly visits to the camel herds in the four cities. On each visit, ticks were collected from the skin of perennial area, ear, neck, thorax, abdomen, tail, udder and forelegs of naturally infested camels. They were carefully manipulated from the host by forceps and orientated anticlockwise until the capitulum was detached from the host; some were placed in labeled clean plastic container with perforated lids to allow ventilation and then immediately transported to the laboratory at the Department of Parasitology, Aswan Faculty of Veterinary Medicine for application with Neem extract. Another samples tick was put in plastic vials of 70% ethanol and 30% glycerin for identification by species and sex by the Standardized International Keys (Hoogstraal, 1956; Walker *et al*, 2003). Ticks were studied using stereomicroscope (SZ-ST Olympus, Japan), and photographed by a built in digital camera.

Ethical statement: The study was approved by the Ethics Committee Board, Faculty of Veterinary Medicine, Aswan University.The experimental animals used were dealt with according the rules of Helsinki (2000).

Results

The results are shown in tables (1, 2 & 3) and figures (1, 2, 3, 4, 5, 6, 7, 8, 9 & 10).

Table 1: Prevalence of *Hyalomma* spp. infestation in camels at different area in Aswan Governorate

City	Examined camels	Infested camels	%	$F_{.05}$	Sig.	LSD
Aswan	180	140 [e]	77.8	35.845	0.000	12.846
Daraw	300	290 [a]	96			
Kom Ombo	240	240 [b]	100			
Nasser	200	190 [d]	95			
Edfu	270	200 [c]	74			
Total	1190	1060	89	a,b,c,d, & e differed significantly (p<.05)		

Table 2: Prevalence of *Hyalomma* spp. among infested camels in relation to age, sex, & seasonal distribution

Variables	Age in years			sex		Season			
Camels	<5	5-10	>10	Male	Female	Summer	Autumn	Winter	Spring
Examined	320	460	410	1100	90	489	210	180	311
Infested	250[a]	420[c]	390[b]	990[b]	70[a]	458[d]	167[b]	80[a]	263[c]
Percentage	78	91.3	97	90	77.8	93.7	79.5	44.4	84.6
$F_{.05}$	11.21			507.84		8.930			
Sig.	0.009			0.000		0.000			
LSD	20.19			a, b, c, & d, differed significantly (p<.05)					

Table 3: Prevalence of *Hyalomma* spp. infestation in different sites of camels

Variables	Face	Chest	Fore limbs	Abdomen	Udder, testes	Hind limbs	Tail
Ex. camels	1190	1190	1190	1190	1190	1190	1190
Infested site	1160[a]	1120[b]	1150[b]	1100[c]	1160[a]	1160[a]	1160[a]
Percentage	97.5	94	96.6	92.4	97.5	97.5	97.5
$F_{.05}$	71.429						a, b & c differed significantly (p<.05)
Sig.	0.000						
LSD	17.51						

Discussion

Ticks are global blood feeding ectoparasites of humans and animals, consequently vectors of many pathogens that causing severe infectious diseases in humans and livestock. Moreover, ticks are responsible for substantial economic losses in a camel productivity as disturbing their health through causing mild to severe anemia, impairment to hide and devitalization udder (Al-Salihi *et al*, 2018). The dissemination restrictions of ticks are not fixed and continuous, but are determined by a complex interaction of factors as climate, host density and host vulnerability (Solomon, 2003). Such responsible factors are essential for effective tick and tick borne diseases (TBDs) control strategies (Alanr, 2011). Therefore, the present study was designed to investigate the up to date prevalence of the hard ticks *Hyalomma* spp. in dromedary camels at Aswan Governorate (Egypt).

In the present study, hard tick infesting camels showed prevalence rate in the four cities Aswan, Daraw, Kom-Ombo, Naser, and Edfu were 77.8%, 96%, 100%, 95%, & 74% respectively, with overall rate of 89%. It was obvious from aforementioned data that the examined camels in different cities of Aswan were heavily infested by hard ticks, in spite of there was a distinct variation on distribution of tick's among these cities, the highest prevalence rate of infestation was observed in Kom-Ombo City (100%, 240/240) followed by Daraw City (96%, 290/300), and Nasser city (95%, 190/200), while the lowest rate was recorded in Aswan City, and Edfu City in rates of (77.8 %, 140/180), and (74%, 200/270), respectively. These variations in prevalence rates among different cities in Aswan Governorate may be attributed to persistent tick's infestation within animal shelters as a result of the bad hygienic system e.g. lack of regular manure removal, old farm, which have wall and ground crakes and overcrowdings with limited ventilation, and/or irregular treatment of infested camels with acaricides, which emerge resistance inside treated ticks.

