Seasonal abundance of ticks (Acari/ Ixodidae) infesting cattle in four irrigated regions in Morocco

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Abstract

A study has been conducted between April 2007 and March 2008 to identify tick species infesting cattle in four irrigated regions in Morocco and to determine their abundance and phenology. The influence of climate, type of farm, age, sex and origin of the animals on the tick infestation were analyzed. 5,777 ticks have been collected and ten species identified, *Hyalomma scupense* 1,544 (26.7%), *Hyalomma marginatum* 1,489 (25.8%), *Hyalomma lusitanicum* 199 (3.4%), *Hyalomma excavatum* 554 (6.1%), *Hyalomma dromedarii* 59 (1.0%), *Hyalomma impeltatum* 26 (0.5%), *Rhipicephalus sanguineus* 266 (4.6%), *Rhipicephalus turanicus* 232 (4.0%), *Rhipicephalus bursa* 391 (10.2%) and *Rhipicephalus (Boophilus) annulatus* 1,017 (17.6%). The activity of most of the species was limited to spring and summer. According to the study, age and type of farm have a significant influence on the degree of infestation of cattle by ticks, whereas the origin and sex of the animals and climate had less influence.

Keywords: Ticks, *Ixodidae*, Cattle, Irrigated areas, Morocco.

Résumé

Une étude a été menée entre Avril 2007 et Mars 2008 au niveau de quatre régions irriguées du Maroc dans le but d'identifier les espèces de tiques qui infestent les bovins et de déterminer leur abondance et leur phénologie. L'influence du climat, le type d'élevage, l'âge, le sexe et la race des bovins sur l'infestation des tiques ont été analysés. 5777 tiques ont été recueillies et dix espèces identifiées, *Hyalomma scupense* 1544 (26,7%), *Hyalomma marginatum* 1489 (25,8%), *Hyalomma lusitanicum* 199 (3,4%), *Hyalomma excavatum* 554 (6,1%), *Hyalomma dromedarii* 59 (1,0%), *Hyalomma Impeltatum* 26 (0,5 %), *Rhipicephalus sanguineus* 266 (4,6%), *Rhipicephalus turanicus* 232 (4,0%), *Rhipicephalus bursa* 391 (10,2%) et *Rhipicephalus (Boophilus) annulatus* 1017 (17,6%). L'activité de la plupart des espèces a été limitée au printemps et à l'été. Selon cette étude, l'âge et le type d'élevage ont une influence significative sur le degré d'infestation des bovins par les tiques, alors que l'origine et le sexe des bovins et du climat ont eu moins d'influence.

Mots clés: Tiques, *Ixodidae*, Bovins, Zones irriguées, Maroc.

INTRODUCTION

Ticks are haematophagous arthropods parasitizing most of the vertebrate animals. About 880 species have been described worldwide (Nava *et al.*, 2009), of which roughly 80 have widely benefited from agricultural development and animal domestication. Ticks of the family Ixodidae or hard ticks have a significant impact on animal health and production, due to their direct action on animals: skin lesions, blood loss and toxic effects, but also because of their role as vectors of many pathogens such as protozoa, rickettsiae, bacteria and viruses responsible for severe diseases in animals. Cattle ticks are a major constraint to livestock development in Africa (Tatchell *et al.*, 1986; Mourad and Balde, 1993; Ogden *et al.*, 2004). In Morocco, 29 species of ticks have been identified and described including 14 species of the family *Ixodidae*, which infest cattle (Bailly-Choumara *et al.*, 1974). Among these species, many are potential vectors of economically important diseases such as piroplasmosis and rickettsiosis. *Hyalomma scupense* is the main vector of protozoan *Theileria annulata* in North Africa, the causative agent of theileriosis in cattle (Sergent *et al.*, 1927; Ouhelli and Flach, 1990; Darghouth *et al.*, 1999), whereas *Rhipicephalus (Boophilus) annulatus* is a natural vector of the protozoa *Babesia bovis*, *Babesia bigemina* and of the rickettsia *Anaplasma marginale*, the causative agents of bovine babesiosis and anaplasmosis in Morocco (Ouhelli and Flach, 1990; Sahibi *et al.*, 1998 a,b).

