Chapter

Spinose Ear Tick *Otobius megnini* Infestations in Race Horses

Rupika S. Rajakaruna and Chulantha Prasanga Diyes

Abstract

Spinose ear tick, *Otobius megnini*, has a worldwide distribution causing otoacariasis or parasitic otitis in animals and humans. It mainly infests horses and cattle. It is a nidicolous, one-host soft tick spread from the New World to the Old World and is now distributed across all the continents. Only the larvae and nymphs are parasitic, feeding inside the ear canal of the host for a long period. Adult males and females are free-living and nonfeeding, and mating occurs off the host. Being inside the ear canal of the host allows the tick to be distributed over a vast geographic region through the distribution of the host animals. The presence of infectious agents *Coxiella burnetii*, the agent of Q fever, spotted fever rickettsia, *Ehrlichia canis*, *Borrelia burgdorferi*, and *Babesia* in *O. megnini* has been reported, but its role as a vector has not been confirmed. Human infestations are mostly associated with horse riding and farming through close contacts with companion animals. Control measures involve use of acaricides, repellants, and biological control methods. However, controlling the tick population and its spread is extremely difficult due to its life cycle pattern, seasonal dynamics, and resistance to certain acaricides.

Keywords: *Otobius megnini*, spinose ear tick, horses, otoacariasis

1. Introduction

The spinose ear tick, *Otobius megnini* (Dugès 1883) (*Acari*: *Ixodida*: *Argasidae*), is an economically important soft tick as it parasitizes livestock mostly cattle, goats, sheep, and horses and also infests humans [1–7]. *Otobius megnini* is a one-host soft tick from the New World with a wide geographical distribution. Its original center of distribution is considered to be the southwestern North America from where it spread to Central and South America [5, 8]. Since the larva and the nymph of this tick feed inside the ear canal of the host for a long period, it allows the tick to be distributed over a vast geographic region transcontinentally through the distribution of the host animals. It has distributed far north as Canada where it is reported southeastern parts of British Columbia infesting mountain goats, mountain sheep, mule, white-tailed deer, elk, cattle, and a house cat [9]. Two scenarios have been put forward to explain how the tick reached the Old World: (1) During the Boer Wars (in the late nineteenth century between the United Kingdom and the Boers of the South African Republic), the movement of horses bringing the tick from South America or Mexico to South Africa and (2) after the Boer Wars, importation of cattle from the United States to South Africa [5]. From there it was introduced to many neighboring countries in the African continent: Madagascar, Lesotho,

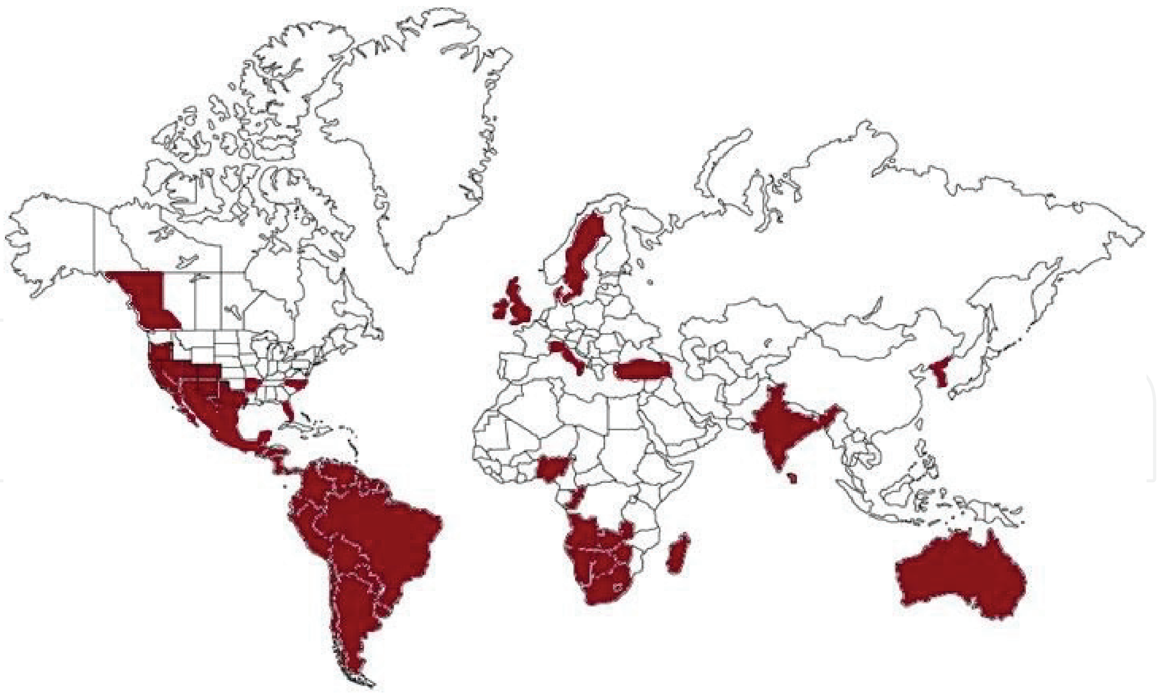

Figure 1.
Geographic distribution of spinose ear tick Otobius megnini (modified from Keirans and Pound [5] with permission).

Botswana, Namibia, Zimbabwe, Zambia, Malawi, Nigeria, and Democratic Republic of Congo [5]. The first report of *O. megnini* from Europe was in 1901 from a US resident who visited the UK with a tick in the ear [10], and there is another unverified report of *O. megnini* from Denmark [11]. Dogs imported from South Africa to Italy [12] and to Sweden carried the tick in the ear canal [13]. In Turkey, it was first recorded in 1988 [14], and it is well established now [15–17]. *Otobius megnini* is thought to have reached India in the mid-1930s together with cattle or horses brought from Southern Africa. This tick species is recorded in race horses brought from farms in northern India for an auction at the Madras Race Club [18]. There is a speculation that *O. megnini* was introduced to Sri Lanka from India via horse trading. The first report of *O. megnini* in Sri Lanka is in 2010 from stable workers and jockeys as an intra-aural infestation [7, 19]. In Sri Lanka, this tick appears to have a limited distribution with no records of it infesting any other domesticated animals other than horses in the racecourses. It has now moved to Far East as Korea [20] and Western Australia [21] and has been recently reported from Iran [22]. **Figure 1** shows the current geographic distribution of *O. megnini* in the world.

The presence of *O. megnini* inside the ear canal is known as otoacariasis or parasitic otitis. It can cause toxic conditions, allergies, paralysis, muscle spasms, irritations, eardrum perforation, and myotonia, and *O. megnini* has been listed as a potential vector for many tick-borne infections [23–25]. Studies have reported deaths of domestic cattle and horses as a result of heavy infestation of *O. megnini* [9, 26–29].