In the present study, the overall prevale nce rate of ticks among camels was (89%). This result was agreed with (Regassa *et al*, 2014; Hassan *et al*, 2017; Isse *et al*, 2017; Al-Salihi *et al*, 2018; Abdul Al-Hussein *et al*, 2020; Perveen *et al*, 2021b). But, disagreed with 28.6% (Abdel-Rady, 2014) in Egypt, 59.25% in Iran (Moshaverinia and Moghaddas, 2015), 60.96% in Aswan (El-Seify *et al*, 2017), 33.6% in Sinai (Allam *et al*, 2018), 68.2% in Saudi Arabia (Alanazi *et al*, 2020), 33.33% in Iran (Shamsi *et al*, 2020), 61.4% in Algeria (Kaaboub *et al*, 2021). Undoubtedly, the bedouins rear large number of camels on several ecosystems including border of the cities, villages, semi-desert and desert areas exposing the camels to tick infestations (Al-Salihi *et al*, 2018) and other ecto-parasites as *Cephalopina titillator* nasal myiasis (Morsy *et al*, 1999), or Sarcoptic mange (Kotb and Abdelrady, 2015).

In the present study, there was a significant relationship between animal age and tick infestation (P< 0.05), camels aged 10-14 years was (97%), 5-10 years was (91.3%), while the lowest was (78%) in aged camel less than 5 years. This more or less agreed with Hussein and Al-Fatlawi (2009), they found (87%) among camel aged 10 years or older followed by (86%) in 5-10 years and lowest was (63%)in camels less than 5 years; Champour *et al.* (2013) found a rate of (94%) in camels less than 5 years (61%) in camels 6-10 years and (45%) in camels > 10 years; Bala *et al.* (2018) found a rate (59.54%) in younger camels (5-10 years), and (0.36%) in 16-20 years that increased to (2.78%) in those aged 20 years. Khelifi-Ouchene *et al.* (2020) in Algeria found that the camels less than one year was 15.08%, between 1-5 years (77.15 %), between 5-10 years (4.31%), and more than 10 years (3.5%). These differences may be attributed to sexually mature camels prone to stress of hormonal changes, which attracted ticks (Hussein and Al- Fatlawi, 2009).

In the present study, sex was another significant risk factor (P< 0.05) as males were at higher risk of tick infestation (90%) than females (77.8%). This observation agreed with Nourollahi Fard *et al.* (2012) they reported (66.2%) in male and (33.8%) female; Champour *et al.* (2013) reported (72.2%) in male, and (27.8%) in female, Bala *et al.* (2018) detected that males (17.27%), and females (82.73%), Khelifi-Ouchene et al. (2020) reported (60.77%) in males, and (39.23%) in females, Abdul Al-Hussein *et al.* (2020) reported males were (93.1%) and females were (99.11%), Shamsi *et al.* (2020) reported (88.46%) in the males and (11.53%) in females. No doubt, high tick rates on males than females since females were kept indoors for reproduction under good and clean observations while males were left outdoors for grazing and thus contact especially contaminated fomites with ticks. However, Al-Salihi *et al.* (2018) in Iraq found the highest infestation (98.48%) in females than (75%) in males and Elati *et al.* (2021) in Tunisia found that female camels were more infested (88.3%) than males 65.5%. The difference between male and female tick's infestation may be attributed the difference in the owners habitats, geographical and ecological factors.

In the present study, a seasonal variations of camels infestation were higher in summer (93.7%), and the lowest infestation occur in winter (44.4%), This agreed with Nourollahi Fard *et al.* (2012), Moshaverinia and Moghaddas (2015), Hassan *et al.* (2017), Perveen *et al.* (2020) and Shamsi *et al.* (2020). But, this disagreed with Bala *et al.* (2018) they found that the autumn rate was (40.22%), followed by winter (30.07%) and summer (29.71%).

In the present study, the face, udder, testes, hind limbs, and tail were the most infested site with rate of (97.5%, 1160/1190) for each, followed by fore limbs (96.6%, 1150/ 1190), chest (94%, 1120/1190), and abdomen (92.4%, 1100/ 1190). This more or less agreed with Nazifi *et al.* (2011) in Iran found adult ticks on axilla (36%), groin (20%), interdigital cleft (14%), genital area (12%), anus (10%), tail-brush (4%) and ears (4%), Nourollahi Fard *et al.* (2012) found that perineum and chest infested rate was (91.1%), external ear (6.3%), shoulder (2.6%), Perveen *et al.* (2020) reported that most c ticks were found attached to the perianal, and vulvar regions, the inner surface of thighs, udder, and inguinal region, but fewer ticks were on pinna, and tchest region, Al-Deeb and Muzaffar (2020) found that the highest number of ticks were on tail area followed by abdomen, and Elati *et al.* (2021) in Tunisia illustrated the preferred attachment sites for adult *Hyalomma* ticks were the sternum (38.3%), around the anus (36.2%), udder (18.4%), and inner thigh (6.9%).