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The tick *Rhipicephalus bursa* is also known to be a vector of *B. bovis*, *B. bigemina* and *A. marginale* in the Mediterranean region (Brumpt, 1931; M'ghirbi *et al.,* 2010; Sergent *et al.,* 1931). Studies focussing on external parasites revealed the existence of ticks in all regions of Morocco because of the presence of suitable environmental factors for tick survival and development (Morel, 1958; Ouhelli and Pandy, 1982; Sahibi *et al.*, 1998 a,b). In Morocco, the number of clinical cases treated by veterinarians indicates a high prevalence of TBDs in most regions. Tick control can prevent or reduce the transmission of haemoparasites minimizing economic losses, problems of diagnosis and treatment. This control must be carried out correctly, and based on biological and ecological studies of the vector. The seasonal dynamics of ticks have a major influence on the transmission of pathogens to cattle (Randolph and Rogers, 1997).

In a large scale study conducted by Bailly-Choumara *et al.* (1976), a map of geographical distribution of tick species existing in Morocco was published. However, during the last decades, large water reservoirs (dams) have been built to supply water for agriculture and cities. These dams create a microclimate around them in a fringe of several kilometers as reported in other countries (George and Chastel, 2002). On the other hand, the national policy to import more productive cattle breeds may also contribute to the introduction of new tick species and therefore may lead to a major change in geographical distribution of tick species. Several similar events have occurred, the most recent and likely important is the introduction of *R. microplus* in West Africa by cattle flown in from Brazil (Madder *et al.*, 2007, 2011, 2012).

This study aims to give an update on the presence of the different tick species (Acari: *Ixodidae*) infesting cattle in four major irrigated regions of Morocco (Gharb, Doukkala, Tadla, Haouz), and to determine their abundance and dynamic. It also intends to determine the influence of some factors (climate, type of livestock, age, sex and breed of cattle) on the infestation of cattle by these ectoparasites. The data collected would allow setting up a strategy to control ticks and TBDs of domestic animals, especially cattle.

MATERIAL AND METHODS

Study site

This study was carried out between April 2007 and March 2008 in four regions in Morocco which are located in the northwestern part of the country between the Atlantic coast to the west and the mountain chain of the Atlas to the east (Figure 1). All these regions have irrigated zones where there is a high concentration of dairy cattle. Four sites were selected in each region:

- **Gharb (G):** Mograne; Sidi Yahya; Sidi Slimane; Sidi Kacem;
- **Tadla (T):** Fqih ben Saleh; Sebt Wlad Namma; Bni Amir; Bni Moussa;
- **Doukkala (D):** Al Ouanate; Had Oulad Fraj, Khmiss Zmamra and Tlat Sidi Bennour;
- **Haouz (H):** Tamallalt; Ait Ourir; Tahanaout; Ras Al Aïn.

Six farms at each site were targeted in this study (3 traditional and 3 modern type), in total 96 farms (48 traditional and 48 modern).

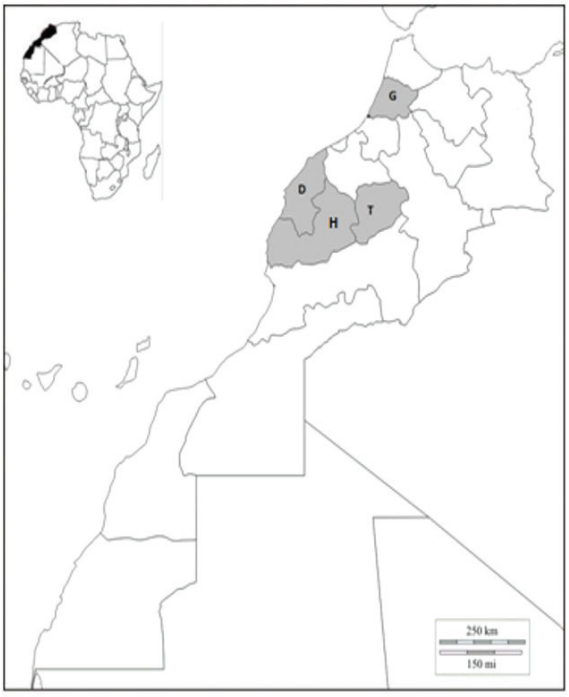

Figure 1: Geographical situation of the different study sites in Morocco (G: Gharb, D: Doukkala, T: Tadla, H: Haouz)

Gharb: it is a plain of 8 805 sq. Km, covering two bioclimatic zones, semi-arid and sub-humid with a temperate winter. The climate is Mediterranean-type with mild and wet winters and hot and dry summers. Rainfall in this region is frequently above the national average, everywhere higher than 600 mm. The average temperature varies between 14 and 23°C. It is a region of Morocco, where agriculture is the most diverse and the most intensive due to the presence of a well-developed irrigation system.

