

# Population dynamics of the tick *Rhipicephalus microplus* in cattle under three grazing systems in the mexican humid tropics

Cruz-González, G.<sup>1</sup>; Pinos-Rodríguez, J. M.<sup>1</sup>; Alonso-Díaz, M. A.<sup>2\*</sup>; Romero-Salas, D.<sup>1</sup>; Vicente-Martínez, J. G.<sup>1</sup>; Fernández-Salas, A.<sup>2</sup>; Jarillo-Rodríguez, J.<sup>2</sup>; Castillo-Gallegos, E.<sup>2\*</sup>

<sup>1</sup> Universidad Veracruzana. Facultad de Medicina Veterinaria y Zootecnia, Veracruz, Veracruz, México. C. P. 91710.

<sup>2</sup> Universidad Nacional Autónoma de México. CEIEGT. Facultad de Medicina Veterinaria y Zootecnia, Km. 5.5 Carr. Fed. Martínez de la Torre-Tlapacoyan, Veracruz, México. C.P. 93600.

\* Correspondence: alonsodm@unam.mx y epigmeniocastillo@comunidad.unam.mx

## ABSTRACT

**Objective:** (1) To determine the population dynamics of *R. microplus* ticks in cattle under three grazing systems in the humid tropics; (2) to compare the effect of the grazing system on *R. microplus* infestations in cattle; and (3) to correlate *R. microplus* infestations in each treatment with environmental variables.

**Methodology:** The experiment was conducted from April 2023 to March 2024 in Tlapacoyan, Veracruz, Mexico. Thirty heifers (3/4 Brahman × 1/4 Holstein), aged 4-7 months, were used and allocated to three experimental groups (n=10; grazing systems). The animals in groups 1 and 2 were managed under rotational grazing with 30 (SP30) and 45 days of rest (SP45), respectively, whereas those in group 3 were kept under a continuous grazing system (no rest) (SP00). Tick counts on the animals were performed every 14 days. Daily measurements of ambient temperature (TA), precipitation (PP), and relative humidity (RH) were recorded.

**Results:** During the evaluation year, five peaks in *R. microplus* population dynamics were observed in the calves of groups SP30 and SP00, whereas only two peaks were recorded in the SP45 group. The tick population peaks in all three groups occurred mainly during the dry and rainy seasons. Animals in the SP45 group had the lowest infestation rates of *R. microplus* throughout the year (P<0.0001). In contrast, animals in the SP30 group showed the highest infestations (P<0.0001).

**Conclusions:** Grazing management and pasture rest periods in the humid tropics influence the population dynamics of *R. microplus* in cattle.

**Keywords:** Livestock, *Rhipicephalus microplus*, dynamic, pastures.

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## INTRODUCTION

The tick *Rhipicephalus microplus* is responsible for the greatest economic losses in cattle production worldwide under tropical conditions, including Mexico (Rodríguez-Vivas *et al.*, 2017), and has the capacity to transmit pathogenic microorganisms, such as the protozoan *Babesia* spp., which compromise animal health and survival (de la Fuente *et*



*al.*, 2023; Rojas-Martínez *et al.*, 2021). The primary method for controlling this tick is the use of chemical acaricides. However, due to the development of acaricide resistance in *R. microplus*, other control alternatives have been proposed (Higa *et al.*, 2020). Among the most notable alternatives are vaccines, the use of plants, bacteria, entomopathogenic fungi, and pasture management through rotational grazing.

This latter strategy reduces methane emissions (Thompson & Rowntree, 2020), making it a sustainable, effective, and environmentally friendly approach (Andreotti *et al.*, 2024) when evaluated in cattle under tropical conditions (Cruz-González *et al.*, 2023). However, it is necessary to determine, over time, the effect that grazing systems have on the population dynamics and biology of *R. microplus*. This would help design improved control strategies based on infestation dynamics according to the grazing system.

The favorable environmental conditions in the tropics for the survival and proliferation of *R. microplus* are high temperature and humidity, which allow the tick to complete up to six generations per year (Sales *et al.*, 2024). For tick control, grazing and resting periods in rotational grazing systems play a fundamental role, as they determine success or failure by directly affecting the tick's biological cycle during the non-parasitic phase (Nava *et al.*, 2024). Both periods (grazing and rest) can modify the micro-environmental and ecological conditions of pastures, negatively impacting tick survival (Teel *et al.*, 1997).