In the present study, genus *Hyalloma* was easily identified from other genera of Ixodid as female (6-17mm), and male (5-7mm) in length, *Hyalomma* scutum brownish in colored. Enamel (= ornamentation) was absent from the scutum and conscutum, basis capituli with angular lateral margins, cervical fields depression was apparent, convex eyes at scutum edge, four pairs of legs with paler rings ended with pulvilli. Festoons were present in males and in females but unclear in fed females. Ventrally had coxae at all legs with uniform dark color and smooth texture, only first pair with distinct paired spurs large, equal internal and external spurs, female genital aperture with deep anterior groove, and posterior lips, ventral plates in males only as three distinct pairs, anal groove was posterior to anus in male and female *Hyalloma*, spiracular plates were large and posterior to fourth legs (Mehlhorn, 2012).

Diagnosis of female *Hyalomma* spp. was difficult in engorged ones, due to variability in taxonomic characters that may overlapped in different species without distinctive characters. Morphological variation in different *Hyalomma* spp. may cause misidentification among closely related taxa, *H. excavatum*, *H. asiaticum* and *H. marginatum*. Taxonomic characteristics to differentiate of species in males included cervical groove, basis capituli and lateral grooves on scutum (Hosseini-Chegeni *et al*, 2013), engorged female *Hyalomma anatolicum* was more closely similar to *H. excavatum* as the females species overlap in some areas (Walker *et al*, 2003).

In the present study, identification of female *Hyalloma* spp. was difficulty and inaccur acy to classify the isolated *Hyalomma* spp. unless using the SEM or diagnostic PCR, which was unavailable. It was important to isolated *Hyalloma* spp., as male of *Hyalomma dromedarii, H. anatolicum, H. excavatum,* and *H. marginatum* easily recognized by keys (Hosseini-Chegeni *et al*, 2013).

Hyalomma dromedarii male, body length 7mm, varied between yellowish brown to dark brown, anterior region, dorsally characterized by presence of blade shape hypostome with paired chelicerae, three palp articles like segments on each hypostome side, basis capituli with blunt lateral angels and medium angular lateral margins, short cornua paired projections from outer margins of posterior dorsal surface of basis capituli, convex eyes at both conscutum edge, apparent large curved cervical field depression along each side of intercervical field, small to medium interstitial punctuation sparsely distributed via male dorsal surface. Ventrally palps which are paired structures of the mouthparts at each side of hypostome and composed of three pairs of articles like segments, and second one longer than first and third article, all legs coxae normal with uniform dark color and smooth texture and first legs with distinct paired spurs (large, equal internal & external spurs). Genital aperture located between second coxae. Posterior region dorsally has short lateral grooves, large paramedian groove upto parma, distinct posteromedian groove, central festoon (parma) pale, and paracentral festoons separate anteriorly, subanal plates projected beyond body posterior margin, and seen dorsally in blood engorged male. Posterior end ventrally characterized by large comma shape spiracular plates posterior to fourth coxae, anal groove posterior to anus, anal shields (3 pairs of ventral plates); pair of adanal plates with round ends and curved medially, pair of subanal plates outside longitudinal axis of adanal plates, and another pair of accessory adanal plates.

Hyalomma an. anatolicum male was distinguished from other closely related species as *H. dromedarii*. *H. anatolicum* 3-4 mm in length, smooth shiny and pale in color, central festoon (parma) pale, paracentral festoons separates anteriorly (a distinctive feature from *H. excavatum*), legs yellow brownish colored or marbled pattern, with indistinct rings, punctuation small with sparse distribution, adanal plates with a round end, subanal plates indistinct, and no accessory adanal plates.

Hyalomma an. excavatum male, 3-4 mm in length, dark in color, Paramedian grooves indistinct, paracentral festoons joined anteriorly to form an arch, central festoon pale, leg marbled light brownish in color, adanal plates with square ends, small accessory adenal plate, and distinct subanal plates.

Hyalomma marginatum male, 3-4 mm in length, dark brown color, lateral grooves long, paramedian grooves small (all posterior grooves shallow indistinct), marbled leg coloration with pale rings, central festoon dark, and paracentral festoons separated anteriorly, adanal plates shape with square ends, small accessory adanal plate, and small distinct subanal plate.