Doukkala: this region extends over an area of 13 285 sq. Km and is located at the centre, on the Atlantic coast. Temperatures remain mild in winter and summer as well near the coast zones as inside the region, they rarely reach 0°C in January and maximum temperatures in this month vary between 14°C and 18°C. In summer, the atmosphere warms up significantly, the most common maximum temperatures in July range between 16°C and 26°C.

Tadla: spread over an area of 17 125 sq. Km and situated at an average altitude of 400 to 700 m between the plates of phosphate and the Middle Atlas. It is categorized as semi-arid to sub-humid, according to the different Mediterranean bioclimatic zones. Frost is common during winter. Summer is very hot because of the hot winds of the south-east (Chergui) that increase the temperature above 40°C (47°C in July 2007), heat waves ending sometimes by severe thunderstorms that cool the soil. It is a region of intensified agricultural development, characterized by an expansion of the irrigation systems, comprising two large areas totalling over 100 000 ha.

Haouz: covers an area of 31 160 sq. km. The climate is arid or semi-arid in general (600 m altitude) and wet in the Atlas (1 500 m to 2 000 m altitude) and the coastline. Rainfall is highly variable, 50% of the area receives less than 300 mm per year and almost 30% between 300 and 400 mm of rainfall per year. The temperature is also very variable, 80% of the region has an average temperature of about 18°C. Vegetation is represented by a degraded steppe formation.

Animals

Ticks were collected from cattle, randomly chosen: 515 male and 525 female animals, 522 European pure breed and crossbred, 518 local breed, 508 aged under one year and 532 more than a year, 520 from traditional farms and 520 in intensive farms and 780 in an arid to semi-arid and 260 in the sub-humid to semi-arid climate.

Collection and identification of ticks

The collections of ticks were carried out once a month. All Ticks of each animal were removed using foreceps from restrained cattle on the following predilection sites: udder, perineum, dewlap, ears and neck. They were then stored in labelled vials containing 70° ethanol, mentioning sex, age and breed of the animal. The identification of ticks was carried out under a stereomicroscope at the Laboratory of Parasitology at the Agronomy and Veterinary Institute Hassan II, Rabat, Morocco. It was based on the morpho-anatomical characteristics described by some authors (Morel, 1976; Walker *et al*., 2003). Identification at genus level was based on overall length of the ticks, hypostome length, banding of the legs, and presence of adanal plates of the males. Further identification at species level for ticks of the genus *Hyalomma* and *Rhipicephalus* was based on scutum punctuation, marginal lines, shape of festoons and adanal plates. Ticks of the genus *Rhipicephalus (Boophilus)* were identified looking at caudal process, hypostome dentitions and spurs on the 2nd and 3th coxae.

Statistical Analysis

The statistical analysis was performed using the Cramer's V test denoted as φc). φc is a centered reduced form of Chi-square ($\chi 2$), it's a measure of association between two nominal variables, giving a value between 0 and +1. Cramer's V varies from 0 (corresponding to no association between the variables) to 1 (complete association) and can reach 1 only when the two variables are equal to each other. Cramer's V is computed by taking the square root of the chi-squared statistic divided by the sample size and the length of the minimum dimension:

$$\varphi c = \sqrt{\frac{\chi 2}{N(K-1)}}$$

N is the grand total of observations and K being the number of rows or the number of columns, whichever is less.

RESULTS

Abundance of ticks

A total of 5 777 ticks (5 500 adults and 277 nymphs) were collected on cattle in the four regions covered by the study. The identification revealed 10 species belonging to two genera of the family Ixodidae, namely: *Hyalomma marginatum* (Koch, 1844), *H. lusitanicum* (Koch, 1844), *H. excavatum* (Koch, 1844), *H. dromedarii* (Koch, 1844), *H. impeltatum* (Schulze and Scholoke, 1930), *H. scupense* (Schultze, 1919), *Rhipicephalus bursa* (Canestrini and Fanzago, 1877), *R. turanicus* (Pomeranzev and Matikas-vililotozki, 1940), *R. sanguineus* (Latreille, 1806) and *R. (Boophilus) annulatus* (Say, 1821).

