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Original Article

Abundance, diversity, and seasonal dynamics of hard ticks infesting cattle in Isfahan Province, Iran

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ABSTRACT

The objectives of this study were to determine the diversity, seasonal dynamics, and abundance of ticks infesting cattle in Isfahan, Iran. The study was conducted in three traditional cattle farms. No acaricides were applied to the cattle at the selected farms. Adult ticks were collected twice a month from different parts of the cattle's body. Environmental data, including relative humidity, temperature, and rainfall, were recorded in each sampling. A total of 1206 ticks (56% males and 44% females) were collected in the selected farms. *Hyalomma anatolicum anatolicum* was the most abundant species (85.5%), followed by *Hyalomma marginatum marginatum* (8.7%) and *Rhipicephalus sanguinus* (6.5%), respectively. Ixodid tick abundance showed a dramatic increase, leading to remarkable abundance peaks during spring (April, May, and June) mainly due to the *H. anatolicum anatolicum* activity. The highest number of *H. marginatum marginatum* was found in the end of spring and early summer. *R. sanguinus* was only collected in March (end of winter) and June (end of spring). Maximum density of the collected hard ticks was in spring (68.4%). Approximately 27.1%, 3.5%, and 1% of the whole tick samples were collected in summer, fall, and winter, respectively. Out of the total samples collected from different parts of the animals' body, the maximum number of ticks were collected from udders (63.2%) followed by 36.1% from under the tail and 0.7% between the legs, while no ticks were found on the other parts of the animals' body. A significant correlation was detected between tick abundance and mean temperature ($P<0.05$). Since tick distribution is used for estimation of the distribution of tick-transmitted pathogens and climate as well as the intensity of livestock are changing in different regions of Iran, further studies regarding the tick ecology and the relationship between ticks and environmental variables are helpful in predicting the probability of new tick species presence and prediction of the risk of tick-borne pathogen transmission in ecological zones of Iran.

Keywords: Hard tick, Cattle, Abundance, Diversity, Seasonal dynamics, Isfahan, Iran

Abondance, diversité et dynamique saisonnière des tiques dures infestant les bovins de la province d'Ispahan, Iran

Résumé: Cette étude a été menée dans trois élevages bovins traditionnels de la région d'Ispahan (Iran) et avait pour objectifs l'évaluation de la diversité, dynamique saisonnière et abondance des tiques infestant les bovins. Au cours de cette étude, aucun acaricide n'a été administré et les tiques adultes ont été prélevées deux fois par mois à partir de différents endroits du corps des bovins. Les informations environnementales comme l'humidité et la température ambiante ainsi que la pluviométrie ont également été enregistrées lors de chaque prélèvement. Un total de 1206 tiques (56% de males et 44% de femelles) ont été prélevées des élevages sélectionnés. L' *Hyalomma anatolicumanatolicum* représentait l'espèce la plus abondante et été suivie respectivement de l' *Hyalomma marginatummarginatum* (8,7%) et de *Rhipicephalus sanguinus* (6,5%). L'abondance des tiques de

la famille des Ixodidae montrait une nette augmentation, atteignant un pic important au printemps (Avril, Mai et Juin) en raison d'une activité accrue de l'*H. anatolicumanatolicum*. Cette espèce proliférait fortement en fin de saison printanière et au début de l'été. L'espèce *R. sanguinus*a été prélevée au mois de Mars (fin de l'hiver) ainsi qu'en juin (fin printemps). La plus forte concentration de tiques dures a été enregistrée au printemps alors qu'environ 27,1%, 3,5% et 1 % des tiques ont été respectivement collectées en été, automne et hiver. La majorité des tiques récoltées étaient localisées au niveau des mamelles (63,2%), suivies par la queue (36,1%) et les entrejambes (0,7%) alors qu'aucune tique n'a été détectée sur les autres parties du corps des bovins. Une corrélation significative a été observée entre l'abondance des tiques et la température ambiante moyenne($P<0,05$). L'étude de la distribution des tiques est particulièrement importante dans l'estimation de la prévalence des pathologies transmises par ces parasites. Etant donné que leur occurrence semble être fortement influencée par des facteurs écologiques comme le changement climatique ainsi que les conditions et intensités spécifiques aux différentes régions d'Iran ; des études complémentaires seront nécessaires afin de mieux comprendre l'écologie des tiques et leurs interactions avec leur environnements. Ces études pourront aboutir à une prédiction et prévention plus efficaces des zoonoses transmises par les tiques dans les différentes zones d'élevage écologiques iraniennes.