Conclusion

Generally, mosquitoes and ticks are the main arthropod-vectors of many zoonotic diseases, whether virus, bacteria or protozoa.

The outcome resulted showed that camels in the four main cities in Aswan Governorate were infested with many *Hyalomma* species. The health of camels can be altered by the direct and indirect effects of ticks, causing significant losses in the production of meat, milk, and leathers, and in many cases the death of the affected camels. The damage produced by ticks when feeding on the blood of their hosts, while the indirect losses are related to the zoonotic infectious agents transmitted by ticks, and the high costs associated to the treatment and control

This must be in mind of the camels' owners as well as the Public Health and the Agricultural Authorities to suggest feasible control measures

References

Abdel-Rady, A, 2014: Epidemiological studies on parasitic infestations in camels (*Camelus dromedaries*) in Egypt. Eur. J. Environ. Ecol. 1, 1: 16-20.

Abdel-Shafy, S, El Namaky, AH, Khalil, FH M, 2011: Scanning electron microscopy, and morphometrics of nymph and larva of the tick *Hyalomma impressum* (Acari: Ixodidae). Parasitol. Res. 109, 6:1509-18.

Abdul Al-Hussein, AH, Shanan, AH, Al-Salihi, KA, 2020: Prevalence of ticks' infestation in dromedary camels (Camelus dromedarius) in area surrounded Sawa Lake/Iraq. MRVSA 9, 3:24-36.

Ahmed, MA, Elmahallawy, EK, Gareh, A, Abdelbaset, AE, El-Gohary, FA, *et al*, 2020: Epidemiological and histopathological investigation of Sarcoptic mange in camels in Egypt. Animals 10, 9:1485. DOI: 10.3390/ani 10091485m.

Alanr, W, 2011: Eradication and control of livestock ticks: Biological, economic and social perspectives: Royal (Dick) School of Veterinary Studies, University of Edinburgh, Summerhall Place, Edinburgh EH9 1QH, UK.

Al-Deeb, MA, Muzaffar, SB, 2020: Prevalence, distribution on host's body, and chemical control of camel ticks *Hyalomma dromedarii* in the United Arab Emirates. Vet. World 13, 1:114-20.

Allam, NAT, El Moghazy, FM, Abdel-Baky, S MM, 2018: Molecular epidemiological updates on spotted fever rickettsioses in animal species and their hard ticks settling Egyptian desert. J. Adv. Pharm. Edu. Res., 8, 1:64-74.

Alanazi, AD, Nguyen, VL, Alyousi, MS, *et al*, 2020: Ticks and associated pathogens in camels (*Camelus dromedarius*) from Riyadh Province, Saudi Arabia. Parasit. Vectors 13:110-8.

Al-Salihi, KA, Karim, AJ, Jasim, HJ, Kareem, FA, 2018: Epidemiology of ticks' fauna of camels in Samawah desert. Adv. Anim. Vet. Sci. 6, 8:311-6.

Bala, DEA, Abakar, AD, Mohammed, MS, *et al*, 2018: Seasonal prevalence and geographical distribution of ticks of camels (*Camelus dromedaries*) in four states of Great Butana, Sudan. J. Entomol. Zool. Stud. 6, 3:1212-20

Champour, M, Mohammadi, G, Chinikar, S, *et al*, 2013: Frequency of hard-ticks and the influence of age and sex of camel on ticks' infestation rates in one-humped camel (*Camelus dromedarius*) population in the northeast of Iran. Sci. Parasitol. 14, 2:89-93.

Constantin, T, Paraschiv, I, Ioniţă, M, Mitrea, IL, 2012: The efficacy of different acaricides against the hard tick *Dermacentor marginatus* on infested sheep. Vet. Med. 58:372-9.

Elati, K, Bouaicha, F, Dhibi, M, *et al*, 2021: Phenology and phylogeny of *Hyalomma* spp. ticks infesting one-humped camels (*Camelus dromedarius*) in the Tunisian Saharan bioclimatic zone. Parasite 28:44-9.

el Kady, GA, 1998: Protozoa parasites in tick species infesting camels in Sinai Peninsula. J. Egypt. Soc. Parasitol. 28, 3:765-76.

El-Seify, MA, Ebrahaium, AA, Hashem, MA, Kamel, ZM, 2017: Studies on role of ticks in transmission of some blood parasites in camel. Kafr-Elsheikh Vet. Med. J.15, 1:105-25.

El-Tigani, MA, Mohammed, AS, 2010: Ticks (Acari: Ixodidae) Infesting Camels in El Butana Area, Mid-Central Sudan. J. Vet. Res. 25:51-4.