Simultaneous infestations by two, three or four species of ticks were encountered in the four regions (*H. scupense* + *H. marginatum; H. scupense* + *R. annulatus*; *R. annulatus* + *H. scupense* + *H. lusitanicum*; *R. annulatus* + *R. bursa* + *H. scupense; H. scupense* + *H. lusitanicum* + *R. bursa* + *R. turanicus*; *H. scupense* + *H. marginatum* + *R. bursa* + *R. annulatus*). All nymphs identified were *R. (Boophilus) annulatus*. The number of each species and percentage is presented in Table 1. Three species are distinguished by their high percentages (*Hyalomma marginatum*, *H. scupense* and *R. (Boophilus) annulatus* with 25.7%, 26.7% and 17.6% respectively) and so could be considered as major species. Four other species have lesser percentages (*H. excavatum*, *R. bursa*, *R. sanguineus* and *R. turanicus* with 9.5%, 6.7%, 4.6% and 4.0% respectively) and could therefore be considered as medium species. Three remaining species with low percentages (*H. lusitanicum*, *H. dromedarii* and *H. impeltatum* with 3.4%, 1.0% and 0.4%) could be regarded as minor species.

Moreover, the abundance of ticks was different from one region to another. Gharb was the most infested region with 26.7% (1543/5777) followed by Doukkala with 25.1% (1454/5777) and Haouz with 24.9% (1440/5777). The lowest number of ticks was collected in Tadla 23.1% (1340/577) as shown in Table 2.

Table 1: Overall number and percentage of tick species collected from cattle in the four sites of the study

Tick species	Number	Percentage (%)
Hyalomma marginatum	1489	25.7
Hyalomma scupense	1544	26.7
R. (Boophilus) annulatus	1017	17.6
Hyalomma excavatum	554	9.5
Rhipicephalus bursa	391	6.7
Rhipicephalus sanguineus	266	4.6
Rhipicephalus turanicus	232	4.0
Hyalomma lusitanicum	199	3.4
Hyalomma dromedarii	59	1.0
Hyalomma impeltatum	26	0.4

Annual dynamics of ticks

The annual dynamics of adult ticks was studied between April 2007 and March 2008. It was clear that each species has its specific monomodal activity period and some species have a bimodal activity. Adult *Hyalomma* exhibit activity between early spring to late summer (March-September), except for the species *H. excavatum*. Adults of *H. scupense* are active between March and September with a peak in May. Adults of *H. marginatum* are active between April and September, with a peak in July. Adults of *H. excavatum* are active throughout the year with peaks in March, May and August. Adults of *H. dromedarii* and *H. impeltatum* are active between June and August with a peak in July. Adults of *H. lusitanicum* are active between April and September with two peaks in May and August. The dynamics of adult *Hyalomma spp.* is shown in Figure 2.

Adults of *Rhipicephalus* exhibit activity between late winter and late summer. Adult *R. bursa* are active from early spring (March) to late summer (late August), with peak activity in June. Adult *R. turanicus* are active since the early spring (March) to late summer (late August), with a peak of activity in late spring (May).Adults of *R. sanguineus* have two activity peaks, in spring (April) and summer (September), and disappeared in August and winter (December-February). Dynamics of adult *Rhipicephalus* is shown in Figure 3.

Adult *R. (Boophilus) annulatus* have two activity periods, in autumn (September-December) with a peak in October; they disappeared in January to re-appear at the end of February until the end of April and disappeared again in summer. The dynamics of adults of *R. (Boophilus) annulatus* is presented in Figure 4. The infestation rate of farms is very high at all study areas, with over 85% found to be infested. In Marrakech-Tensift-Al Haouz however, all farms visited, traditional and intensive were infested as shown in Table 3.

Table 3: Infestation parameters of the different farm types

Region	Type of Farms	Number of farms	Number and percentage of farms infested by ticks
Gharb	Modern	12	5 (41.7 %)
	Traditional	12	12 (100 %)
Doukkala	Modern	12	8 (66.7 %)
	Traditional	12	12 (100 %)
Tadla	Modern	12	10 (83.3 %)
	Traditional	12	12 (100 %)
Haouz	Modern	12	12 (100 %)
	Traditional	12	12 (100 %)
Total		**96**	**83 (86.5 %)**

Influence of receptivity factors on the infestation by cattle ticks

Statistical analysis showed that age (φ_c=0.51) and type of farm (φ_c=0.59) have a significant influence on the infestation by cattle ticks, while the factors breed (φ_c=0.44), climate (φ_c=0.25) and sex (φ_c=0.20) have less influence as shown in the Table 4.

