

Integrated tick control on a farm with the presence of capybaras in a Brazilian spotted fever endemic region

Controle integrado do carrapato em uma fazenda com presença de capivaras em região endêmica para febre maculosa brasileira

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Abstract

Ticks of the *Amblyomma cajennense* complex present high infestation rates. These ticks transmit the bacterium *Rickettsia rickettsii*, which causes Brazilian Spotted Fever. For this reason, an integrated tick control system was adopted on a farm in the municipality of Itu, state of São Paulo. On this farm, which borders the Tietê river, domestic animals are in contact with populations of capybaras. Six locations were monitored and evaluated between the years of 2015 and 2017. During this work 1271 nymphs and adult ticks were caught, all of them from the *Amblyomma sculptum* species, except for a single individual from the *Amblyomma dubitatum* species. The integrated tick management reduced the overall infestation levels to zero. Adult tick population dropped in the first year of the study, while larvae population dropped in the second year. Nymph population dropped in both years, decreasing in higher numbers in the first year. The estimated mean infestation levels for all of the tick's life cycle forms in the six monitored spots did not reach one individual in the end of the study. Estimated mean infestation levels for nymphs in these places equaled zero.

Keywords: Integrated pest management, *Amblyomma sculptum*, *Hydrocoerus hydrochaeris*.

Resumo

Em virtude de alta infestação por carrapatos do complexo *Amblyomma cajennense*, parasitos que transmitem a bactéria *Rickettsia rickettsii*, causadora da Febre Maculosa Brasileira, adotou-se um sistema de controle integrado dos carrapatos numa propriedade rural localizada no município de Itu – SP. Na propriedade, que margeia o rio Tietê, os animais domésticos mantinham contato com populações de capivaras. Seis locais foram avaliados e monitorados nos anos de 2015 a 2017. Dentre os 1271 espécimes capturados (adultos e ninfas) um foi identificado como *Amblyomma dubitatum* e os demais com *Amblyomma sculptum*. De um modo geral, houve controle da infestação de carrapatos visto que todos os estágios ao final de 2017 apresentaram níveis próximos ou igual a zero. A população de adultos teve queda no primeiro ano e a de larvas no segundo. As ninfas apresentaram queda nos dois anos, sendo mais acentuada no primeiro ano. A média da estimativa do nível de infestação para cada estágio do carrapato nos seis locais monitorados não chegou a 1 indivíduo ao final do experimento, sendo que a média da estimativa para as ninfas foi de zero em todos esses locais.

Palavras-chave: Manejo integrado de pragas, *Amblyomma sculptum*, *Hydrocoerus hydrochaeris*.

Introduction

Ticks are parasites with the capacity to infest a large number of animal species such as reptiles, amphibians, birds and mammals (GUIMARÃES et al. 2001).

Based on morphological and genetic studies, there are at least two species of the *Amblyomma cajennense* species complex in Brazil: *A. cajennense* sensu stricto; and *Amblyomma sculptum*. The later

species is the only one found in the southeastern region (NAVA et al., 2014; MARTINS, 2016). Therefore, in studies conducted in the southeastern region of Brazil before the ones mentioned above, ticks referred to as *A. cajennense* are now identified as *A. sculptum*.

A. sculptum ticks are associated with transmission of a variety of infectious agents, such as bacteria and protozoa, (MENEZES, 2017). This tick can also act as vectors for the bacterium *Rickettsia rickettsii*, which is responsible for causing Brazilian spotted fever (BSF) (LABRUNA et al., 2009).

The impact of human interference, decreased biodiversity and climate change have promoted exchanges of pathogens between

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the populations of domestic and wild animals and humans (AGUIRRE et al., 2002; DASZAK et al., 2004).

A. sculptum presents a low host specificity and may parasitize diverse domestic animals, including humans. However, horses, capybaras and tapirs are its main hosts for all of its life cycle forms (PACHECO et al., 2009; KRAWCZAK et al., 2014). Any of these forms transmits rickettsioses via its salivary glands, during all of its developmental stages (larva, nymph and adult) (FIOL et al., 2010). According to the Health Department of the state of São Paulo (2019), 795 cases of BSF were recorded between 2007 and 2019, resulting in 424 deaths (SSE-SP 2019)

In addition to the to public health risks associated with the possible transmission of BSF by infected *A. sculptum* ticks, they also disturb recreational activities using horses. In the same context, public or private parks with populations of capybaras (*Hydrochoerus hydrochaeris*) become areas at risk. Horse breeding itself is affected because of the damage caused by hematophagy, which causes clinical deterioration on highly-parasitized individuals.

Because of the importance of these ticks in relation to parasitism in production animals and the risks of transmitting diseases to humans, treatment of primary hosts using chemical acaricides has been used to control them. According to Bittencourt et al. (1997), tick control using chemicals leads to appearance of resistant populations and has an impact on the environment. Exclusive use of chemical control methods is unviable in practical and economic terms, and use of alternative methods within an integrated control system is indicated (BARROS & EVANS, 1989).