Hassan, MI, Gabr, HSM, Abdel-Shafy, S, *et al*, 2017: Prevalence of tick-vectors of *Theileria annulata* infesting the one humped camels in Giza, Egypt. J. Egypt. Soc. Parasitol. 47, 2:425-32.

Hoogstraal, H, 1956: Editor African Ixodoidea Vol. 1, Published by NAMRU-3, Cairo, Egypt

Hosseini-Chegeni, A, Hosseini, R, Tavakoli, M, *et al*, 2013: The Iranian *Hyalomma* (Acari: Ixodidae) with a key to the identification of male species. Persian J. Acarol. 2, 3:503-29.

Hussein, MH, Al-Fatlawi, MMA, 2009: Study the epidemiology of ticks infected *Camelus dromedaries* in Al Qadysia City. Al-Anbar J. Vet. Sci. 2, 1:1-7

Isse, F, Saed, A, Ali, M, 2017: Hard tick distribution of camels in and around Galkaio District, Somalia. Global J. Med. Res. 17, 1:12-6

Kaaboub, EA, Ouchene, N, Ouchene-Khelifi, NA, *et al*, 2021: Investigation of the principal vectors of abortive diseases in one-humped camels (*Camelus dromedarius*). Iraqi J. Vet. Sci. 35, 3:411-5.

Karesh, WB, Cook, RA, Bennet, EL, Newcomb, J, 2005: Wildlife trade and global disease emergence. Emerg. Infect. Dis. 11:1000-2.

Khelifi-Ouchene, NA, Ouchene, N, Dahmani, A, Kaaboub, E, *et al*, 2020: Investigation of internal and external parasites of the camels (*Camelus dromedarius*) in Algeria, Ann. Parasitol. 66, 3:331-7.

Kotb, S, Abdel-Rady, A, 2015: Sarcoptic mange of camel in Upper Egypt; prevalence, risk assessment, and control measures. J. Adv. Anim. Res. 2, 4:410-7.

Loftis, AD, Reeves, WK, Szumlas, DE, Abbassy, MM, Helmy, IM, *et al*, 2006: Rickettsial agents in Egyptian ticks collected from domestic animals. Exp. Appl. Acarol. 40, 1:67-81

Mazyad, SAM, Khalaf, SAA, 2002: Studies on *Theileria* and *Babesia* infecting live and slaughtered animals in Al Arish and El Hasanah, North Sinai Governorate, Egypt. J. Egypt. Soc. Parasitol. 32, 2:601-10.

Mehlhorn, H, 2012: Arthropods as Vectors of Emerging Diseases, Parasitology Research Monographs 3, Springer-Verlag Berlin Heidelberg. DOI:10.1007/978-3-642-28842-5_8.

Mohsen, C, Gholamreza, M, Sadegh C, *et al*, 2013: Frequency of hard-ticks and the influence of age and sex of camel on tick's infestation rates in one-humped camel *(Camelus dromedaries)* population in the northeast of Iran. Sci. Parasitol. 14, 2:89-93.

Morsy, TA, Farrag, AMK, Mazyad, SAM, Abou-Gamra, M, 1999: Evaluation of ELISA kit hypodermosis in serodiagnosis of *Przhevalskiana silenus* in goats and *Cephalopina titillator* in camels. J. Egypt. Soc. Parasitol. 29, 3: 709-20

Morsy, TA, Sallam, TA, Fouad, MAH, 2021: Overview on tick borne diseases and paralysis with reference to Egypt. J. Egypt. Soc. Parasitol. 51, 1:55-62

Mosabah, AAA, Morsy, TA, 2012: Tick paralysis: First zoonosis record in Egypt. J. Egypt. Soc. Parasitol. 42, 1: 71-8.

Moshaverinia, A, Moghaddas, E, 2015: Prevalence of tick infestation in dromedary camels (*Camelus dromedarius*) brought for slaughter in Mashhad abattoir, Iran. J. Parasit. Dis. 39, 3: 452-5.

Musa, MT, Osman, OM, 1990: An outbreak of suspected tick paralysis in one-humped camels (*Camelus dromedarius*) in the Sudan. Rev. Elev. Méd. Vét. Paystrop. 43:505-10.

Nazifi, S, Tamadon, A, Behzadi, M, *et al*, 2011: One-humped camels (*Camelus dromedaries*), the hard ticks infestation in Qeshm Island, Iran. Vet. Res. Forum 2:135-8.