Rest periods (without animals) may prevent the “encounter phase” of the biological cycle of the monoxenous tick *R. microplus* from occurring, or may reduce its likelihood of success, thereby significantly decreasing infestation peaks in cattle. It is estimated that 95% of the total tick population in cattle production units is found in pastures in free-living life stages (Campos-Pereira and Labruna, 2008; Andreotti *et al.*, 2024). Therefore, the population dynamics and biology of *R. microplus* in cattle in the humid tropics of Mexico require information on the effects of different grazing strategies. The objective was to quantify the population dynamics of the tick *R. microplus* in cattle under three site-specific grazing systems, to compare the effect of the grazing scheme on *R. microplus* infestations in cattle, and to correlate tick infestations with environmental variables.

## **MATERIALS AND METHODS**

### **Location**

The experiment was conducted from April 2023 to March 2024 at the Teaching, Research, and Extension Center for Tropical Livestock (CEIEGT) of the Faculty of Veterinary Medicine and Animal Science of the National Autonomous University of Mexico, located in Tlapacoyan, Veracruz, Mexico (20° 02' N, 97° 06' W) (INEGI, 2021). The grazing area has been used exclusively for cattle grazing for the past thirty years. The established pasture species is African star grass (*Cynodon nlemfuensis*).

### **Experimental design**

Three grazing systems were established in the same area with African star grass: (1) SP30, a rotational system with 3 days of grazing and 30 days of rest, using 2 ha divided into 11 paddocks of 0.18 ha each; (2) SP45, a rotational system with 3 days of grazing and 45

days of rest, using 2 ha divided into 16 paddocks of 0.12 ha each; and (3) SP00, a continuous grazing system on 2 ha with no internal divisions and no rest periods for the pastures.

Thirty heifers with a 3/4 Brahman  $\times$  1/4 Holstein genotype, an initial average weight of  $98 \pm 13$  kg, and ages ranging from 4 to 7 months were selected. The animals were distributed according to weight into three groups of 10 individuals each and randomly assigned to each treatment. At the beginning of the study, the stocking rate for each treatment was 2.1 animal units per hectare (AU = 450 kg live weight).

### **Calf Management**

Each calf received 1 kg of concentrate feed daily and had free access to water. The established treatments were conducted in separate areas, where each group had exclusive mobile waterers and feeders, preventing interaction between animals from different groups. The animals had been exposed to ticks since birth and were regularly treated with pyrethroids and organophosphates for ectoparasite control.

To ensure that the heifers were free of internal and external parasites at the start of the experiment, they were treated 15 days prior to the beginning (day 0) with albendazole to control gastrointestinal parasites, and coumaphos to eliminate ticks and flies. Throughout the study, the animals did not receive any acaricide treatment; however, they were under constant veterinary supervision to monitor tick infestations and clinical signs of disease. Animal management was approved by the Bioethics and Animal Welfare Committee of the Faculty of Veterinary Medicine and Animal Science of the Universidad Veracruzana (UV-FMVZ), under registration number 015/21.

### **Tick Counts in Cattle**

To evaluate parasitic load in the heifers, tick counts were performed at 14-day intervals between 7:00 and 9:00 a.m., using a compression ramp. *R. microplus* ticks longer than 4.5 mm were recorded without removing them from the animal, following the methodology validated by Miraballes *et al.* (2022). A total of 26 counts were conducted over the year, all performed at the same time and by the same researcher.

### **Recording of Climatic Variables**

Climatic data for the study site were obtained from the National Meteorological Service database, corresponding to the two weeks prior to the start and throughout the experiment. Daily measurements of ambient temperature (TA, °C) and rainfall (PP, millimeters) were recorded. Relative humidity (RH) data were obtained through the Weather Channel mobile application, using the exact coordinates of the study area. The geographic area is classified as warm and humid, with three well-defined climatic seasons: rainy (June-September), winter (October-January), and dry (February-May).