Table 2: Number and percentage of the different tick species in the regions of study

Region	Total number of ticks identified	Number and percentage of ticks								
		H. marginatum	*H. scupense*	*H. lusitanicum*	*H. excavatum*	*H. impeltatum*	*H. dromedarii*	*R. sanguineus*	*R. turanicus*	*R. bursa*	*R. annulatus*
Gharb	1543	362 (23.4)	164 (10.6)	71 (4.6)	148 (9.5)	0 (0.0)	0 (0.0)	61 (3.9)	25 (1.6)	149 (9.6)	563 (36.4)
Doukkala	1454	394 (27.1)	464 (31.9)	41 (2.8)	118 (8.1)	0 (0.0)	0 (0.0)	83 (5.7)	82 (5.6)	104 (7.1)	168 (11.5)
Haouz	1440	395 (27.4)	432 (30.0)	50 (3.5)	176 (12.2)	14 (1.0)	28 (1.9)	60 (4.2)	86 (5.9)	92 (6.4)	107 (7.4)
Tadla	1340	338 (25.2)	484 (36.1)	37 (2.7)	112 (8.3)	12 (0.8)	31 (2.3)	62 (4.6)	39 (2.9)	46 (3.4)	179 (13.3)

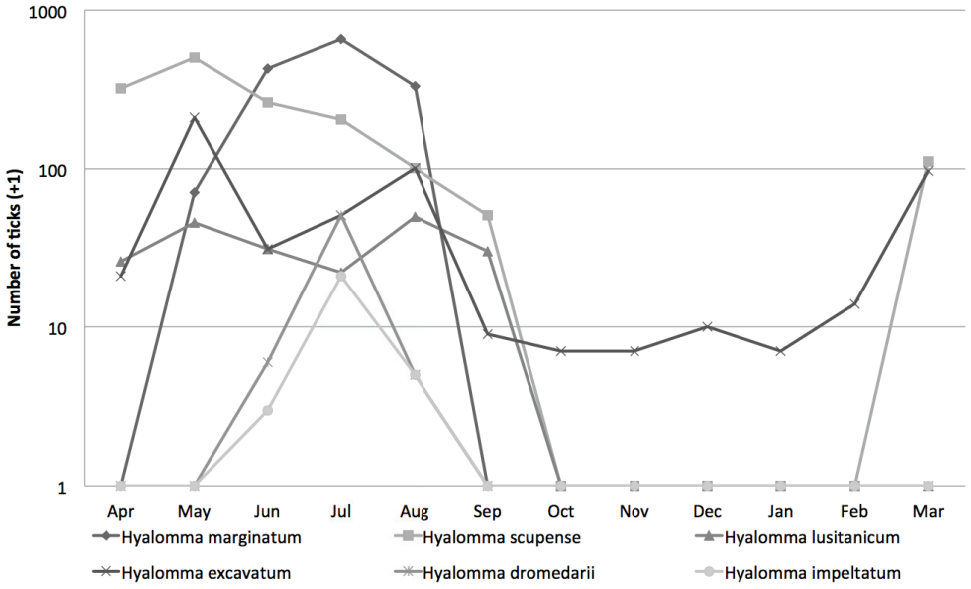

Figure 2: Annual activity of adult Hyalomma ticks between April 2007 and March 2008