2. Horse otoacariasis

Otobius megnini is the causative agent of horse otoacariasis. This condition can cause serious injury and occasionally death in horses [9, 30], and common clinical signs include abnormal head carriage, head shaking, and head rubbing [31]. Early studies report nervous disease [32] and auricular nerve paralysis [33] due to the presence of *O. megnini* in the ear canal of horses. Intermittent painful muscle

DOI: http://dx.doi.org/10.5772/intechopen.80784

Figure 2.
Spinose ear tick Otobius megnini inside the ear canal of a racehorse.

cramps not associated with exercise were described in horses that were severely infested with *O. megnini* [34]. Infested horses show cramping of pectoral, triceps, and abdominal muscles lasting from minutes to a few hours with severe pain that often resembles colic [34]. Between muscle cramps, horses appear to be normal, and once the ticks are removed, clinical signs are reduced and recovered within 12–36 h [34]. While a neurological pathology that includes muscle tremors and muscle contractions are observed, electromyographic measurements suggest these may be due to increased motor unit activity [34]. No conclusive evidence supports the classification of *O. megnini* as a paralysis tick. The fact that this tick feeds within the ears of its hosts where inflammatory reactions could affect the balance of the host and lead to symptoms that could be interpreted as being neurological in origin should be considered. Recently, from Northern Mexico, a 2-year-old quarter breed was reported having myotonia and colic associated with the infestation of *O. megnini* [35]. **Figure 2** shows larvae and nymphs of *O. megnini* inside the horse ear canal.

3. Life cycle

The life cycle pattern of soft ticks varies considerably among the populations of the same species as well as between species of the family *Argasidae*. *Otobius megnini* has four stages in its life cycle: egg, six-legged larva, nymph, and adult. The number of nymphal instars in the life cycle varies and is controversial. Studies have reported the presence of either one [6, 36, 37] or two nymphal stages [5, 20, 38] and also the presence of a third nymphal instar [39]. Unfed larval stage is highly active showing constant and rapid movements. Nymphs have distinct integument covered with short blunt spines and hence the name spinose ear tick. The adults have spineless-granulated integument. Only the larvae and nymphs are parasitic and stay attached inside the ear canal for extended periods of time, while the adult is a nonfeeding free-living stage [40]. The life cycle pattern of *O. megnini* closely resembles that of a one-host hard tick by having a long parasitic period and a short nonparasitic period.

The larvae and nymphs feed for several days to months [6, 38, 41, 42]. Fully engorged nymphs detach after a long parasitic phase, drop off, and molt on the ground to nonfeeding adults [42]. *Otobius megnini* has a single gonotrophic cycle; hence, females die soon after oviposition. Successful completion of the life cycle depends on the efficacy of the blood meal which is determined by the interactions with their host and environmental conditions [43, 44]. Temperature and humidity have been identified as the main climatic variables that contribute to the nature of the life cycle [45] on which the egg incubation and hatching success, larval and nymphal feeding, survival and pre-molting periods, and female oviposition and survival are dependent [42, 46–48]. Female ticks, compared to males, tend to take a larger blood [42, 49]. Under laboratory conditions, *O. megnini* can feed on rabbits and complete the life cycle successfully (**Figures 3** and **4**) [42].

Ticks developing in temperatures between 21 and 28°C typically have oviposition 6–12 days after dropping as nymphs from their hosts. The number of eggs, which are laid in the nesting grounds of potential hosts, can range from 398 to 1187 depending on the weight of the female [40]. Egg incubation ranges from 14 to 19 days in laboratory studies [50] and 18–23 days in field studies [26]. Once hatching occurs, larvae seek hosts for survival; unfed larvae have been found to survive in the laboratory up to 78 days [51]. Larvae feed on the host for 1–5 weeks and then molt into the nymph. The majority of nymphs feed between 2 and 4 months [50] but some up to 6 months [51].

A tropical population of *O. megnini* successfully completed the life cycle within 123 days [42]. Only the larger larvae and nymphs weighing more than 0.9 mg molt to the next stage. Larvae do not molt if the temperature is below 10°C, and there is a higher survival of larvae at 28°C. Nymphs undergo diapause if the temperatures are below 10°C [42]. Females survive longer (313–629 days) than males (142–321 days). Some females lay eggs without mating. However, parthenogenesis is not confirmed. Apart from the descriptive study on Sri Lankan population of *O. megnini* [42], life history of laboratory populations of Nearctic population of *O. megnini* from the Southwestern USA (duration of the life cycle: 52–248 days; [52]); Texas, USA (92–125 days; [53]); California, USA (62–118 days; [50]); Maryland, USA (60–120 days; [54]); neotropical population of *O. megnini* from Córdoba, Argentina (101.4 days, [9]) and oriental population of *O. megnini* from Madras, India (69–98 days; [36]) and Bangalore, India (118–207 days, [38]) has been reported with considerable variations in parasitic period, molting period, fecundity, and survival. These variations can be attributable to the

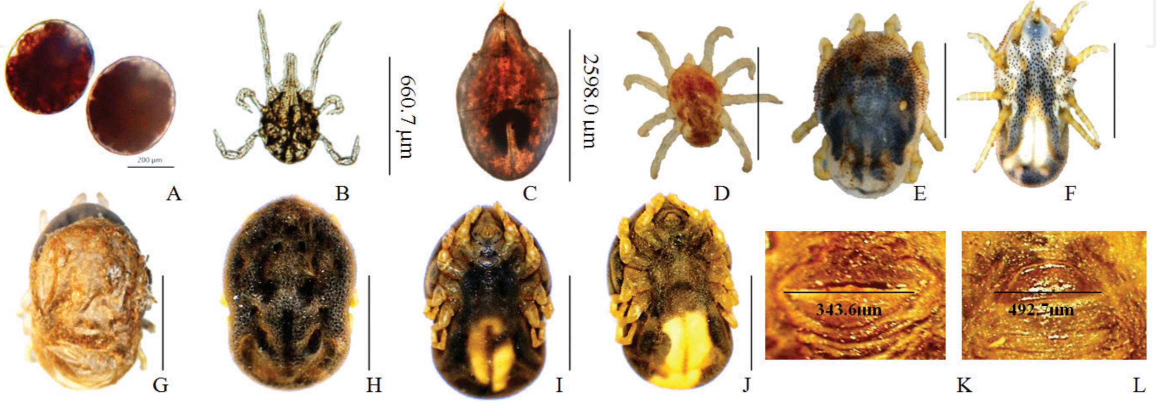

Figure 3.
Life-history stages of Otobius megnini. (A) Eggs. Larvae: (B) unfed free-living larva soon after hatching, (C) Engorged larva. Nymphs: (D) unfed nymph soon after hatching inside the ear canal, (E) dorsal view of the engorged nymph fed on horse, (F) ventral view of engorged nymph, (G) nymph molting. Nonfeeding adults: (H) dorsal view, (I) ventral view of a female, (J) ventral view of a male, (K) female genital pore (L), and male genital pore (scale bar indicating 1 cm).

Figure 4.
Larvae and nymphs of Otobius megnini feed on New Zealand white rabbits under laboratory conditions.

differences in laboratory conditions that the ticks were exposed and the host animals used to feed the immature *O. megnini* (e.g., rabbits, cattle). However, data obtained from these laboratory studies cannot entirely extrapolate to the natural context uncritically because the survival period of *O. megnini* greatly depends on their niche condition (e.g., air temperature, soil temperature, relative humidity and amount of direct light) [45] and the presence of pathogens, predators, and parasitoids [55]. The remarkable survival strategy of *O. megnini* has enabled the global expansion of this tick.