The climatic classification, according to García's (2004) formula based on the Köppen system, corresponds to an "Af(m)w"e g" climate, which is characterized as warm and humid with rainfall throughout the year, intra-summer droughts, temperature extremes, and a Ganges-type climate in March.

### Statistical Analysis

Data obtained from tick counts were analyzed using descriptive statistics. Normality and homogeneity of variance were subsequently evaluated using the Anderson-Darling, Shapiro-Wilk, and Kolmogorov-Smirnov tests. The results indicated that the data did not follow a normal distribution, nor did they exhibit equal variances. Means of the three treatments were compared within each sampling date using the Kruskal-Wallis test. Possible associations of temperature, RH, and precipitation with tick load were assessed using Spearman's correlation. A significance level of  $\alpha=0.05$  was considered statistically significant. All statistical procedures were performed using Statistica 10.0 software (StatSoft, Inc., Tulsa, OK, USA).

### RESULTS AND DISCUSSION

The dynamics of *R. microplus* infestations in cattle varied significantly among the three grazing systems ( $P<0.05$ ).

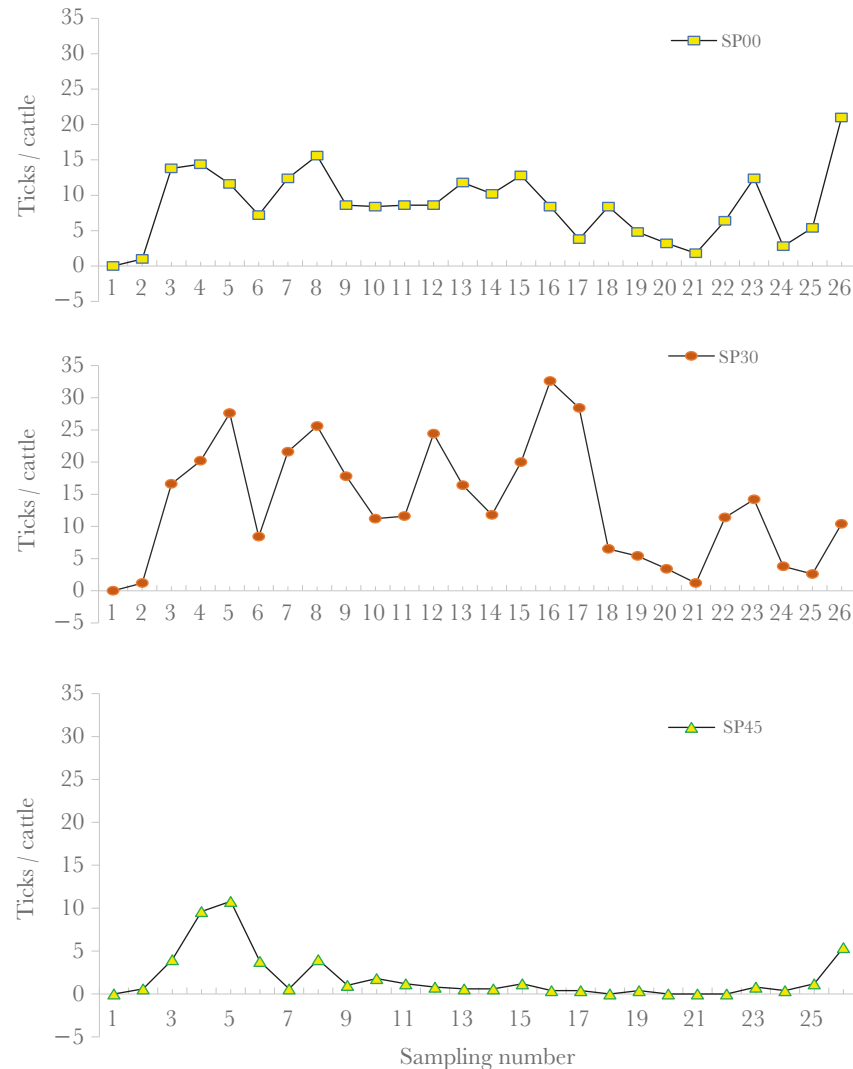
The highest infestations were observed in animals from the SP30 group, with five well-defined population peaks identified during the study period (Figure 1B). The first peak occurred in May (27.6 ticks on average), the second in July (25.6 ticks), the third in August (14.2 ticks), the fourth in October (32.6 ticks), and the fifth in December (14.2 ticks). A similar five-peak pattern was recorded in the SP00 group, although with a lower parasitic load (between 11 and 20 ticks) (Figure 1A). In contrast, the SP45 group showed a different dynamic, characterized by a single peak of only 10.8 ticks on average at the end of the dry season (May) and a significantly low tick count for the rest of the year (Table 1; Figure 1C).