Based on the concept of integrated pest management (IPM) described in a report by FAO (2018), activities were defined in the present study aiming the integrated control program for the tick *A. sculptum*. These activities include a series of measures for training of human resources for farm work, adequate management of pasture areas, facilities and animals, and strategic use of acaricides based on appropriate chemical groups.

The objective of the present study was to evaluate the efficacy of the integrated pest management to control the population of *A. sculptum* on an environment with an abundance of capybaras in a BSF endemic region in the São Paulo state.

Material and Methods

The present study was conducted on the farm Fazenda da Ponte, located in the municipality of Itu (23° 15' 57" South; 47° 17' 57" West), in the state of São Paulo, between June 2015 and July 2017. This farm is characterized by the presence of various domestic and wild animals, mainly capybaras, and by bordering the Tietê river.

Employee training

Employees were trained regarding the diversity, biology and ecology of the ticks that are present on the farm, and how to control them. They were given guidance about BSF, especially regarding the symptoms of the disease and the proper way to deal with it. They were also instructed about how to conduct environmental and animal management.

Environmental management

Grasslands and pastures were mowed every 30 days between December and April. During other periods of the year they were mowed with a lesser frequency, whenever it was needed to maintain the vegetation as low as possible. Pasture being grazed by horses were not mowed at all. The mowed grass was removed from the pastures and burned elsewhere in the farm.

Electric fences were activated in order to avoid the passage of capybaras from the pastures close to the river into the other areas of the farm under management and monitoring. This fence consisted only of an electric wire elevated some 20 cm from the ground and was installed in the lower part of conventional barbed wire fences (Figure 1).

Horse management

Due to the degree of infestation by *A. sculptum*, all of the eight horses of the farm were treated using deltamethrin-based acaricides with the amount and concentration recommended by the manufacturer and applied with a hand spraying machine. Initially, spraying was conducted weekly between August and October 2015. Subsequently, the schedule proposed by Labruna et al. (2004) was used, with weekly sprayings between April and July.

The different domestic species were separated. The horses were relocated from the area beside the river into a new pasture location (identified as "horse"). Therefore, these individuals were kept without contact with other animals, especially capybaras, since these are primary hosts of *A. sculptum*.

Tick collection and counting

Traps made of rectangular cuts of white synthetic cloth (made of polypropylene and viscose and popularly known as "tnt" in Brazil) were used to collect ticks. Each of these cloths presented

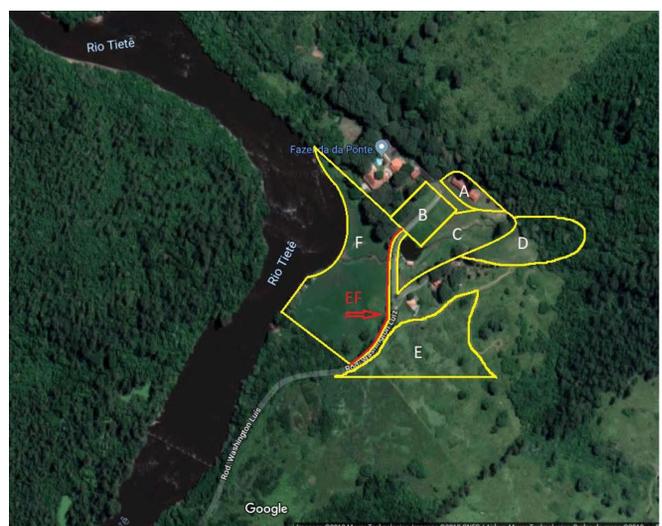


Figure 1. Fazenda da Ponte: Overall farm aspect with the following assigned locations: A: pen; B: picket; C: stream; D: waterfall; E: horse; and F: river. EF: Electric Fence.

an area of approximately 350 cm², and 100 g of dry ice were placed at the center of the rectangles so that the CO₂ (released during sublimation) would attract ticks. After one hour, the traps were recovered in accordance with the technique proposed by Gray (1985).

The cloths were stored in sealed plastic bags and properly identified. They were then sent to the laboratory for counting of larvae, nymphs and adults. Subsequently, the tick species found were identified with the aid of a magnifying glass, in accordance with the taxonomic keys proposed by Nava et al. (2014) and Martins (2016). Because of the lack of taxonomic keys for identifying the larvae of *Amblyomma sp.*, individuals in this stage could not be identified at the species level and were classified only according to their genus.

Evaluation and monitoring of infestation levels

In June 215 traps were set in several locations, which were defined as: house, chapel, pen, stream, mine, mine trail, river, picket and waterfall. These were used to determine the locations with high infestation levels, which then defined the strategic locations for monthly evaluations for the integrated control program during the first year, and for bimonthly evaluations during the second year. These locations were identified as: “pen - A”, “picket - B”, “stream - C”, “waterfall - D”, “horse - E” (pasture to which the horses were relocated) and “river - F” (Figure 1).

Monitoring was conducted monthly between July 2015 and June 2016, and bimonthly between July 2016 and July 2017, by setting traps in the locations of highest infestation levels that had previously been identified.