4. Seasonal dynamics

Otobius megnini is adapted to survive in diverse ecological niches in tropics, subtropics, and temperate regions [6, 37, 41, 52]. In nidicolous ticks that have distinct seasonal activity, reproductive diapause with respect to temperature and photoperiod has been suggested as the main mechanism, which controls the seasonal activity. However, ambient climatic conditions needed for better survival of ticks greatly vary from region to region [41, 56, 57]. Therefore, there is a high geographic variation in seasonal population dynamics of ticks. In temperate region where distinct seasonal pattern is pronounced, the activity of different development stages of ticks is directly linked with the changing environmental condition. However, in the tropics, the altering of rainy and dry periods has been identified as main contributing factors of tick seasonal activity [41].

Studies conducted in Argentina [6, 58], South Africa [59, 60], and Texas, USA [61] have reported discordant results for seasonal activity for *O. megnini* indicating absence of a clear seasonal pattern. Further, climatic factors such as annual rainfall, temperature, and altitude appear to have no profound effect on distribution and seasonal dynamics of *O. megnini* populations in Argentina and the Union of South Africa [58, 60, 62]. In the tropics, the larvae show clear seasonal dynamics with a high larval activity during warmer and dryer months [42]. Information about seasonal dynamics of *O. megnini* is important in controlling populations because the sanitary measures and applications of biocides considering the seasonal dynamics have been able to minimize the tick abundance [63].

5. Infectious agents

Since *O. megnini* is a one-host tick and the adult females do not feed, spreading of infectious diseases from one host to another is limited unless the infectious agent shows both transovarial and transstadial transmission like *Rickettsia bellii* maintained in *Ixodes loricatus* [64]. Studies on infectious agents of *O. megnini* are few and mostly carried out retrospectively. First, as early as 1948, infection of *Coxiella burnetii*, the causative agent of Q fever, was recovered from *O. megnini* collected from dairy cattle in Southern California [24]. Q fever, first reported in Australia as an outbreak in 1935 in nine patients [65], has now been listed as a zoonotic disease transmitted to humans primarily through inhalation of contaminated dust or aerosols and through ticks. Infection with *C. burnetii* is therefore recognized as an occupational hazard for people who work with or around waste and birth products of livestock and may include farmers, veterinarians, zoo, and slaughterhouse workers [66]. Although ticks may readily transmit *C. burnetii* in experimental systems, they only occasionally transmit the pathogen in the field. Furthermore, there are many *Coxiella*-like bacterial endosymbionts which are widespread in ticks and may have been misidentified as *C. burnetii*. Desjardins and co-workers in [67] examined the presence of antibodies and DNA of *C. burnetii* in horses, ticks, and equine environment and the potential expression of clinical disease in horses in Southeast France, a region known to be hyperendemic for human Q fever [68–70]. Although few horses (4–12%) reported as seropositive and DNA in ticks and dust being qPCR positive, horse blood was qPCR negative and did not observe any statistical association between seropositive horses and positive ticks. Although the analysis consisted of 149 ticks, none of them were *O. megnini* [67].

One specimen of *O. megnini* collected from a human in Turkey was tested for Rickettsial DNA and reported PCR negative [16]. An early record from Mexico shows two cases of spotted fever *Rickettsia* infested with nymphs of *O. megnini* [23]. Studies have shown that *O. megnini* can be naturally infected with *Ehrlichia canis* but does not transmit the agent [71]. Experimental transmission of *E. canis* by laboratory-reared *O. megnini* was attempted, but neither transstadial nor transovarial transmission occurred [71]. A specimen recovered from a child who had serologic evidence ehrlichiosis was examined microscopically, but no evidence of infection was found [71]. In a study carried out to determine equine Lyme borreliosis in a large horse riding school in Natal Province, South Africa reported *Borrelia burgdorferi* seropositive cases of 3 horse riders and owner of a stable, 71 horses, and 5 dogs, but none of the *O. megnini* specimens collected from these hosts were positive for the infection [72].

A laboratory study carried out on *O. megnini* collected from the ear canal of 11 race horses in Sri Lanka investigated the presence of three infectious agents: *Rickettsia*, *Theileria*, and *Babesia* and reported that the ticks collected from two horses being PCR positive for *Babesia* infections [25]. However, there are no records whether these horses showed any clinical symptoms of babesiosis. The study provides the first record of *Babesia* infections in *O. megnini*. Further investigations to confirm the *Babesia* species and blood samples from horses to verify its vector capacity are important. In 1967 Uilenberg reported that the vector of equine piroplasmosis is unknown and reported the presence *O. megnini* horses together with other tick species [73].

6. Human infestations

Presence of ticks in the human external auditory canal is a common parasitic otopathy reported in many parts of the world including South Africa [4, 74], Chile [3], the USA [75], Nepal [76], Malaysia [77], India [78], and Sri Lanka [79].

However, only few cases are presented with *O. megnini,* most of these are either associated with horse riding or grooming or farmers working closely with livestock [3, 7, 26, 71, 74]. The first record is in as early as 1917 [26]. Seven otoacariasis cases of *O. megnini* infesting human ear canal have been reported in New Mexico, USA [75]. More recent cases came from South Africa where a 15-year-old girl from Pretoria, a keen equestrian visited a riding school east of Pretoria and acquired infestation possibly while she was grooming or riding her horse [4]. Another case of 13-year-old girl reported with *O. megnini* inside her ear canal after a riding holiday in the Eastern Cape, South Africa [74]. Five patients visiting the Ear, Nose, Throat (ENT) clinic in Nuwara Eliya General Hospital in Sri Lanka reported having *O. megnini* in the ear canal. All these patients are horse riders or stable worker from a racecourse nearby [7]. In Turkey, *O. megnini* infections were reported from 29 females and 2 males between the ages from 17 to 72 years involved in agriculture and livestock mostly living in rural area but with no complications [80]. This tick was found in the ear of a woman who had the habit of basking in the sun on the lawn near a sheep shed at the Sheep Breeding Research Station in Sandynallah, India [18].

Tick paralysis is the most widespread and dominant form of tick toxicosis. Usually, the intra-aural tick infestation results facial paralysis, edema [81], otitis externa, bleeding [82], and acute labyrinthitis [83]. Human ear infestations by *O. megnini*, however, do not result in paralysis although irritation and pain was common [75]. However, there is one human case from 1958 reporting tick paralysis following infestation of *O. megnini*. Since having *O. megnini* inside the ear canal can be very painful in humans, development of the larva to next stage nymph is unlikely because the patient in this case becomes aware of the tick after the larva has engorged [84]. For *O. megnini* infestations, differential diagnosis should be followed whenever painful otitis externa with wax and debris is not responsive to conventional treatment [84]. Since the tick feeds intermittently and does not attach firmly, it may be easier to flush it from the ear canal unlike the hard ticks [84]. Tick inside the ear canal is removed using various methods. K.V.G Medical College, India recommends the use of turpentine and xyclocane prior to removing the tick [78]. However, the ENT clinics in general hospitals in Kandy and Anuradhapura in Sri Lanka use two different methods to remove the tick inside the ear canal [85]. In Anuradhapura General Hospital, lignocaine is used as a local anesthetic and the tick is removed immediately after using a suction pump. In Kandy General Hospital, glycerine is used to fill up the ear canal and followed by removal of the tick 2–3 weeks later by using a suction pump [85]. The method using local anesthesia is best for removal of *O. megnini* as the tick does not attach firmly and permanently but feeds intermittently.