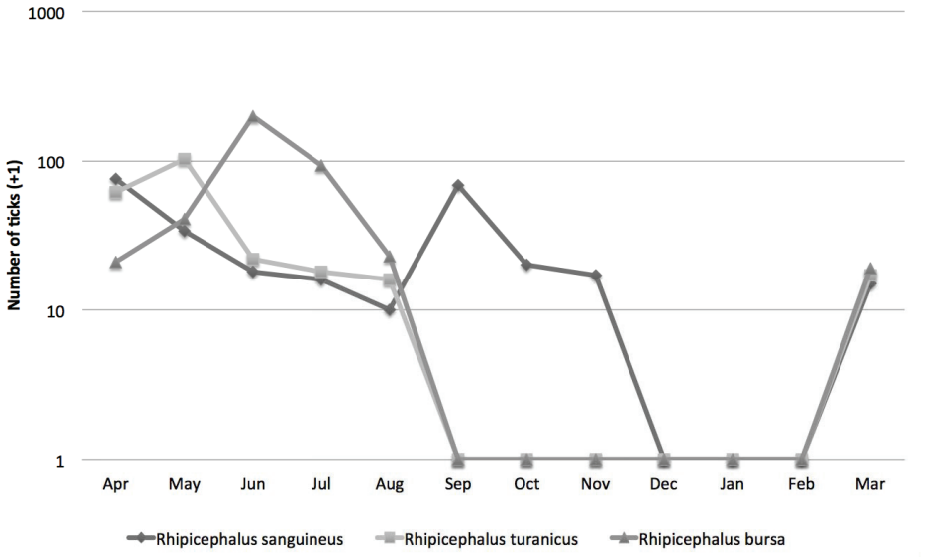

Figure 3: Annual activity of the adults Rhipicephalus ticks between April 2007 and March 2008

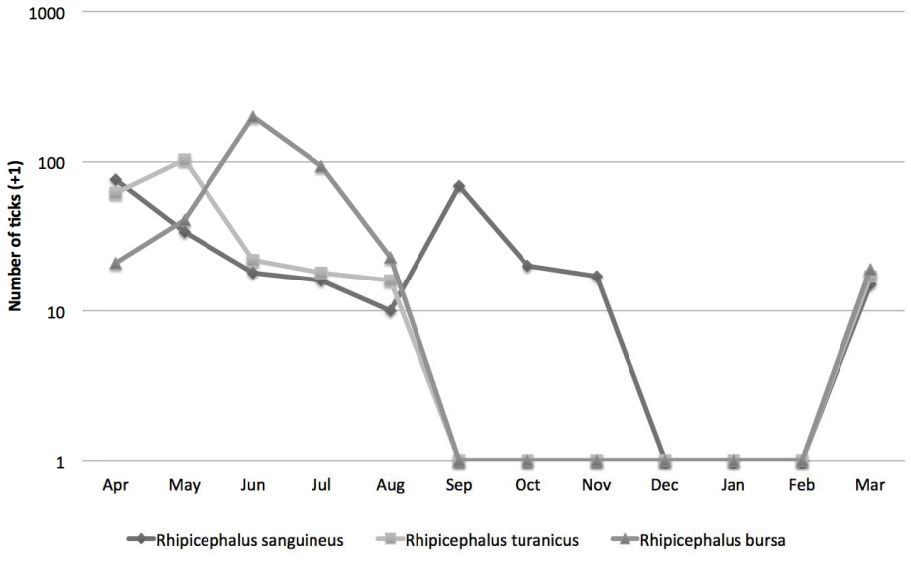

Figure 4: Annual activity of the adults of Rhipicephalus (Boophilus) annulatus between April 2007 and March 2008

Table 4: Effect of climate, type of farm, age, sex and breed of cattle on the infestation of cattle by ticks

Factor		Degree of infestation by ticks	$\chi 2$	φ_c
Age	<1 year (n=508)	81 (15.9%)	**362.5**	**0.51**
	>1 year (n=532)	398 (74.8%)		
Sex	Male (n=515)	204 (39.6%)	**41.6**	**0.20**
	Female(n=525)	313 (59.6%)		
Breed	Local (n=518)	142 (27.4%)	**246.4**	**0.44**
	Pure breed & Crossbreed (n=522)	397 (76.1%)		
Climate	Sub-humid/Semi-arid (n=260)	169 (65.0%)	**71.8**	**0.25**
	Semi-arid/Arid (n=780)	273 (35.0%)		
Type of farm	Traditional (n=520)	441 (84.8%)	**565.1**	**0.59**
	Modern (n=520)	58 (11.2%)		