Mots clés: Tiques dures, Bovins, Abondance, Diversité, Dynamique saisonnière, Ispahan, Iran

INTRODUCTION

Hard ticks are the most important ectoparasites of ruminants and are responsible for substantial economic losses worldwide. Ticks not only cause direct damage (anaemia, dermatitis, paralysis, and loss of production), but also can transmit several protozoa, rickettsia, and viral diseases (Radostits et al., 2006). The estimated annual global costs associated with ticks and tick-transmitted pathogens in cattle range between 13.9 and 18.7 billion US$ (de Castro et al., 1997). In previous studies conducted in Iran, 24 tick species and subspecies were identified (Hoogstraal and Wassef, 1979; Ahmed et al., 2007; Rahbari et al., 2007).

There are approximately 500,000 Holstein, crossbred (Holstein with local breeds), and native cattle under semi-industrial and traditional dairy farming in Isfahan Province, central Iran. In traditional and semi-industrial farming systems, the cattle are fed indoors all through the year. The house of these cattle is constructed by soil bricks and is not usually hygienic. Cattle in this region often suffer from abundant tick infestations and exposure to tick-borne diseases. Tick fauna in domestic ruminants is reported in Isfahan Province (Noaman et al., 2008) and tick-borne diseases such as anaplasmosis and tropical theileriosis are the most economically important diseases of cattle in this region of Iran (Noaman and Shayan, 2009, 2010b, a; Noaman, 2013). The impact of climatic conditions such as temperature, rainfall, and relative humidity on the survival rates, as well as abundance and diversity of ticks is well-documented. In addition, it is known that different species require specific climatic patterns for survival and reproduction (Rahbari et al., 2007).

In Iran, although numerous investigations have been conducted for identification of hard ticks, few studies have described the effects of environmental factors on the tick activities (Rahbari et al., 2007). Thus, we aimed to investigate the effects of environmental factors on the abundance, diversity, and seasonal dynamics of hard ticks in central Iran.

MATERIALS AND METHODS

Isfahan Province covers an area of approximately 107,027 square km and is situated in the center of Iran. This province has a moderate and dry climate with a temperature ranging between 40.6 °C (maximum temperature on a hot summers day) and 10.6 °C on a cold day in winter. The average annual temperature has been recorded as 16.7 °C and the average annual rainfall has been reported as 116.9 mm. The study was

conducted in three traditional cattle farms in Borkhar area near Isfahan city. The farms were about next to each other. No acaricides were applied to the cattle at the selected farms. Tick collection was conducted in the three selected farms during January 2009-December 2010. Ticks were collected twice a month using tweezers and rubber gloves. Ticks were collected from different parts of the body; each specimen was given a label and was stored in a vial containing 70% ethanol. Environmental data, including relative humidity and temperature, were also recorded using a portable thermo-hygrometer. Rainfall data were obtained from meteorological station near Isfahan city. The ticks were brought to the laboratory and examined morphologically with the help of an identification key according to Estrada-Peña and Salman (2013). Using SPSS version 18, correlation analysis was carried out to evaluate the relationship of tick count with temperature, relative humidity, and rainfall and to calculate 95% confidence interval. P-value less than 0.05 was considered statistically significant.