Nourollahi Fard, SR, Fathi, S, Norouzi. AE, *et al*, 2012: Hard ticks on one-humped camel (*Camelus dromedarius*) and their seasonal population dynamics in southeast, Iran. Trop. Anim. Hlth. Prod. 44:197-200.

Okely, M, Anan, R, Gad-Allah, S, Samy, AM, 2021: Hard ticks (Acari: Ixodidae) infesting domestic animals in Egypt: diagnostic characters and a taxonomic key to the collected species. Med. Vet. Entomol. 16 January 2021; https:// doi. org/10.1111/mve.12502

Perveen, N, Muzaffar, SB, Al-Deeb, MA, 2020: Population dynamics of *Hyalomma dromedarii* on camels in the United Arab Emirates. Insects 11, 320; doi: 10.3390/insects11050320.

Perveen, N, Muzaffar, SB, Al-Deeb, MA, 2021: Ticks and tick-borne diseases of livestock in the Middle East & North Africa: A review. Insects 12,83:https://doi.org/10.3390/insects12000.

Perveen, N, Muzaffar, SB, Al-Deeb, MA, 2021: Prevalence, distribution, and molecular record of four hard ticks from livestock in the United Arab Emirates. Insects 12, 1016: https:// doi.org/10.3390/insects12111016.

Regassa, A, Awol, N, Hadush, B, *et al*, 2014: Internal and external parasites of camels (*Camelus dromedarius*) slaughtered at Addis Ababa Abattoir, Ethiopia. J. Vet. Med. Anim. Hlth. 6, 7:12-9

Saleh, MSM, Morsy, ATA, Ismail, MAM, Morsy, TA, 2016: Tick-borne infectious diseases with reference to Egypt. J. Egypt. Soc. Parasitol. 46, 2:273-98.

Schulza, A, Kargerb, A, Bettin, A, *et al*, 2020: Molecular discrimination of *Hyalomma* tick species serving as reservoirs and vectors for Crimean-Congo hemorrhagic fever virus in sub-Saharan Africa. Ticks Tick-bor. Dis. 11:101382.

Shamsi, L, Samaeinasab, S, Haghighatkhah, A, 2020: Identification of ectoparasites of camels in Sabzevar City, Iran. Ann. Parasitol. 66, 4:555-9.

Solomon, G, Nigist, M, Kassa B, 2003: Seasonal variation of ticks on calves at Sebeta in Western Shewa Zone. Ethiop. Vet. J. **7**:17-30.

Wall, R, Shearer, D, 2001: Veterinary Ectoparasites: Biology, Pathology & Control, 2nd ed., Longman Scientific and Technical, NY, USA.

Walker, AR, Bouattour, A, Camicas, JL, Estrada-Peña, A, Horak, IG, *et al*, 2003: Ticks of Domestic Animals in Africa: A Guide to Identification of Spec-ies; Bioscience Reports: Edinburgh, the United Kingdom.

Explanation of figures

Fig. 1: *Hyalomma* spp. female with variable length (6mm- 17mm).

Fig. 2: *Hyalomma* spp. female (Dorsal view); a- Fully engorged female, b- Engorged female, c- Partially engorged female, d- Non- engorged female.

Fig. 3: *Hyalomma* spp. female (Ventral view); a- Fully engorged female, b- Engorged female, c- Partially engorged female, d- Non- engorged female.

Fig. 4: *Hyalomma* spp. engorged female, anterior end Left D.V. a- Basis capituli with sharp angular lateral margins. b- Cervical apparently depressed. c- Convex eyes at scutum edge. d- Intercervical field. e- Scutum posterior margin slightly sinuous Right V.V., a- Coxae of all legs

normal with a uniform dark color and smooth texture and only first legs with distinct paired spurs (large, equal internal and external spurs). b- Genital aperture with deep anterior groove. c- Genital aperture posterior lips have a narrow V shape.

Fig. 5: *Hyalomma* spp. engorged female posterior end, Left D.V., Right V.V.: a- Anal opening. b- Anal groove. c- Large spiracular plate posterior to legs 4.

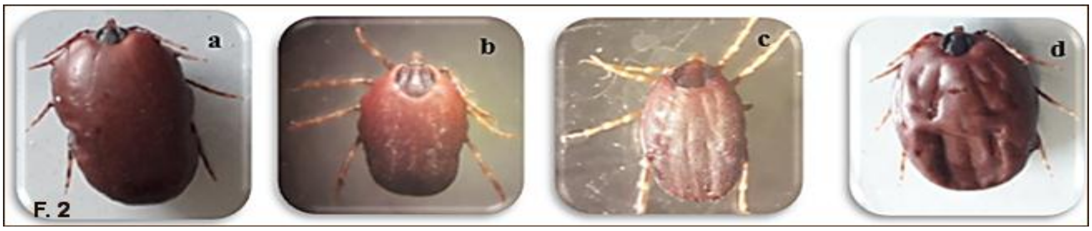
Fig. 6: *Hyalomma* spp. engorged male with variable length (5-7mm).