In addition to the ear, the *O. megnini* has been found attached to other parts of the body. Larval *O. megnini* in the conjunctiva of a 2-year-old child's eye has been reported from Arizona, USA [2].

7. Control methods

Ticks can be controlled using acaricidal chemicals, natural repellants, and biological control agents. Application of synthetic acaricides: carbamate, organophosphate, synthetic pyrethroid, formamidine, macrocyclic lactone, and pyrazole have played pivotal role in controlling both soft and hard ticks in the world [86]. Combinations of hexachlorocyclohexane, xylol, and pine oil provide protection from *O. megnini* for a minimum of 17 days [87]. Using insecticide impregnated ear tags are shown to be effective [88]. A list of acaricide recommended for tick control including *O. megnini* is given in Spackman and Lloyd [89]. Feeding sulfur to calves

does not have any effect on controlling *O. megnini* in the ear canal of the host [90]. Moreover, ivermectin is effective for controlling arthropod pests of livestock, but it is not an effective control measure for nymphs of *O. megnini* in the ears of cattle and horses [61]. However, control of *O. megnini* is challenging, due to its nidicolous lifestyle, abundant progeny and site of attachment deep in the ear canal [41]. Although acaricides are the best control and eradication effort because they offer quick and cost-effective suppression of tick populations, long-term use has developed acaricide resistance in many tick species worldwide and thereby reducing their effectiveness in controlling ticks [91, 92], impaired environmental and human health with negative effects on non-target organisms, and poor quality in animal products (e.g., milk, meat, and hide; [93]). Regular monitoring of the ticks for development of resistance against the acaricides used is therefore important. Detection of resistance level of an acaricide in a tick population is important before applying it as a control measure. Susceptibility of larvae of *O. megnini* to four acaricides, Permethrin, DDT, Malathion, and Flumethrin, has been tested in an *O. megnini* population in the stabled horses in Nuwara Eliya racecourse in Sri Lanka [94]. Flumethrin is the most susceptible acaricide against *O. megnini*, while the presence of resistance for DDT and possible presence of resistance to other three acaricides tested have been reported. Prevalence of the mutations in the resistant gene/genes has to be investigated to conclude the extent of resistance in *O. megnini* for these chemicals.

Use of alternative and more sustainable control measures as biological control and host immunization are therefore increasing rapidly [95], and the application of acaricide substitutes such as the extracts of plants like *Azadirachta indica*, *Calotropis procera*, and *Nicotiana tabacum* [96] is also being promoted. Although plant extractions have been used in general tick control, there are no studies conducted specifically for *O. megnini*.

In the biological control of ticks, Samish and Rehacek [55] have listed three types of potential natural enemies including pathogens like bacteria, fungi, and nematodes that infect ticks, predators like birds and ants, and parasitoid dipterans and hymenopterans that deposit eggs on ticks. Later, Samish et al. [95] have shown that these natural enemies can be used as potential candidates in controlling some hard and soft tick species under field and laboratory conditions. Bacterial species such as *Rickettsia* sp., *Cedecea lapagei* sp., and *Proteus mirabilis*, which are pathogenic to *Dermacentor andersoni*, *Amblyomma hebraeum*, and *Hyalomma marginatum* [97] may change the tick behavior, interfere with the development, cause changes in salivary and ovarian tissues, and also induce abnormalities in subsequent generations. Among protozoans, *Nosema ixodis* and *Babesia bigemina* cause deaths and minimize egg production of *Rhipicephalus microplus*, respectively [98]. Six out of 57 major genera of entomopathogenic fungi are known to infect ticks [99]. Of these fungi, *Metarhizium anisopliae* and *Beauveria bassiana* are shown to be effective in controlling *R. microplus* and *Rhipicephalus appendiculatus* [55, 100]. Even though nematodes have been listed as potential biological agents against ticks, these pathogens have never been reported in ticks in nature. However, under laboratory conditions some nematodes infest *Rhipicephalus annulatus* [55].

The role of predators in controlling ticks has been well documented. So far, predator-tick relationship of 28 arthropod families has been recognized of which many are ants (*Hymenoptera*: *Formicidae*), followed by carabid beetles (*Coleoptera*: *Carabidae*) and some spiders (*Araneae*: *Lycosidae*; [101]). Other than arthropods, some vertebrates like the amphibians (*Bufo parcnemis*; [55]), birds (oxpeckers, egrets, domestic fowl; [95]), and mammals (shrews, rodents; [55]) occasionally feed on ticks. Among the ants, 27 species belonging to 16 genera including *Solenopsis* sp., *Pogonomyrmex* sp., *Iridomyrmex* sp., *Aphaenogaster* sp., and *Monomorium* sp. have been identified as potential biological control agents of ticks [55, 95]. They target different developing

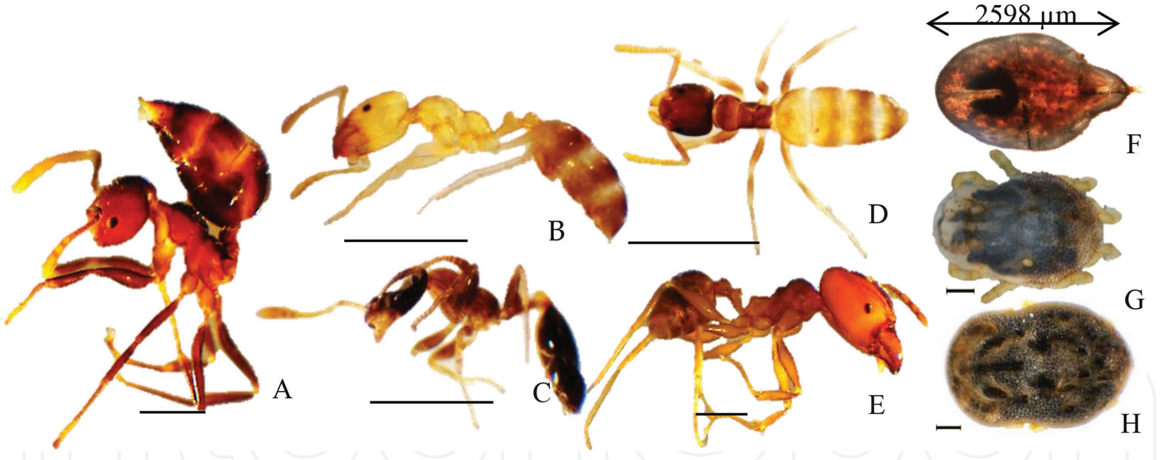

Figure 5.
Ant species that infest different life-history stages of Otobius megnini. (A) Crematogaster sp., (B) Monomorium sp. 1, (C) Monomorium sp. 2, (D) Tapinoma melanocephalum, (E) Pheidole sp., (F) engorged larvae, (G) nymph, and (H) adult of Otobius megnini. Scale bar represents 1 mm.

stages of the ticks. However, many of these ants occasionally target ticks as their main food source but are natural predators of tick species including *Argas miniatus* [102], *R. microplus,* and *R. annulatus* [102], *O. megnini*, and *Ornithodorus moubata* [53]. Five ant species, *Tapinoma melanocephalum*, two species of *Monomorium*, one species of *Pheidole*, and one species of *Crematogaster* feed on eggs fed and unfed larvae and adults of *O. megnini* (**Figure 5**) [103]. Among these, *T. melanocephalum* is the best predator as it feeds all free-living stages (eggs and adults) [103].

