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# Prevalence, intensity and population dynamics of hard ticks (Acari: Ixodidae) on sheep in the humid tropics of Mexico

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**Abstract** Hard ticks are a perennial problem in livestock systems throughout Mexico. No data are currently available on tick prevalence, infestation intensity and population dynamics for sheep in the humid tropics of Mexico. Blackbelly sheep (n = 30) in Tabasco state, Mexico, were examined every 3 weeks for 1 year, and all Ixodidae ticks were counted and removed for analysis. Tick species were identified, infestation prevalence and intensity calculated per animal, and infestation per body zone determined. Overall infestation on the studied animals was 51.9%. Four tick species were identified (*Amblyomma mixtum, A. imitator, Rhipicephalus microplus* and *R. annulatus*), the most abundant being *A. mixtum* (94.9%). Prevalence was highest during the northwinds season (61.9%), followed by the dry (48.5%) and rainy (47.3%) seasons; however, the intensity (2.01–2.07 ticks/sheep) did not differ between seasons. Infestation was most frequent in certain zones including the axilla, crotch, udder, abdomen, thorax and rib area. Sheep in the humid tropics of Tabasco, Mexico, are parasitized by four hard tick species and prevalence is highest in the northwinds season. The present data constitute an important baseline for developing sustainable tick control programs for sheep in the humid tropics of Mexico.

**Keywords** Prevalence · Sheep · Ixodidae · *Amblyomma mixtum*

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## Introduction

Ticks and the diseases they transmit are among the most important public health and veterinary problems worldwide. Infestation with ticks causes numerous losses in livestock from the direct effects of fixation ("tick worry"); toxin injection; anemia; morbidity and mortality associated with transmitted pathogens; and secondary effects such as increased transmission of dermatophilosis (by ticks of the genus *Amblyomma*), myasis or udder damage (Rodríguez-Vivas et al. 2005; Cortés 2011).

Tick infestation in productive livestock can negatively impact production by diminishing milk and meat yield, lowering fertility and delaying growth. Old estimated worldwide losses from ticks are 7 milliard US dollars, with 1 milliard US dollars in losses in Latin America alone (Harrow et al. 1991; Cortés 2011). In Mexico alone, estimated annual losses from the tick *Rhipicephalus microplus* in cattle are $574 million US dollars (Rodríguez-Vivas et al. 2017).

Most of the data on tick infestation and its effects in Mexico come from cattle. However, sheep producers in the country's tropical regions have also reported tick infestations. Sheep production in Mexico depends largely on grazing, meaning animals are exposed to parasitism from vectors such as ticks. One recent study does exist on *R. microplus* and *Amblyomma mixtum* infestation on sheep in southeast Mexico (Rodríguez-Vivas et al. 2016), but there are still no data on tick species abundance, intensity and population dynamics in sheep. The present study objective was to identify the hard tick (Ixodidae) species infesting hair sheep in a humid tropical region of Mexico, and estimate their prevalence, intensity and population dynamics over a 1-year period.

## Materials and methods

### Study area

The study was done in the Sheep Production Farm of the Livestock Sciences and Academic Division, Juarez Autonomous University of Tabasco (Universidad Juárez Autónoma de Tabasco–UJAT) in Centro municipality, in Tabasco State, Mexico. Regional climate is warm with year-round rains. Mean annual temperature is 27 °C, average maximum temperature is 36 °C, average minimum temperature is 18.5 °C (De Dios-Vallejo 2001), and average annual rainfall is 2550 mm (INEGI 2011).

### Experimental design and animals

A prospective, observational study was done from September 2014 to September 2015. Thirty adult female Blackbelly sheep of different weights and physiological stages were randomly selected. After identification at the beginning of the experiment, they were inspected every 3 weeks (17x in the 1-year study period). The animals were allowed to graze for 8 h a day during daylight hours and were corralled at night. Water was freely available throughout the study period.

### Data collection

On data collection days, the selected animals were kept in the corral in the morning. Each animal was held and laid over by a wrangler and inspected for the presence of ticks in different stages. In a well-lighted area, sheep were carefully inspected from head to tail following the technique of Ogore et al. (1999). Average inspection time per animal was 10 min.

### Tick collection

All ticks present were counted and collected, noting the zones of the body from which they were collected. Ticks of every stage were removed using traction force applied with the thumb and index finger, taking care not to damage them or break the mouth parts. They were immediately placed in a glass flask containing 70% ethyl alcohol, and marked with collection data and a sampling number. Samples were sent to the General Office of Animal Health (Dirección General de Sanidad Animal, Servicio Nacional de Sanidad, Inocuidad y Calidad Agroalimentaria–SENASICA) for taxonomic identification.