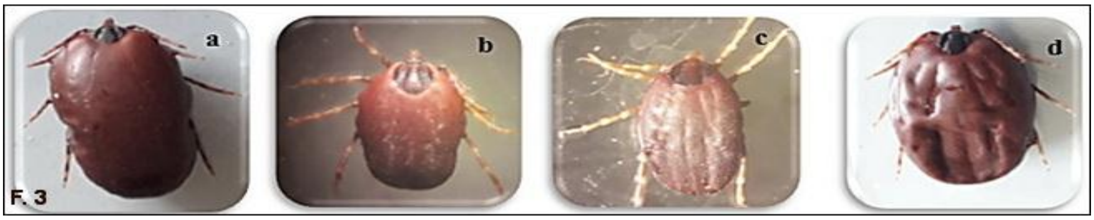
Fig. 7: *Hyalomma* spp. (Left); fully engorged female with 17mm in length, (Right); fully engorged male (7mm)

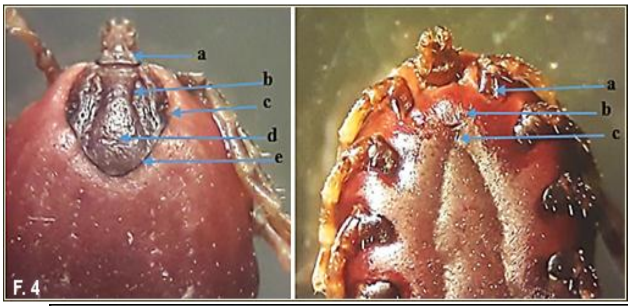
Fig. 8: *Hyalomma dromedarii:* fully engorged male anterior region Left D.V.: a- Hypostome. b- Palp articles. c- Basis capituli with medium angular lateral margins. d- Convex eyes at conscutum edge. e- Scapular or cervical depressed. f- Punctation large size, punctation sparsely distributed). g- Intercervical field. Right V.V.: a- Palp articles 2 longer than articles 1 & 3. b- Coxae of all legs normal with a uniform dark color and smooth texture and first legs with distinct paired spurs (large, equal internal &external spurs). c- Genital aperture between coxae 2.

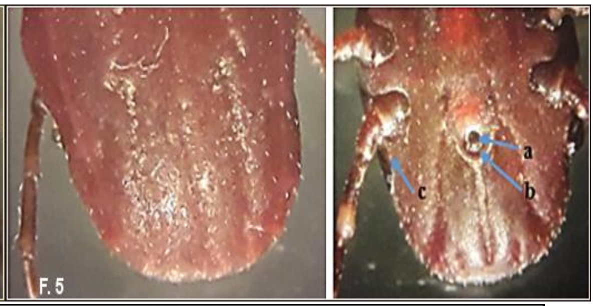
Fig. 9: *Hyalomma dromedarii:* fully engorged male posterior region, Left D.V. a- short lateral grooves, b- Large paramedian grooves, c- Posteromedian groove, d- Central festoon is pale colored. Paracentral festoons are separate anteriorly. e- Festoons. f- Subanal plates projected beyond posterior margin of the body. Right V.V.: a-Large spiracular plate posterior to legs 4. b- Anus. c- Anal groove. d- Accessory adanal plates. e- Adanal plates. f- Subanal plates.

Fig. 10: Illustration of male *Hyalomma dromedarii*, *H. anatolicum*, *H. excavatum* and *H. marginatum*.