Among the opportunistic parasitoid dipterans, *Megaselia scalaris* and *Megaselia rufipes* (Family: Phoridae) have been identified infesting hard and soft ticks successfully [55, 95, 104]. *Megaselia scalaris* actively infests laboratory colonies of *O. megnini* [104] and other tick species [105]. It is a cosmopolitan fly, 2–3 mm long with medical, forensic, and veterinary importance commonly known as scuttle flies or hump-backed flies due to their erratic movement on surfaces and morphological features of the thorax, respectively (**Figure 6**) [104, 106]. These flies are capable

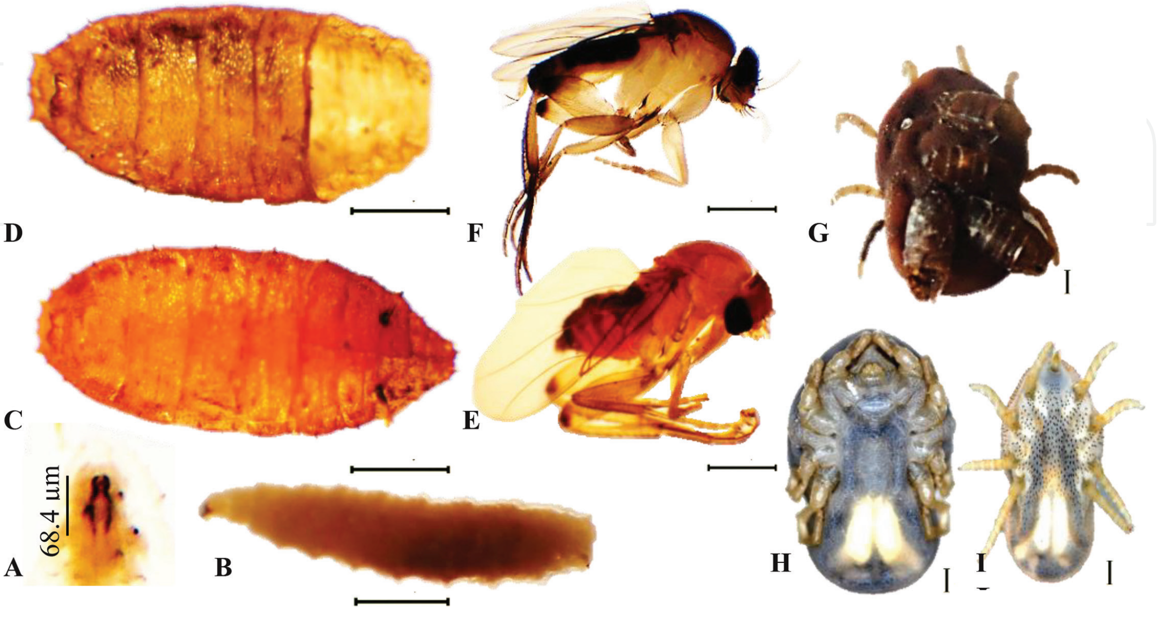

Figure 6.
Life-history stages of Megaselia scalaris and Otobius megnini. (A) Cephalopharyngeal structure of second instar larva, (B) second instar larvae, (C) pupa, (D) open pupal case, (E) female imago, and (F) male imago of M. scalaris. (G) O. megnini adult female with several pupa attached on dorsal side. (H) Ventral side of a healthy O. megnini female. (I) O. megnini nymph. Scale bars represent length of 1 mm.

of exploiting diverse ecological niches in tropics and subtropics [107]. *Megaselia scalaris* has adapted to polyphagous lifestyle, feeding, and breeding in wider spectrum of plant and animal matter [107–109]. They are attracted to putrid odors and lay eggs on decaying organic matter. The larva (maggot) undergoes two molts leading to three larval stages. Saprophagous (feeding on decaying organic matter), sarcophagous (feeding on flesh), and necrophagous (feeding on carrion) modes of feeding, as well as parasitic behaviors of *M. scalaris* larvae are well documented [107, 110]. Larvae of *M. scalaris* feed on larvae and nymphs of *O. megnini*, and when the development of the fly is completed, pupae attach to adult ticks, and all nymphs were found dead [103].

8. Conclusions

Infestation of *O. megnini* has become a problem worldwide. Controlling tick populations is hard because of its life cycle and seasonal dynamics and development of acaricide resistance. Among horses, *O. megnini* infests only well-groomed horses but not those with hairy ears. If the horses are left without trimming the hair in and around ears during racing off season, together with integrated pest control methods, the infestations can be effectively controlled and will alleviate the painful experience and other complications in the horse having the ticks inside the ear. The presence of many infectious agents has been detected in the tick; however, whether *O. megnini* acts as a vector or a reservoir in spreading the infection needing to be substantiated.

Conflict of interest

None.

Author details

Rupika S. Rajakaruna[1,3]* and Chulantha Prasanga Diyes[1,2,3]

1 Department of Zoology, University of Peradeniya, Peradeniya, Sri Lanka

2 Department of Biology, University of Saskatchewan, Saskatoon, Saskatchewan, Canada

3 Postgraduate Institute of Science, University of Peradeniya, Peradeniya, Sri Lanka

*Address all correspondence to: rupikar@pdn.ac.lk

References

[1] Becklund WW. Ticks of veterinary significance found on imports in the United States. Journal of Parasitology. 1968;**54**:622-628

[2] Jensen LA, Snow RL, Clifford CM. Spinose ear tick, *Otobius megnini*, attached to the conjunctiva of a child's eye. Journal of Parasitology. 1982;**68**:528

[3] Burchard L, Lorenas N, Ramos P. Otoacariasis humana por *Otobius megnini* en Calama Chile. Boletín Chileno de Parasitología. 1984;**39**:15-16

[4] Naudé TW, Heyne H, van der Merwe IR, Benic MJ. Spinose ear tick, *Otobius megnini* (Dugès, 1884) as the cause of an incident of painful otitis externa in humans. Journal of the South African Veterinary Association. 2001; **72**:118-119

[5] Keirans JE, Pound JW. An annotated bibliography of the spinose ear tick, *Otobius megnini* (Dugès, 1883) (Acari: Ixodida: Argasidae) 1883-2000. Systematic and Applied Acarology. 2003;**13**(1):-68

[6] Nava S, Mangold AJ, Guglielmone AA. Field and laboratory studies in a Neotropical population of the spinose ear tick, *Otobius megnini*. Medical and Veterinary Entomology. 2009;**23**:1-5

[7] Ariyarathne S, Apanaskevich DA, Amarasinghe PH, Rajakaruna RS. Diversity and distribution of tick species (Acari: Ixodidae) associated with human otoacariasis and socio-ecological risk factors of tick infestations in Sri Lanka. Experimental and Applied Acarology. 2016;**70**:99-123

[8] Estrada-Pena A, Jongejan F. Ticks feeding on humans: A review of records on human-biting Ixodoidea with special reference to pathogen transmission. Experimental and Applied Acarology. 1999;**23**:685-715