### Tick distribution on animals

Following Ogden et al. (1998), data on tick distribution on the animals were grouped into four zones: Zone 1, head and neck; Zone 2, feet, chest and shoulders; Zone 3, axilla, crotch, udder, abdomen, thorax and rib area; and Zone 4, tail, perianal region and vulva.

### Taxonomic identification

The collected ticks were identified with a stereoscopic microscope, classifying them by sex (male, female) and stage (nymph, adult). Species and sex identification was done using published taxonomic guides (Martinez-Ibañes 2015).

### Data analysis

Infestation prevalence was expressed as a percentage calculated with the formula: number of sheep infested with Ixodidae ticks/the number of examined sheep × 100%.

Average intensity was also expressed as a percentage calculated with the following formula: total number of ticks/number of infested sheep × 100%.

The effect of season on infestation prevalence and average intensity was determined by calculating the frequency of tick-infested sheep per season; that is, dry season (March–May), rainy season (June–October), and northwinds season (November–February). Tick frequency per body zone was also calculated. The difference between tick infestation prevalence by season and tick frequency by zone was calculated with a $\chi^2$ test. Seasonal differences in tick infestation prevalence were identified using ANOVA. Statistical analyses were run with the SAS v. 14 statistical package.

## Results

Overall Ixodidae tick infestation prevalence in the studied sheep was 51.9% (241/464). Four tick species were identified in any developmental stage (*A. mixtum, A. imitator, R. microplus* and *R. annulatus*) (Table 1), of which the most abundant was *A. mixtum* (94.9%).

**Table 1** Number, percentage and stage of Ixodidae hard tick species identified in sheep in the humid tropics of Mexico

| Tick species | Adults | | | Nymph | Total | % |
|---|---|---|---|---|---|---|
| | Engorged females | Semi-engorged females | Males | | | |
| *Amblyomma mixtum* | 8 | 129 | 159 | 190 | 486 | 94.92 |
| *Amblyomma imitator* | 0 | 9 | 4 | 0 | 13 | 2.34 |
| *Rhipicephalus microplus* | 1 | 11 | 0 | 1 | 13 | 2.54 |
| *Rhipicephalus annulatus* | 0 | 0 | 1 | 0 | 1 | 0.20 |
| Total | 9 | 149 | 164 | 191 | 5013 | 100 |

Seasonal prevalence was highest (61.9%) in the northwinds season (Fig. 1, Table 2), followed by the dry season (48.5%) and the rainy season (47.3%). However, infestation intensity did not vary between seasons. Zone 3 exhibited the highest tick frequency per body zone, and Zone 4 the lowest (both $p < 0.05$) (Table 3).

## Discussion

In the present study 51.9% of the sampled sheep in a humid tropical region in Mexico were infested with Ixodidae ticks. Ixodidae tick infestation in sheep varies mainly in response to climate conditions and the species present in a given area. For example, prevalence in sheep is reported to be as high as 81.7% in Ethiopia (Mohammed and Admasu 2015), and

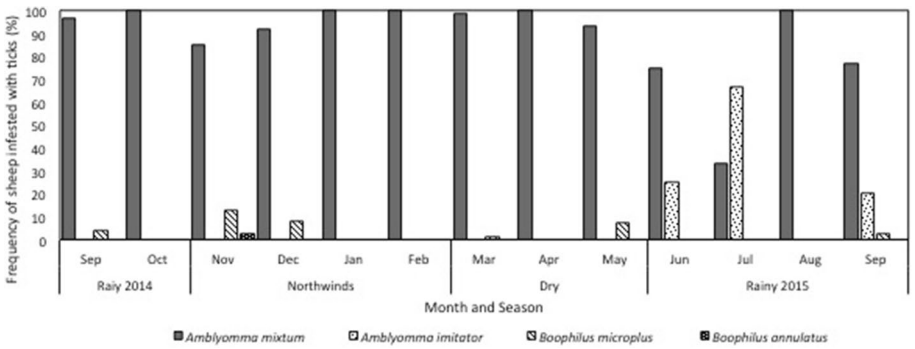


**Fig. 1** Frequency (%) of Ixodidae hard tick species collected by month and season from sheep in the humid tropics of Mexico

**Table 2** Prevalence and intensity of Ixodidae hard tick infestation by season in sheep in the humid tropics of Mexico

| Season | Number | Positives | Prevalence (%) | Intensity (range) |
|---|---|---|---|---|
| Rainy | 222 | 105 | 47.3a | 2.02a (1–11) |
| Dry | 103 | 50 | 48.5a | 2.01a (1–14) |
| North winds | 139 | 86 | 61.9b | 2.07a (1–13) |
| Total | 464 | 4.41 | 51.9 | 2.03 (1–14) |