DISCUSSION AND CONCLUSION

Many studies have been carried out in Maghreb countries to access ticks and the diseases they transmit to cattle (Sergent *et al.*, 1927; Morel, 1969; Bouattour *et al.*, 1996, 1999; Darghouth *et al.*, 1999; Benchikh-Elfegoun *et al.*, 2007). In Morocco, similar studies are relatively recent and limited (Bailly-Choumara *et al.,* 1974, 1976; Ouhelli *et al.*, 1982, 1989, 1990; Ouhelli, 1988; Flach and Ouhelli 1993; Flach *et al.*, 1993,1995; Kachani *et al.*, 1997; Sahibi *et al.*, 1998 a,b; El Haj *et al.*, 2002; Ait Hamou *et al.*, 2011, 2012 a,b). The results of this study show that cattle ticks are widely distributed in the irrigated areas of Morocco as evidenced by the large number of ticks collected in one year (5 777) and the variety of tick species encountered (10 species). The most infested region is Gharb (26.7%), as often reported in previous studies (Ouhelli and Pandy 1982). The sub-humid to semi-arid climate in this region is partly responsible for this proliferation. However, there are other zones of our study, were the overall climate is rather semi-arid to arid, that have high infestation rates: Doukkala (25.1%), Haouz (24.9%) and Tadla (23.1%) with the same diversity in tick species (eight species found in the four regions). The hypothesis to explain the high infestation rates is the presence of the irrigation systems built in recent years in these areas that create microclimates and increase the survival and the development of ticks. This hypothesis is strengthened by the fact that *R. (Boophilus) annulatus*, a hygrophilous species, was encountered in exceptionally high numbers in these regions. As reported by other authors (George and Chastel, 2002). Of the 10 species of ticks identified, eight have been found in the four regions covered by the study, indicating that, despite the distance and the difference of geography and climate, these species have populated these regions and have adapted to the local climates.

Hyalomma ticks were the most represented (67 %) followed by the one-host *R. (Boophilus) annulatus* tick (17.6%) and other *Rhipicephalus* species (15.3%). The most dominant species are *H. scupense*, *H. marginatum* and *R. annulatus* with, respectively, 26.7%, 25.7% and 17.6%. These three species were also most frequently found during previous studies on ticks in Morocco (Ouhelli and Pandy, 1982; Ouhelli, 1988). In Tunisia, on 5 083 adult ticks studied by Bouattour *et al.* (1996), *H. scupense* represented 84.3%. According to our results, *H. scupense* is most dominant at three regions; Tadla (36.11%), Doukkala (31.6%) and Haouz (30%), regions dominated by an arid to semi-arid climate where most farms are build in clay bricks and hay (Pisa). These offer ideal conditions for this endophilic tick, while in Gharb, where the climate is predominantly sub-humid, it is the species *R. (Boophilus) annulatus* which was the most dominant (36.4%). Species like *H. dromedarii* and *H. impeltatum* are less abundant with respectively 1 % and 0.4 %. However, their presence on cattle in two regions of our study (Haouz and Tadla) is interesting, insofar as they are naturally linked to camels and Saharan climate, far away from our study areas. This could be explained by the occasional presence of camels in these areas for tourism, and in the absence of their natural hosts, they might infest cattle and adapt to the climate of these regions characterized by a dry and very hot summer. Moreover, among the three most dominant tick species, two are known to be natural vectors of protozoa responsible for the transmission of haemoparasites of cattle (piroplasmosis) that are of veterinary and economic importance in Morocco and around the world. *H. scupense* is the main vector of the protozoan *Theileria annulata*, the causative agent of theileriosis, in North Africa (Sergent *et al.*, 1927; Ouhelli *et al.*, 1989; Bouattour *et al.*, 1996). Also in North Africa, *R. (Boophilus) annulatus* is the main vector of *Babesia bovis*, *B. bigemina* and *Anaplasma marginale*, the causative agents of bovine babesiosis and anaplasmosis (Mahoney and Mirre, 1971; Morzaria *et al.*, 1977; Purnell *et al.,* 1981; Camus and Barré, 1995). According to Ouhelli and Pandey (1982), this tick represented 30% of the tick population in Morocco and was limited to sub-humid and humid regions. Ticks of the genus *Rhipicephalus*, excluding the one-host ticks *R. (Boophilus) annulatus*, are moderately abundant and well distributed across the four regions of the study area, *R. bursa*, *R. sanguineus* and *R. turanicus*, with an abundance of 6.7%, 4.6% and 4.0%, respectively. Their abundance has increased significantly since the study of Ouhelli and Pandy (1982) carried out at four different climate regions of Morocco, where, at that time, these three species were represented by only 3.9% of all the ticks collected in a year. According to the same study, the tick *R. bursa* represented only 0.8%, whereas in the present study it is 6.76%. This shows that many species proliferated over the last twenty years. In the case of *R. bursa*, the increase might have a considerable impact on the epidemiology of bovine babesiosis both for *B. bovis* and *B. bigemina* (Sergent *et al.*, 1927; Bourdeau, 1993).