At the beginning of the experiment, during the first two counts, tick infestations did not differ among the treatments; in fact, infestations were low in all groups (Table 1). However, from count 3 to 24 (except for count 5), the SP45 group consistently showed a lower number of ticks compared to the other two groups ( $P<0.0001$ ) (Table 1). The highest average infestations were recorded in animals from the SP30 group ( $P<0.006$ ), followed by those in the SP00 group (Table 1).

Table 2 presents the data on temperature, relative humidity, and precipitation recorded during the study. No association was found between the degree of *R. microplus* infestation and the climatic variables among the treatments ( $P<0.0001$ ). However, it is noteworthy that the highest infestations occurred at the end of the dry season, during the rainy season, and at the beginning of the winter season, corresponding with the annual increase in ambient temperature (TA) (Table 2), particularly in the groups with the highest tick counts (Figure 1).

Some grazing systems in tropical cattle (*e.g.*, paddock rotation) have been reported as a non-chemical alternative for controlling tick infestations in both animals and pastures (Cruz-González *et al.*, 2024). In the present study, the population dynamics of *R. microplus* were evaluated in cattle under three grazing systems.

During the experiment, variation was observed in the number of *R. microplus* population peaks during their parasitic phase among the experimental groups. In the humid tropics of Mexico, the seasonality of *R. microplus* is characterized by annual generation peaks ranging from 4 to 5 per year (Lagunes-Quintanilla *et al.*, 2024). This is consistent with the findings



**Figure 1.** Population dynamics of *Rhipicephalus microplus* infestations on Cattle (Brahman × Holstein) over one year under continuous grazing (A) and rotational grazing with 30- and 45-day rest periods (B and C).

of the present study for the SP30 and SP00 groups, where five population peaks of *R. microplus* were observed. One of the main factors influencing tick survival and reproduction is environmental conditions, particularly temperature and microenvironmental humidity, and their interaction with the parasite's biological cycle (Campos-Pereira and Labruna, 2008).

It has been documented that under favorable temperature (TA), relative humidity (RH), and precipitation (PP) conditions, *R. microplus* can produce 4 or 5 generations per year. In this study, population peaks occurred mainly during the dry season, the rainy season, and the beginning of winter, when environmental temperatures exceeded 24 °C and RH was above 70%, conditions that are favorable for tick development (embryonic and larval development and egg hatching). The synchronization of these peaks with the seasons (dry and rainy) under “optimal” environmental conditions demonstrates the parasite's plasticity