RESULTS

During 2009–2010, a total of 1206 ticks (56% males and 44% females) were collected in the selected farms. *Hyalomma anatolicum anatolicum* was the most abundant species (85.5%) followed by *Hyalomma marginatum marginatum* (8.7%) and *Rhipicephalus sanguinus* (6.5%). Seasonal variation in activity of three adult tick species is illustrated in Figure 1. Furthermore, seasonal dynamics of the tick population related to the recorded climatic factors (i.e., temperature, relative humidity, and rainfall) are demonstrated in Figure 2. During spring (April, May, and June) with the average temperature, relative humidity, and rainfall ranging between 13.8◦C and 24.8◦C, 22% and 32.5% 2.9 and 9.9 mm, respectively, ixodid tick abundance showed a dramatic increase, which led to remarkable abundance peaks during this season mainly due to *H. anatolicum anatolicum* activity. The highest number of *H. marginatum marginatum* was found in the end of spring and early in summer, with the average temperature, relative humidity, and rainfall ranging between 25.8 °C and 29.5 °C, 14.5% and 18%, and 0 mm and 2.3 mm, respectively. In addition, *R. sanguinus* was only collected in March (end of winter) and June (end of spring), 2010. Maximum density of the collected hard ticks belonged to spring (68.4%). About 27.1%, 3.5%, and 1% of the whole tick samples were collected in summer, fall, and winter, respectively (Table 1). Out of the total collection from different parts of the animals' body, the maximum number of ticks were collected from udders (63.2%), followed by under the tail (36.1%) and between the legs (0.7%), while no ticks were found on the other parts of the animals' body (Table 1). A significant correlation was found between tick abundance and mean temperature ($P<0.05$, $r=0.374$). In addition, a significant positive correlation was noted between relative humidity and rainfall ($P<0.01$, $r= 0. 778$). There was a significant negative correlation between mean temperature and relative humidity ($P<0.01$, $r=-0. 801$) and rainfall ($P<0.05$, $r=-0. 23$; Table 2).

DISCUSSION

In the present study, two genera (*Hyalomma* and *Rhipicephalus)* and three species were identified. The adults of *Hyalomma* species were found in spring, summer, and autumn with a peak in summer and spring, depending on temperature and relative humidity. *Rhipicephalus* species were found in winter and spring; they were more prevalent in spring. The data shows that climatic patterns, including temperature and rainfall, have a direct impact on the survival rates of ticks (Dantas-Torres, 2010).The genera *Hyalomma* and *Rhipicephalus* have the maximum extension and adaptation to the Middle East climate, including areas with cold winters and dry summers, and are prevalent in wide areas of these regions. Most of them are vectors of animal and human pathogens (Gray et al., 2009). The two tick species are suggested to be in equilibrium with the current climate. In spite of the fact that the bio-

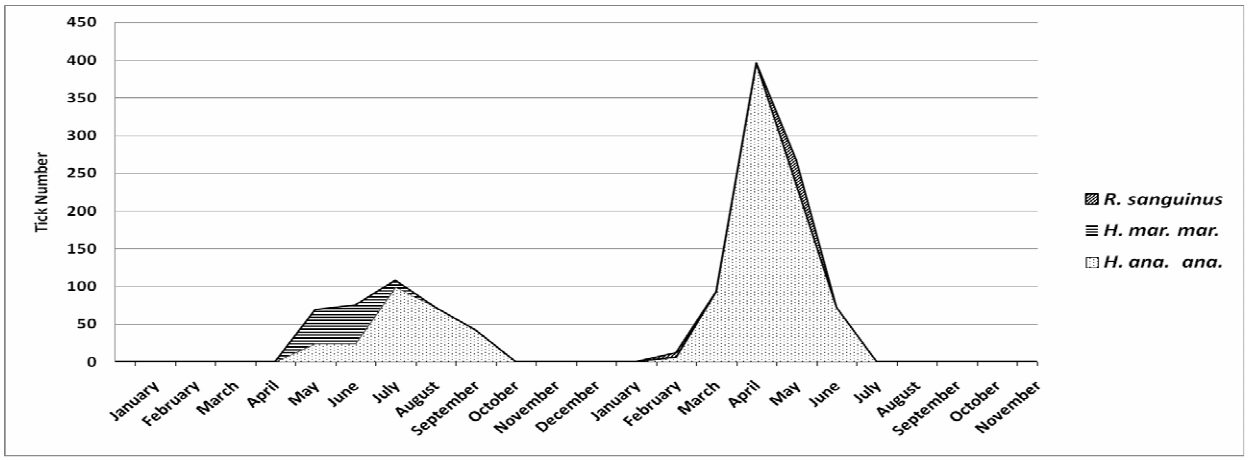

Figure 1. Seasonal variation in activity of the three adult tick species collected in Isfahan