Different letters in the same columm mean statistical differences

**Table 3** Ixodidae hard tick infestation frequency in four body zones on sheep in the humid tropics of Mexico

| Body zone | Number of examinations | Positives | Frequency (%) |
|---|---|---|---|
| Zone 1. Head and neck | 464 | 123 | 26.50a |
| Zone 2. Feet, chest and shoulders | 464 | 80 | 17.24b |
| Zone 3. Axilla, crotch, udder, abdomen, thorax and ribs area | 464 | 343 | 73.92c |
| Zone 4. Tail, perianal region and vulva | 464 | 11 | 2.37d |

55.7% (Shemshad et al. 2011) and 40.0% in Iran (Moshaverina et al. 2012), and as low as 20.0% in Libya (Mohamed et al. 2013). These variations in infestation prevalence are largely due to differences in humidity, which affect population dynamics and survival in different species (Kadir et al. 2012).

All four of the hard tick species found to be parasitizing the sheep in the present sample (*A. mixtum, A. imitator, R. microplus* and *R. annulatus*) have been previously identified in Mexico parasitizing ruminants such as cattle, sheep, goats, white-tailed deer (*Odocoileus virginianus*) and red deer (*Cervus elaphus*) (Rodríguez-Vivas et al. 2005, 2013, 2014, 2016).

The most abundant tick species in the present sample was *A. mixtum* (94.9%), most commonly found in wild animals in Mexico and other countries (Guglielmone et al. 1991; Guzmán-Cornejo et al. 2011; Rodríguez-Vivas et al. 2016). The *Amblyomma* genus parasitizes a wide range of hosts, including mammals, amphibians, reptiles, birds and human beings (Guglielmone et al. 1991, 2014). Presence of *A. mixtum* and *A. imitator*, another species identified in the present study, is worrisome because both species consume large amounts of their host's blood and can transmit *Rickettsia honei* (Labruna et al. 2007) and *R. rickettsii* to humans (Labruna 2009; Oliveira et al. 2010).

The tick species *R. microplus* has a 65% prevalence in cattle in Mexico and *R. annulatus* has a 31% prevalence. Both pose health risks to cattle via direct damage and disease transmission (*Babesia bovis, B. bigemina* and *Anaplasma marginale*) (Rodríguez-Vivas et al. 2005). They are not known to transmit disease to sheep, but may cause direct effects since a fully engorged female can decrease daily weight gain in cattle by 1.18 g (Jonsson 2006). This effect could seriously diminish productivity in sheep. Presence of these two species on the sampled sheep was probably due to the sharing of their grazing fields with cattle throughout the 1-year study period.

Seasonal tick infestation of animals is mainly influenced by climatic factors. For instance, in Iran the higher humidity (> 80%) and rainfall in the spring provides optimum environmental conditions for development, causing increased frequencies of tick species (*Hyalomma anatolicum, Rhipicephalus turanicus* and *R. sanguineus*) in sheep (Kadir et al. 2012). Previous research on the single-host tick *R. microplus* in southeast Mexico found that it exhibits four cycles a year with the highest infestation rates in the transition between the dry and rainy seasons at humidity between 70 and 80%, and low rainfall (Rodríguez-Vivas et al. 2014, 2016). In contrast, the three-host tick *A. mixtum* was the main parasite in sheep in the present study.

Tick frequency per body zone was highest in Zone 3 (axilla, crotch, udder, abdomen, thorax and rib area), a trend described previously (Rasouli et al. 2010; Yakhchali et al. 2011; Moshaverina et al. 2012). A variety of factors influence tick preference for certain

body areas, including lack of or minimum hair coverage, the animal's inability to groom the area, and more intense release of some pheromones (Sonenshine and Roe 2014). In addition, the ventral areas are more likely to be parasitized due to their greater blood flow and lower hair density (Asmaa et al. 2014). Beside this general behavior of ticks, some tick species are characterized to prefer specific body zones. In a study carried out in India to identify the preferred feeding sites of ixodid ticks in bovines, Shahardar and Narsapur (2003) found that *R. microplus* and *Haemaphysalis intermedia* are present all over the body, whereas *R. haemaphysaloides* was restricted to anterior portions of the body.

Tick infestations were present year round in the studied sheep, but at low intensities (2.3 ticks/sheep). Comparably low intensities (3.5 ixodid ticks/sheep, average) have been reported for sheep in Iran (Monfared et al. 2015).

In summary, sheep in the state of Tabasco, Mexico, are parasitized by four hard tick species with the highest prevalence during the northwinds season. These findings are important baseline data for developing sustainable tick control programs in sheep production in the humid tropics of Mexico.

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**Compliance with ethical standards**

**Conflict of interest** The authors declare no conflict of interest.

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