**Table 1.** Number of *Rhipicephalus microplus* ticks on cattle under three grazing systems over one year.

Sampling number	Date	Tick count					
		SP00		SP30		SP45	
		Means <sup>1</sup>	SD±	Means	SD±	Means	SD±
1	30/03/2023	0.00 <sup>a</sup>	0.00	0.00 <sup>a</sup>	0.00	0.00 <sup>a</sup>	0.00
2	13/04/2023	1.00 <sup>a</sup>	1.84	1.20 <sup>a</sup>	1.60	0.60 <sup>a</sup>	1.28
3	27/04/2023	13.80 <sup>a</sup>	6.16	16.60 <sup>a</sup>	7.85	4.00 <sup>b</sup>	2.68
4	11/05/2023	14.40 <sup>a</sup>	3.56	20.20 <sup>a</sup>	7.35	9.60 <sup>b</sup>	3.67
5	25/05/2023	11.60 <sup>a</sup>	5.50	27.60 <sup>b</sup>	18.59	10.80 <sup>a</sup>	3.71
6	08/06/2023	7.20 <sup>a</sup>	5.67	8.40 <sup>a</sup>	3.20	3.80 <sup>b</sup>	1.89
7	22/06/2023	12.40 <sup>a</sup>	15.72	21.60 <sup>b</sup>	7.89	0.60 <sup>c</sup>	0.92
8	06/07/2023	15.60 <sup>a</sup>	12.26	25.60 <sup>b</sup>	10.61	4.00 <sup>c</sup>	3.22
9	20/07/2023	8.60 <sup>a</sup>	4.48	17.80 <sup>b</sup>	9.14	1.00 <sup>c</sup>	2.05
10	03/08/2023	8.40 <sup>a</sup>	6.44	11.20 <sup>a</sup>	6.46	1.80 <sup>b</sup>	2.09
11	17/08/2023	8.60 <sup>a</sup>	6.26	11.60 <sup>a</sup>	5.92	1.20 <sup>b</sup>	1.33
12	31/08/2023	8.60 <sup>a</sup>	4.48	24.40 <sup>b</sup>	23.75	0.80 <sup>c</sup>	1.83
13	14/09/2023	11.80 <sup>a</sup>	8.65	16.40 <sup>a</sup>	14.85	0.60 <sup>b</sup>	1.80
14	28/09/2023	10.20 <sup>a</sup>	7.24	11.80 <sup>a</sup>	6.29	0.60 <sup>b</sup>	0.92
15	12/10/2023	12.80 <sup>a</sup>	5.31	20.00 <sup>b</sup>	12.46	1.20 <sup>c</sup>	1.83
16	26/10/2023	8.40 <sup>a</sup>	4.80	32.60 <sup>b</sup>	21.22	0.40 <sup>c</sup>	0.80
17	09/11/2023	3.80 <sup>a</sup>	3.84	28.40 <sup>b</sup>	18.43	0.40 <sup>c</sup>	0.80
18	23/11/2023	8.40 <sup>a</sup>	6.86	6.50 <sup>a</sup>	5.14	0.00 <sup>b</sup>	0.00
19	07/12/2023	4.80 <sup>a</sup>	3.60	5.40 <sup>a</sup>	3.47	0.40 <sup>b</sup>	0.80
20	21/12/2023	3.20 <sup>a</sup>	4.31	3.40 <sup>a</sup>	3.35	0.00 <sup>b</sup>	0.00
21	04/01/2024	1.80 <sup>a</sup>	2.27	1.20 <sup>a</sup>	1.60	0.00 <sup>b</sup>	0.00
22	18/01/2024	6.40 <sup>a</sup>	3.32	11.40 <sup>a</sup>	4.48	0.00 <sup>b</sup>	0.00
23	01/02/2024	12.40 <sup>a</sup>	4.54	14.20 <sup>a</sup>	4.14	0.80 <sup>b</sup>	1.33
24	15/02/2024	2.80 <sup>a</sup>	3.71	3.80 <sup>a</sup>	3.52	0.40 <sup>b</sup>	0.80
25	29/02/2024	5.40 <sup>a</sup>	6.26	2.60 <sup>a</sup>	3.10	1.20 <sup>a</sup>	1.33
26	14/03/2024	21.00 <sup>a</sup>	10.17	10.40 <sup>b</sup>	8.09	5.40 <sup>a</sup>	4.57

<sup>1</sup> Arithmetic mean of tick counts. a-c Values within a row with different superscripts differ significantly. SD standar deviation.

to adapt and maximize its reproductive success under different management conditions (Sales *et al.*, 2024; Andreotti *et al.*, 2024).

In this study, despite the fact that the animals were exposed to the same environmental conditions as the other treatments, the SP45 group exhibited only two *R. microplus* infestation peaks, indicating that other factors, such as pasture height and density, influenced the tick's biology.