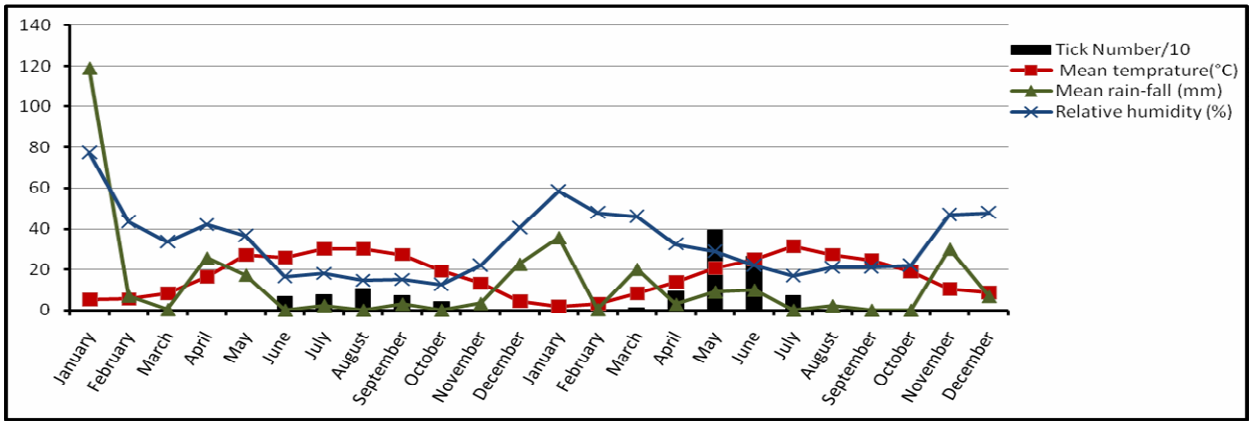

Figure 2. The recorded climatic factors (temperature, relative humidity, and rainfall) and tick dynamics in each sampling

climatic approach provides a useful estimation of the geographic distribution of various tick species, many other factors such as the scattering ability of the host and vegetation might have a potential impact on this issue (Pearson and Dawson, 2003). Four different climatic zones in Iran are the Caspian region, mountainous areas, the Persian Gulf region, and the desert region in the center. Isfahan Province is located in central region of Iran that borders with deserts in the North and East. Three main species of *H. anatolicum anatolicum* (the most abundant species), *H. marginatum marginatum*, and *R. sanguinus* were collected from the infested cattle. The obtained results are consistent with previous reports on the distribution of tick fauna in Iran (Rahbari et al., 2007), but this is the first study performed in Isfahan considering climatic conditions. Rahbari et al. (2007) reported that *Hyalomma* is the most abundant genus in each zone, especially in the desert region, but climatic changes of the recent years can influence the diversity, seasonal dynamics, and abundance of ticks infesting ruminants. *H. anatolicum anatolicum* is the most studied species and is common in every part of Iran, which can be due to adaptation of this species to different environmental conditions of Iran. *H. anatolicum anatolicum* was the most frequently identified tick species recorded in this study. All specimens of this species were found from the end of March to the beginning of October, when the temperature is high and the relative humidity is low. The present study showed that this species is

thermophilic and tolerant to low relative humidity during warm periods. It is vector of causative organism of tropical theileriosis and transmits a variety of pathogenic organisms such as *Theileria lestoquardi*, *Th. equi, Babesia cabali*, *Trypanosoma theileri*, and Crimean- Congo haemorrhagic fever virus (Nabian and Rahbari, 2008).