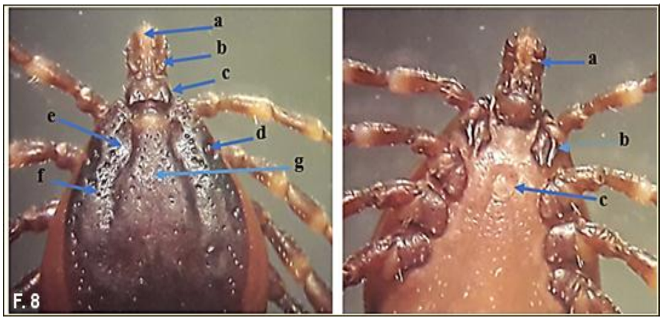









F. 7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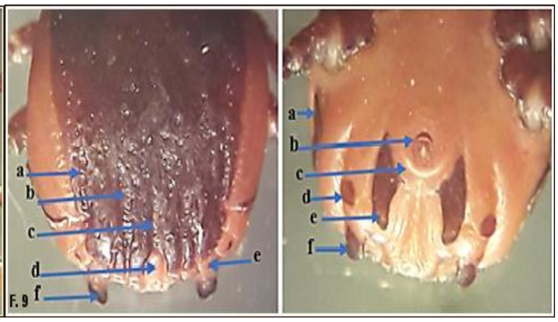
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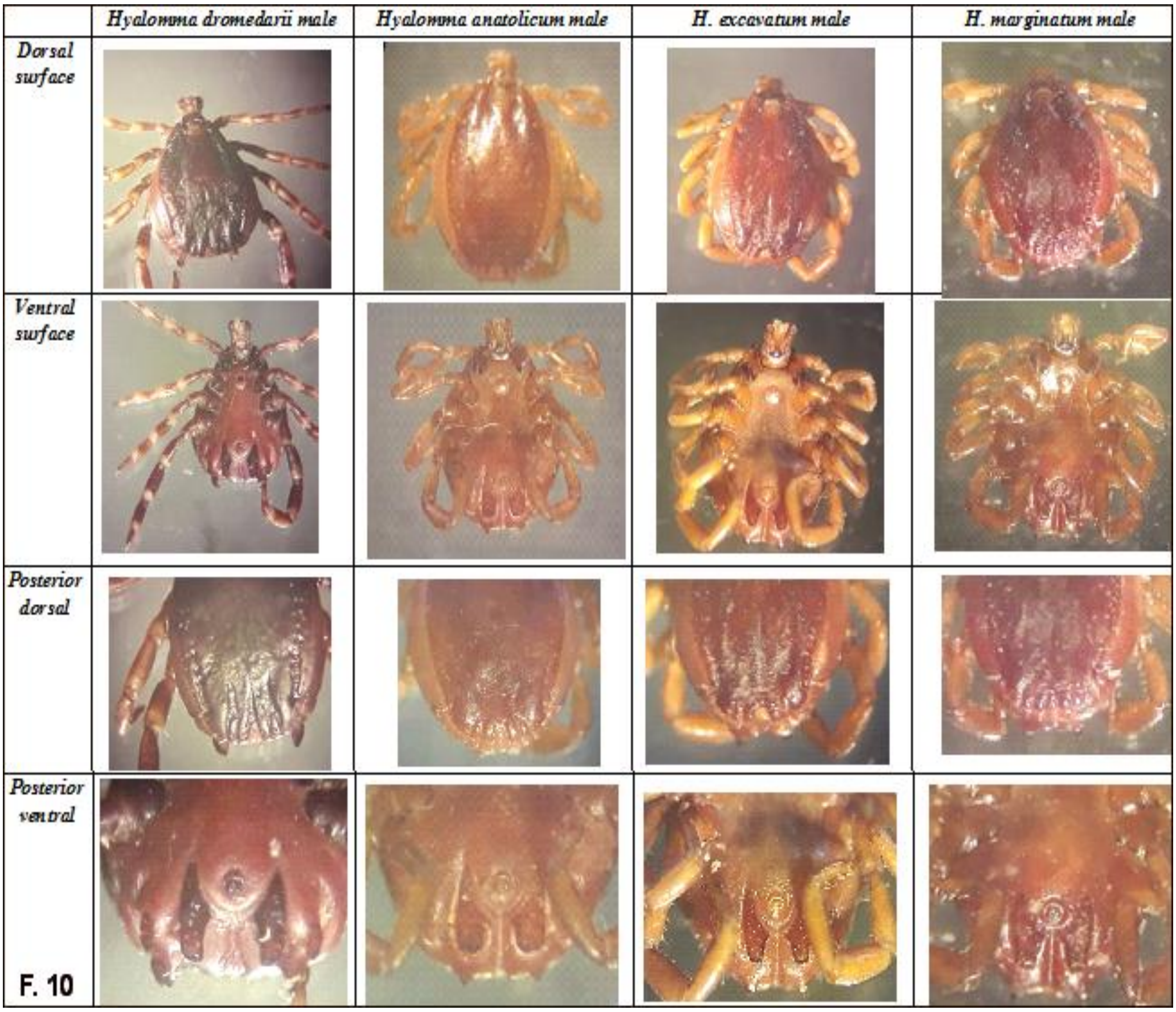
Hyalomma dromedarii male
Hyalomma anatolicum male
H. excavatum male
H. marginatum male
Dorsal surface
Ventral surface
Posterior dorsal
Posterior ventral
F. 10