This information suggests that the interaction between management practices and the parasite's biology is complex, highlighting the need to explore other factors to achieve effective control of *R. microplus*. In addition to environmental and microenvironmental factors, other factors such as cattle breed, control methods/strategies, and grazing systems

**Table 2.** Average precipitation, relative humidity, and temperature at CEIEGT from April 2023 to March 2024.

Seasons	Month	Precipitation (mm)	HR (%)	Temperature (°C)
Dry	April	356.8	83	24
	May	7.3	73	25
Rainy	June	26.6	70	28
	July	113.4	74	26
	August	232.0	75	24
	September	0.5	76	25
Winter	October	312.3	81	24
	November	57.6	82	21
	December	164.5	84	20
	January	67.2	84	19
Dry	February	32.9	75	19
	March	40.6	76	23

mm: millimeters; RH: Relative Humidity.

can modify the biology of monoxenous parasites like *R. microplus* (Andreotti *et al.*, 2024). It is likely that the 45-day rotation period affected the quest/encounter rates of *R. microplus* larvae, making it necessary to conduct studies focused on evaluating the effect of pasture rest periods on the viability of the parasite's infective larvae. Knowledge of this population dynamics can help predict the need for treatment during certain periods when infestations tend to be higher (Nava *et al.*, 2024).

In this study, it was found that the 30-day rest and three-day grazing system had no effect on controlling *R. microplus* ticks in cattle; in fact, it appeared to favor parasitism. This outcome is related to the duration of the tick's life cycle. This observation is consistent with recent findings by Nava *et al.* (2024) in Argentina, who reported that a 30-day pasture rest period, without acaricide application, was not sufficient to reduce *R. microplus* infestations in cattle.

Similarly, Nicaretta *et al.* (2020) reported that a 20-day pasture rest period does not affect the biological cycle of *R. microplus* in cattle in Brazil. The higher parasitism observed in the present study may be due to the biological dynamics of the larvae in the pastures. Considering that, under tropical conditions, larvae reach peak activity 48-50 days after oviposition, a 30-day rest period would result in cattle returning to the pasture at 60 days (second grazing), when the larvae are at an optimal stage of vigor, consequently increasing infestation. This phenomenon can be explained by Nava *et al.* (2024), who indicate that short rest periods can increase the frequency of high population density, thereby enhancing the quest/encounter rates of *R. microplus* larvae with hosts.

In contrast, the grazing system with a 45-day rest period was effective in reducing tick infestations. In this case, animals would enter paddocks with 45-day-old larvae (without adequate maturation) and return only after 90 days, by which time 40-42 days had passed since the larvae's peak infestation capacity. In the continuous grazing system (without rotations), infestations were also higher than in the SP45 group, although lower than in the

SP30 group. These results are consistent with the studies by Cruz-González *et al.* (2023 and 2024), who reported that a 45-day rest period is effective in controlling tick infestations in F1 (Holstein × Brahman) and Brahman cattle under tropical conditions. Some authors have suggested extending rest periods to 84 days (Andreotti *et al.*, 2024) or 105 days (Nicaretta *et al.*, 2020); however, this could compromise pasture nutritional quality. These findings highlight the importance of evaluating different pasture rest periods according to the region of application, in order to optimize effectiveness while assessing the nutritional characteristics of the pastures and their impact on animal weight gain.

In the present study, no correlation was found between environmental conditions and infestations among the groups; however, the highest infestations occurred when temperatures were higher. It is noteworthy that in the groups with the highest tick infestations, ticks were present throughout the year, consistent with reports by Alonso-Díaz *et al.* (2007). In contrast, other studies have reported lower tick numbers during the rainy season, attributing this to probable leaching due to excessive soil water (Lima *et al.*, 2000; Gallardo and Morales, 1999), a pattern not observed in this study for the SP00 and SP30 groups, where infestations persisted. The main outcome of this evaluation is that tick populations in cattle behave in accordance with previously reported findings regarding climate across all three treatments. It is strongly recommended to conduct evaluations at the pasture or microenvironment level to determine whether infestations in pastures are affected by grazing treatments in correlation with soil-level temperature and humidity.

## CONCLUSIONS

Grazing and pasture rest periods in the humid tropics influence the population and life cycle of *R. microplus* in cattle. A 45-day pasture rest period is an effective alternative for controlling *R. microplus* in cattle, as it affects the tick's life cycle. No association was found between the degree of *R. microplus* infestation and climatic variables among the treatments.

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