Table 1. The distribution of hard ticks according to season, location, species, and sex

Category	Level	Tick number	Prevalence (%) (95 % confidence interval)
Season	Winter	12	1 (0.5–1.7)
	Spring	825	68.4 (65.7–70.9)
	Summer	327	27.1 (24.6–29.6)
	Fall	42	3.5 (2.5–4.6)
Location	Udder	762	63.2(60.4–65.8)
	Under the tail	435	36.1(33.4–38.8)
	Between the legs	9	0.7(0.4–1.4)
	Ear	0	0
Species	*Hyalomma anatolicum anatolicum*	1035	85.8 (83.7–87.6)
	Rhipicephalus sanguinus	66	5.5(4.3–6.9)
	Hyalomma marginatum	105	8.7(7.2–10.4)
Sex	Male	675	56(53.1–57.8)
	Female	531	44(41.2–46.8)
Tick	All	1206	100(99.7–100)

Table 2. Correlation analysis between ticks collected, temperature, relative humidity and rainfall

	Tick number	Mean temperature (◦C)	Rainfall (mm)
Mean temperature(◦C)	.374*		
Rainfall (mm)	-.161	-.423*	
Relative humidity (%)	-.321	-.801**	.778**

* Correlation is significant at the 0.05 level (1-tailed).
** Correlation is significant at the 0.01 level (1-tailed).

H. marginatum marginatum was found as the second abundant species in this study. This species was recorded as the most dominant species in Zagrous mountainous area (Nabian and Rahbari, 2008). *H. marginatum* is a vector of the dangerous viral zoonosis Crimean-Congo hemorrhagic fever (CCHF). Due to climate requirements, this species extended into the Middle East; however, temperature is a limiting factor for its establishment of permanent population (Gray et al., 2009). Adult *H. marginatum marginatum* were active during June-August, with a peak in July. This species can bite humans and is a vector of some animal and human pathogens. *R. sanguineus* was the least frequently identified tick and was found during March-July. This genus is considerably resistant to adverse climatic conditions and was the most important tick found in both mountainous and plain areas and infested a great number of domestic ruminants (Shemshad et al., 2012). *R. sanguineus* is the most common dog tick and can transmit *Babesia* spp. and *Ehrlichia* spp. in dogs. Aktas et al. (2009) found *Anaplasma ovis* DNA in the salivary glands of this species. Noaman (2012) in a study on the prevalence of tick species found on sheep in Isfahan reported that *R. sanguineus* could be involved in the transmission of *A. ovis.* In tropical climates, *R. sanguineus* is active all year round, whereas in temperate regions, it is active only from late spring to early autumn (Dantas-Torres, 2010). When temperature drops below 18°C and/or relative humidity falls below 50%, their lifecycle is severely limited or hampered (Silveira et al., 2009). *R. sanguineus* is less dependent upon a moisture-rich habitat for survival and is more resistant to desiccating conditions (Dantas-Torres, 2010). *R. sanguineus* has a worldwide distribution mainly because they infest dogs, but are rarely found in temperate and cold regions (Gray et al., 2009). Temperature is a major limiting factor for the establishment of tick populations in cold temperate zones (Dantas-Torres and Otranto, 2011). Global warming and rising global temperature is changing the Earth's climate and the environment. Many blood-feeding arthropods such as ticks spend the main part of their life cycle in the environment, and their development, survival, and population dynamics

depend on several factors including host availability, vegetation coverage, and climate (Dantas-Torres, 2010). Temperature is the only regulator of tick molting, and each tick species can develop adequately at an optimal rate only under specific thermal conditions. Similarly, a water saturation deficit in the air, rather than rainfall or relative humidity, is correlated with the survival and activity rate of ticks. Both temperature and water content regulate the persistence of permanent populations of ticks, provided that hosts are available at adequate densities (Estrada-Peña and Salman, 2013). Climate change may influence tick distribution and density, as well as the risk of tick-borne pathogen transmission to animals in Iran. Since tick distribution is the principal indicator used to estimate the distribution of tick-transmitted pathogens and climate as well as the diversity of livestock is changing in different places of Iran, further studies on the tick ecology and the relationship between ticks and environmental variables is helpful in predicting the probability of new tick species presence and prediction of the risk of tick-borne pathogen transmission in ecological zones of Iran.

Therefore, in future tick surveys not only the distribution and abundance of ticks but also additional information regarding the ecological conditions, such as the climate and vegetation, to which they are exposed should be considered.

Ethics

I hereby declare all ethical standards have been respected in preparation of the submitted article.

Conflict of Interest

The authors declare that they have no conflict of interest.

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