Simultaneous infestations by two, three or four species of ticks were found in the four regions. This phenomenon is probably due to the heterogeneity of domestic animals observed in farms in the study areas offering a variety of different species of hosts for ticks. In addition, this study showed that each species has its own period of activity. Some have a limited activity period in only one season

(*H. dromedarii* and *H. impeltatum*), others are active in two seasons (*H. scupense, H. marginatum, H. lusitanicum, R. bursa, R. sanguineus, R. turanicus* and *R. annulatus*) whereas others are active throughout the year (*H. excavatum*). A study in Algeria showed that adults of the genus *Rhipicephalus* (*R. bursa, R. sanguineus* and *R. turanicus*) are active only in spring (Benchikh-Elfegoun *et al.*, 2007). The warmer climate in summer irrigated areas in Morocco could explain this bi-saisonal activity of these species. According to our results, the adults of the species *R. bursa* are active from early spring (March) to late summer (late August), with peak activity in June. Adults *R. turanicus* are active from early spring (March) to late summer (late August), with a peak of activity in late spring (May).

Adults *R. (Boophilus) annulatus* have two activity periods, the first in autumn (September-December) with a peak in October, whereafter they disappear in January. The second activity period starts at the end of February until the end of April and the ticks disappear again in summer. In Algeria, the adults of this species are active only during summer (Yousfi-Monod and Aeschlimann, 1986; Benchikh-Elfegoun *et al.*, 2007), although in Tunisia, this species is characterized by a continuous activity with a peak in fall, probably because of more favorable weather conditions (Van Den Ende, 1970; Bouattour *et al.*, 1996, 1999). This study also shows that the age of cattle has a significant influence on the infestation by ticks. Cattle less than one year are less susceptible to tick infestation and therefore less exposed to blood parasites they transmit. This phenomenon has been reported in previous studies and relates to the role of the innate immune system which usually lasts for just one year (Hall *et al.*, 1968, Woodford *et al.*, 1990). El Haj *et al.* (2002) have studied the influence of individual characteristics of animals (age, breed and sex) on the prevalence of infection in cattle by the protozoan *B. bigemina*. The study revealed that the proportion of infected cattle increased with age. In fact, in the endemic areas, studies have shown that the number of infected animals increased with the number of seasons animals were exposed to diseases and therefore with age (Woodford *et al.*, 1990; Fernandez Ruvalcaba *et al.*, 1995; Flach *et al.*, 1995; Kachani *et al.*, 1996). The type of farms also had a significant influence on the infestation of cattle by ticks. The number of infested cattle is significantly higher in traditional farms compared to modern farms. This could be explained by their extensive nature, the way the buildings are constructed. They offer suitable hiding placed for ticks, especially *H. scupense*, to develop and the lack of appropriate and regular acaricide treatment. The origin or breed of cattle appear to have significant influence on the infestation of cattle by ticks: imported cattle are relatively more infested than local cattle.

According to our results, sex seems to have little influence on the infestation level. However, Flach *et al.* (1995) reported that male cattle were the most infested by the tick *H. scupense*. The climate of the region seems to have a slight influence on the infestation of cattle by ticks; this could be explained by the fact of the existence of specific microclimate in all irrigated areas around the irrigation network. Based on our results, the rate of tick infestation of farms is very high in all regions studied. Thus, 86.5% of the farms visited were infested by ticks. It also shows that 100% of traditional farms were infested. It is in the region of Haouz where all the farms visited (traditional and modern) were infested by ticks. These high rates could be explained by the presence of favorable conditions for the development of ticks in the irrigated areas in Morocco.

These results contribute to the understanding of the distribution and dynamics of ticks infesting cattle in Morocco, especially in irrigated areas and this to optimize the control of these parasites. Data on tick species and their distribution will be used for veterinary practitioners to better direct diagnosis of haemoparasites. Data on factors favouring the development of ticks can be used to reduce the risk of infestation by ticks of livestock and thereby reducing the risk of infection by blood parasites.

Thus, any strategy against the T and TBDs in Morocco should take into account the complexity of this phenomenon through awareness campaigns for breeders, veterinarians and policymakers.

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