[9] Rich GB. The ear tick, *Otobius megnini* (Dugès), (Acarina: Argasidae), and its record in British Columbia. Canadian Journal of Comparative Medicine and Veterinary Science. 1957;**21**:415-418

[10] Simpson JC. Case of a parasite-*Argas* (or *Ornithodorus*) *megnini* Duge's-in each ear. (With a note on the anatomy of the specimen by E. G. Wheler). Lancet. 1901;**57**(4052):1197-1198

[11] Hallas TE. Fortegnelse over danske mider (Acari). Entomologiske Meddelelser. 1978;**46**:27-45

[12] Manfredi MT. Infestazione da *Otobius megnini* in cani importati. Praxis V. 1999;**20**:15-17

[13] Lindström A, Lindström J. First report of spinose ear tick, *Otobius megnini* (Acari, Argasidae), in Sweden. Experimental and Applied Acarology. 2017;*72*(2):179-181

[14] Özer E, Aydin L. Malatya'da siirlarda *Otobius megnini* (Duges, [sic] 1883)'nin bulunuu. (Presence of *Otobius megnini* (Duges, [sic] 1883) in cattle in Malatya). Turkish Journal of Veterinary and Animal Sciences. 1996;**20**:231-234

[15] Bursali A, Keskin A, Tekin S. A review of the ticks (Acari: Ixodida) of Turkey: Species diversity, hosts and geographical distribution. Experimental and Applied Acarology. 2012;**57**:91-104

[16] Orkun Ö, Karaer Z, C¸ akmak A, Nalbantog˘lu S. Spotted fever group rickettsiae in ticks in Turkey. Ticks Tick Borne Disseases. 2014;**5**:213-218

[17] İnci A, Yıldırım A, Düzlü Ö. The current status of ticks in Turkey: A 100-year period review from 1916 to 2016. Türkiye Parazitolojii Dergisi. 2016;**40**:152-157

[18] Joseph SA. Studies on the ecology, zoophilic and anthropophilic habits of the argasid ticks of Tamil Nadu. Cheiron. 1982;**11**:266-269

[19] Ariyarathne S, Rajakaruna RS, Ekanayake DH, Dilrukshi PRMP, Balasooriya PS, Amarasinghe PH. Occurrence and distribution of tick species associated with human otoacariasis in selected districts of Sri Lanka. In: Proceedings of the 15th Peradeniya University Research Sessions. Sri Lanka: University of Peradeniya; 2010

[20] Kang YB, Noh JW. Report on *Otobius megnini* (Duges, [sic] 1884) adult female molted from second nymphal stage in laboratory. Korean Journal of Veterinary Public Health. 1989;**13**:121-125

[21] CVO M. Spinose Ear Tick (*Otobius megnini*). Factsheet No. 1/2003. February 2003. South Perth, Western Australia: Western Australian Department of Agriculture; 2010

[22] Chegeni AH, Khedri J, Telmadarraiy Z, Faghihi F. *Otobius megnini* (Acari: Argasidae) in Iran: Exotic or established? Persian Journal of Acarology. 2018;**7**(2)

[23] Bustamante ME, Varela G, Ortiz Mariotte C. Estudios de fiebre manchada en Mexico. Fiebre manchada en la laguna. Revista del Instituto de Salubridad y Enfermedades Tropicales. 1946;**7**:39-49

[24] Jellison WL, Bell EJ, Huebner RJ, Parker RR, Welsh HH. Q fever studies in Southern California. IV. Occurrence of *Coxiella burnetii* in the spinose ear tick, *Otobius megnini*. Public Health Reports. 1948;**63**:1483-1489

[25] Diyes GCP, Rajapaksha RPVJ, Rajakaruna RS. Molecular evidence of *Babesia* infections in spinose ear tick, *Otobius megnini* infesting stabled horses in Nuwara Eliya racecourse. Ceylon Journal of Science. 2018 (in press)

[26] Herms WB. Contribution to the life-history and habits of the spinose ear tick, *Ornithodoros megnini*. Journal of Economic Entomology. 1917;**10**:407-411

[27] Hoogstraal H. The influence of human activity on tick distribution, density and diseases. Wiadomości Parazytologiczne. 1972;**18**(4):501-511

[28] Kettle D. Medical and veterinary entomology. CAB International, Wallingford Fig. 1 The nymphal *Otobius megnini* removed from the dog's ear by veterinarian JL 180. Experimental and Applied Acarology. 2017;**72**:179-181

[29] Walker A, Bouattour A, Camicas J-L, Estrada-Peña A, Horak I, Lati A, et al. Ticks of Domestic Animals in Africa: A Guide to Identification of Species. Edinburgh: Bioscience Reports; 2003

[30] Hall MC. Parasites and parasitic diseases of sheep. United States Department of Agriculture Farmers' Bulletin No. 1330. 1923. pp. 1-53

[31] Perris EE. Parasitic dermatoses that cause pruritus in horses. The Veterinary Clinics of North America: Equine Practice. 1995;**11**:11-28

[32] Ramanujachari G, Alwar VS. Notes of parasitological interest. Ceylon Veterinary Journal. 1955;**3**:38-40

[33] Food and Agriculture Organization. First meeting of the joint FAO/OIE expert panel on tickborne diseases of livestock. London, England. Food and Agriculture Organization of the United Nations, Meeting Report, No. 1958/24; 1958

[34] Madigan JE, Valberg SJ, Ragle C, Moody JL. Muscle spasms associated with ear tick (*Otobius megnini*) infestations in five horses. Journal of the American Veterinary Medical Association. 1995;**207**:74-76

[35] Zarate-Ramos JJ, Garza AMN, Avila DEZ, Tovar LER. Myotonia and colic associated with the spinose ear tick, *Otobius megnini*, in a horse in Northern Mexico. Journal of Parasitology Research. 2014;**9**:16-20

[36] Koshy TJ, Rajavelu G, Lalitha CM. Studies on the life cycle of *Otobius megnini* (Dugès, 1883). Cheiron: The Tamil Nadu Journal of Veterinary Science and Animal Husbandry. 1979;**8**:52-56

[37] Diyes GCP, Rajakaruna RS. Seasonal dynamics of spinose ear tick *Otobius megnini* associated with horse otoacariasis in Sri Lanka. Acta Tropica. 2016;**159**:170-175

[38] Jagannath MS, Lokesh YV. Life cycle of *Otobius megnini* (Acari: Argasidae). Progress in Acarology. 1989:91

[39] Boero JJ. Las Garrapatas de la República Argentina (Acarina-Ixodoidea). Buenos Aires: Departamento Editorial Universidad de Buenos Aires; 1957. p. 113

[40] Nava S, Elshenawy Y, Eremeeva ME, Sumner JW, Mastropaolo M, Paddock CD. *Rickettsia parkeri* in Argentina. Emerging Infectious Diseases. 2008;**14**(12):1894

[41] Sonenshine DE. Biology of Ticks. Vol. 2. New York Oxford: Oxford University Press; 1993

[42] Diyes GCP, Rajakaruna RS. Life cycle of spinose ear tick, *Otobius megnini* (Acari: Argasidae) infesting the race horses in Nuwara Eliya, Sri Lanka. Acta Tropica. 2017;**166**:164-176

[43] Poulin R. Host and environmental correlates of body size in ticks (Acari: Argasidae and Ixodidae). Canadian Journal of Zoology. 1998;**76**:925-930

[44] Landulfo GA, Pevidor LV, dos Santos Sampaio J, Luz HR, Onofrio VC, Faccini JLH, et al. Life cycle of *Ornithodoros mimon* (Acari: Argasidae) under laboratory conditions. Experimental and Applied Acarology. 2012;**58**:69-80

[45] Leger E, Vourch G, Vial L, Chevillon C, McCoy KD. Changing distributions of ticks: Causes and consequences. Experimental and Applied Acarology. 2013;**59**:219-244

[46] Phillips JS, Adeyeye OA. Reproductive bionomics of the soft tick, *Ornithodoros turicata* (Acari: Argasidae). Experimental and Applied Acarology. 1996;**20**:369-380

[47] Vial L. Biological and ecological characteristics of soft ticks (Ixodida: Argasidae) and their impact for predicting tick and associated disease distribution. Parasite. 2009;**16**:91-202

[48] Darvishi MM, Youssefi MR, Changizi E, Shayan P, Lima RR, Rahimi MT. Biology of *Dermacentor marginatus* (Acari: Ixodidae) under laboratory conditions. Asian Pacific Journal of Tropical Disease. 2014;**4**:S284-S289

[49] Pound JM, Campbell JD, Andrews RH, Oliver JH Jr. The relationship between weights of nymphal stages and subsequent development of *Ornithodoros parkeri* (Acari: Argasidae). Journal of Medical Entomology. 1986;**23**:320-325

[50] Loomis EC. Life histories of ticks under laboratory conditions (Acarina: Ixodidae and Argasidae). Journal of Parasitology. 1961;**47**:91-99

[51] Wanchinga DM, Barker RW. Colonization and laboratory development of *Otobius megnini* (Acari: Argasidae). Journal of Economic Entomology. 1986;**79**:999-1002

[52] Hooker WA, Bishopp FC, Wood HP. The Life History and Bionomics of Some North American Ticks. Bureau of

Entomology. United States Department of Agriculture Bulletin. 1912;**106**:1-239

[53] Panish HE. Recent studies on life history and habits of the ear tick. Journal of Economic Entomology. 1949;**42**(3):416-419

[54] Hoogstraal H. Argasid and Nuttalliellid ticks as parasites and vectors. Advances in Parasitology. 1985;**24**:135-238

[55] Samish M, Rehacek J. Pathogens and predators of ticks and their potential in biological control. Annual Review of Entomology. 1999;**44**:159-182

[56] Cumming GS. Comparing climate and vegetation as limiting factors for species ranges of African ticks. Ecology. 2002;**83**:255-268

[57] Monello RJ, Gompper ME. Biotic and abiotic predictors of tick (*Dermacentor variabilis*) abundance and engorgement on free-ranging raccoons (Procyonlotor). Parasitology. 2007;**134**:2053-2062

[58] Guglielmone AA, Mangold AJ. La distribución geográfica de *Otobius megnini* (Dugès, 1884) (Acarina: Ixodoidea: Argasidae) en la Argentina. Veterinaria Argentina. 1986;**3**:582-587

[59] Theiler G, Salisbury LE. Zoological survey of the Union of South Africa. Tick survey: Part XI. The distribution of *Otobius megnini*, the spinose ear tick. Onderstepoort Journal of Veterinary Research. 1958;**27**:605-610

[60] Dreyer K, Fourie LJ, Kok DJ. Tick diversity, abundance and seasonal dynamics in a resource-poor urban environment in the Free State. Onderstepoort Journal of Veterinary Research. 1998;**65**:305-316

[61] Drummond RO. Seasonal activity of ticks (Acarina: Metastigmata) on cattle in southwestern Texas. Annals of the Entomological Society of America. 1967;**60**:439-447

[62] Guglielmone AA, Mangold AJ, Aufranc CR. *Haemaphysalis juxtakochi, Ixodes pararicinus* (Ixodidae) and *Otobius megnini* (Argasidae) in relation to the phytogeography of Argentina. Annales de Parasitologie Humaine et Comparée. 1992;**67**:91-93

[63] Nava S, Guglielmone AA. Difficulties to control natural infestation with *Otobius megnini* (Acari: Argasidae) nymphs in cattle with systemic biocides. Research in Veterinary Science. 2009;**87**:258-259

[64] Horta MC, Pinter A, Schumaker TT, Labruna MB. Natural infection, transovarial transmission, and transstadial survival of *Rickettsia bellii* in the *tick Ixodes loricatus* (Acari: Ixodidae) from Brazil. Annals of the New York Academy of Sciences. 2006;**1078**:285-290

[65] Derrick EH. The epidemiology of Q fever. Epidemiology and Infection. 1944;**43**:357-361

[66] Garner MG, Longbottom HM, Cannon RM, Plant AJ. A review of Q fever in Australia 1991-1994. Australian and New Zealand Journal of Public Health. 1997;**21**:722-730

[67] Desjardins I, Joulié A, Pradier S, Lecollinet S, Beck C, Vial L, et al. Seroprevalence of horses to *Coxiella burnetii* in an Q fever endemic area. Veterinary Microbiology. 2018;**215**:49-56

[68] Fournier PE, Dubourg G, Raoult D. Clinical detection and characterization of bacterial pathogens in the genomics era. Genome Medicine. 2014;**6**:114

[69] Tissot-Dupont H, Torres S, Nezri M, Raoult D. Hyperendemic focus of

Q fever related to sheep and wind. American Journal of Epidemiology. 1999;**150**:67-74

[70] Tissot-Dupont H, Amadei MA, Nezri M, Raoult D. Wind in November, Q fever in December. Emerging Infectious Diseases. 2004;**10**:1264

[71] Ewing SA, Harkess JR, Kocan KM, Barker RW, Fox JC, Tyler RD, et al. Failure to transmit *Ehrlichia canis* (Rickettsiales: Ehrlichieae) with *Otobius megnini* (Acari: Argasidae). Journal of Medical Entomology. 1990;**27**:803-806

[72] Fivaz BH, Botha P, Cairns LM. A putative outbreak of equine Lyme borreliosis in Natal. Journal of the South African Veterinary Association. 1991;**61**:128-129

[73] Uilenberg G. Note sur la piroplasmose équine à Madagascar. Revue d'Élevage et de Médecine Vétérinaire des Pays Tropicaux. 1967;**20**:497-500

[74] Huchzermeyer HF. Another human ear tick case. Journal of the South African Veterinary Association. 2002;**73**:2

[75] Eads RB, Campos EG. Human parasitism by *Otobius megnini* (Acari: Argasidae) in New Mexico, USA. Journal of Medical Entomology. 1984;(2):244-244

[76] Fegan D, Glennon J. Intra-aural ticks in Nepal. Lancet. 1996;**348**:1313

[77] Indudharan R, Dharap AS, Ho TM. Intra-aural tick causing facial palsy. Lancet. 1996;**348**:613

[78] Somayaji KG, Rajeshwari A. Human otoacariasis. Indian Journal of Otolaryngology and Head and Neck Surgery. 2007;**59**(3):237-239

[79] Edussuriya BD, Weilgama DJ. Case reports: Intra-aural tick infestations in humans in Sri Lanka. Transactions of the Royal Society of Tropical Medicine and Hygiene. 2003;**97**:412-413

[80] Gökdoğan S, Çetin BA, Bahat PY, Aydın AA, Akça A. Preeklamptik gebelerde 24 saatlik idrarda protein miktarı ile spot idrarda protein/kreatinin oranının karşılaştırılması. Perinatal Journal/Perinatoloji Dergisi. 2016;**24**:3

[81] Kene KKİHC, Paralizi IBFS. Facial nerve paralysis due to intra-aural *Hyalomma* tick infestation. Türkiye Parazitolojii Dergisi. 2012; **36**:254-257

[82] Zamzil AA, Baharudin A, Shahid H, Din SS, Nor AMJ. Isolated facial palsy due to intraaural tick (ixodoidea) infestation. Archives of Orofacial Sciences. 2007;**2**:51-53

[83] Shibghatullah AH, Abdullah MK, Pein CJ, Mohamad I. Acute labyrinthitis secondary to aural tick infestation. The Southeast Asian Journal of Tropical Medicine and Public Health. 2012;**3**:857-859

[84] Oberholzer G, Ryke PAJ. Medies belangrike parasiete, draers en gifdiere van Suider-Afrika. Pretoria: HAUM Tersiêr; 1993

[85] Bandaranayaka K, Rajakaruna R, Rajapakse RPVJ, Abeysundara U, Rajapakshe M. Seasonal pattern and risk factors of otoacariasis in Anuradhapura district, Sri Lanka. In: Proceedings of the Peradeniya University International Research Sessions. Vol. 18. Sri Lanka: 2014. p. 484

[86] Lovis L, Perret JL, Bouvier J, Fellay JM, Kaminsky R, Betscharta B, et al. A new in vitro test to evaluate the resistance level against acaricides of the cattle tick, *Rhipicephalus* (*Boophilus*) *microplus*. Veterinary Parasitology. 2011;**182**:269-280

[87] Kemper HE, Roberts IH, Peterson HO. Hexachlorocyclohexane as an acaricide for the control of the spinose ear tick on cattle. The North American Veterinarian. 1947;**28**:665-668

[88] Ahrens EH, Deer JA, McWhorter GM. Field Evaluation of Insecticide Impregnated Ear Tags and Bands for the Control of the Gulf Coast Tick. Folia Entomologia Mexicana. 1978;197

[89] Spackman EW, Lloyd JE. Control of Insect Pests of Beef Cattle. Bulletin-Wyoming University, Agricultural Extension Service (USA). 1976;544R:18

[90] Babcock OG, Boughton B. Sulfur-feeding tests for the control of ectoparasites of animals. Journal of the American Veterinary Medical Association. 1943;**103**:209-212

[91] Foil LD, Coleman P, Eisler M, Fragoso-Sanchez H, Garcia-Vazquez Z, Guerrero FD, et al. Factors that influence the prevalence of acaricide resistance and tick-borne diseases. Veterinary Parasitology. 2004;**125**:163-181

[92] Guerrero FD, Lovis L, Martins JR. Acaricide resistance mechanisms in *Rhipicephalus (Boophilus) microplus*. Revista Brasileira de Parasitologia Veterinária. 2012;**21**:1-6

[93] Rajput ZI, Hu S, Chen W, Arijo AG, Xiao C. Importance of ticks and their chemical and immunological control in livestock. Journal of Zhejiang University. Science. 2006;7(11):912-921

[94] Diyes GCP, Bandara KMUJ, Rajakaruna RS, Karunaratne SHPP. Assessment of susceptibility of the spinose ear tick, Otobius megnini (Acari: Argasidae) to selected acaricides. In: Proceedings of the Peradeniya University Research Sessions. Sri Lanka: University of Peradeniya; 2016

[95] Samish M, Glazer GH. Biological control of ticks. Parasitology. 2004;**129**:389-403

[96] Zaman MA, Iqbal Z, Abbas RZ, Khan MN, Muhammad G, Younus M, et al. In vitro and in vivo acaricidal activity of a herbal extract. Veterinary Parasitology. 2012;**186**:431-436

[97] Burgdorfer W, Ormsbee RA. Development of *Rickettsia prowazekii* in certain species of ixodid ticks. Acta Virologica. 1968;**12**:36-40

[98] De Vos AJ, Stewart NP, Dalgliesh RJ. Effect of different methods of maintenance on the pathogenicity and infectivity of *Babesia bigemina* for the vector *Boophilus microplus*. Research in Veterinary Science. 1989;**46**:139-142

[99] Tanada Y, Kaya HK. Insect Pathology. San Diego: Academic Press; 2012

[100] Kaaya GP, Mwangi EN, Ouna EA. Prospects for biological control of livestock ticks, *Rhipicephalus appendiculatus* and *Amblyomma variegatum*, using the entomogenous fungi *Beauveria bassiana* and *Metarhizium anisopliae*. Journal of Invertebrate Pathology. 1996;**67**:15-20

[101] Samish M, Alekseev EA. Arthropods as predators of ticks (Ixodoidea). Journal of Medical Entomology. 2001;**38**:1-11

[102] Bishopp FC. The cattle tick: Its biology and control [PhD thesis]. Columbus: Ohio University; 1932

[103] Diyes GCP, Karunarathna NB, Silva THSE, Karunaratne WAIP, Rajakaruna RS. Ants as predators of the spinose ear tick, *Otobius megnini* (Dugès) in Sri Lanka. Acarologia. 2017;**57**:747-753

[104] Diyes GCP, Karunaratne WAIP, Tomberlin JK, Rajakaruna RS. Case

study first record of *Megaselia scalaris* (Loew) (Diptera: Phoridae) infesting a spinose ear tick, *Otobius megnini*, colony in Sri Lanka. Tropical Biomedicine. 2015;**32**:791-795

[105] Barré N, Mauléon H, Garris GI, Kermarrec A. Predators of the tick *Amblyomma variegatum* (Acari: Ixodidae) in Guadeloupe, French West Indies. Experimental and Applied Acarology. 1991;**12**:163-170

[106] Sukontason KL, Boonsriwong W, Siriwattanarungsee S, Piangjai S, Sukontason K. Morphology of puparia of *Megaselia scalaris* (Diptera: Phoridae), a fly species of medical and forensic importance. Parasitology Research. 2006;**98**:68-272

[107] Costa J, Almeida CE, Esperança GM, Morales N, Mallet JRDS, Gonçalves T, et al. First record of *Megaselia scalaris* (Loew) (Diptera: Phoridae) infesting laboratory colonies of *Triatoma brasiliensis* Neiva (Hemiptera: Reduviidae). Neotropical Entomology. 2007;**36**:987-989

[108] Karunaweera ND, Ihalamulla RL, Kumarasinghe SP. *Megaselia scalaris* (Diptera: Phoridae) can live on ripe bananas—A potential health hazard? Ceylon Medical Journal. 2002;**47**:9-10

[109] Disney RHL. Natural history of the scuttle fly, *Megaselia scalaris*. Annual Review of Entomology. 2008;**53**:39-60

[110] Koch NM, Fontanarrosa P, Padró J, Soto IM. First record of *Megaselia scalaris* (Loew) (Diptera: Phoridae) infesting laboratory stocks of mantids (*Parastagmatoptera tessellata*, Saussure). Art. 2013;**2**:1-6