Statistical analysis

Time periods and locations were compared regarding the numbers of adults, nymphs and larvae of ticks that were found, and according to the number of events or, in other words, each trap collected over time. The zero-inflated Poisson model was used within a Bayesian approach (MAZIN et al., 2008).

The calculation was conducted using the WinBUGS software with Gibbs sampling and Metropolis-Hastings algorithms in order to obtain estimations of the model parameters. Fifteen thousand samples were generated, and five thousand out of them were discarded (“burn-in samples”) in order to exclude the effect of the initial values used in the simulation algorithm. In addition, consecutive interactions (100a, 200a, 300a and so on) were used. This resulted in a final sample of 100 simulated chains for each parameter. Algorithm conversion was evaluated using time graphs of the samples generated, by means of standard techniques available in the literature (GELMAN & RUBIN, 1992).

Results and Discussion

Table 1 shows all the data referring to the total number of ticks collected during the study. A total of 1,721 free-living ticks were collected, all belonging to the genus *Amblyomma*. Out of

the total number of ticks collected, 450 were larvae, 1,090 were nymphs and 181 were adults. Among the adults collected, a single specimen was identified as *Amblyomma dubitatum*, while the others were identified as *A. sculptum*.

Figure 2 shows that control over the overall tick infestation was achieved, since all stages presented levels close to or equal to zero by the end of the study (July 2017). The adult population presented a decrease during the first year, and the larval population decreased during the second year. Nymphs presented decreases during both years, but the decrease was more pronounced during the first year.

The mean estimated population for each tick stage (Table 2) at all six locations monitored did not reach one single individual at the end of the experiment, and the estimation for nymphs was zero at all locations. This result can be seen better in Figure 3.

Locations A, B, C and D presented the same profile throughout the study (Figure 3). However, location E presented an increase in the mean estimated infestation level of all stages in 2016, especially in the numbers of larvae and nymphs.

At the beginning of the work at the farm Fazenda da Ponte, the horses were kept without any type of chemical treatment and were allocated to pastures often visited by capybaras. This can be considered to be a factor related to the high infestation level of ticks of the species *A. sculptum*, spread throughout the property. This is concordant with the findings of Labruna et al. (2004), who recorded that the tick load was high when horses were not treated with acaricides. In the light of this situation, horse management using chemical treatment conducted according to the technique proposed by Labruna et al. (2004) was established, with transferal of these animals to the location “horse” (E).

The present study also indicated that another management measure for the farm was to keep the height of the vegetation low in

Table 1. Number of free-living ticks and species found on the farm Fazenda da Ponte in the municipality of Itu, São Paulo, between July 2015 and July 2017.

Tick species	Larva	Nymph	Adult	Total
<i>Amblyomma</i> spp.	450	-	-	450
<i>Amblyomma sculptum</i>	-	1090	180	1270
<i>Amblyomma dubitatum</i>	0	0	1	1

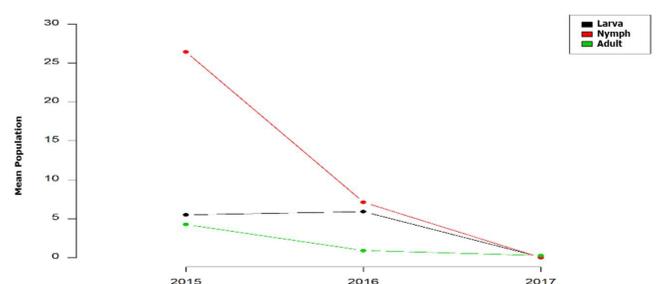


Figure 2. Estimated mean numbers of larvae, nymphs, and adults of the *Amblyomma sculptum* on the farm between July 2015 and July 2017.

Table 2. Estimation of the infestation level of larvae, nymphs and adults of *A. sculptum* in the six evaluated locations on the farm Fazenda da Ponte, Itú, between 2015 and 2017. Locations on the farm where evaluations were conducted: A – Pen; B – Picket; C – Stream; D – Waterfall; E – Horse; and F – River. CI: confidence interval.

Year	Location	Larva			Nymph			Adult			Total		
		Estimate	95% CI		Estimate	95% CI		Estimate	95% CI		Estimate	95% CI	
2015	A	10.20	7.66	13.17	2.00	1.02	3.45	8.09	5.87	10.75	20.52	16.81	24.70
	B	3.42	2.06	5.32	5.18	3.46	7.48	4.05	2.58	6.06	13.08	10.16	16.51
	C	1.31	0.57	2.55	0.29	0.04	1.00	0.48	0.13	1.27	2.04	1.07	3.51
	D	0.75	0.24	1.77	0.26	0.04	0.91	6.56	4.60	8.96	7.65	5.49	10.35
	E	5.51	3.74	7.85	23.23	19.27	27.60	1.22	0.51	2.43	30.07	25.52	35.11
	F	11.04	8.32	14.19	127.00	117.00	137.10	4.26	2.70	6.29	142.50	132.40	153.00
2016	A	0.07	0.00	0.39	0.90	0.40	1.69	0.15	0.02	0.49	0.97	0.46	1.78
	B	0.15	0.02	0.56	0.18	0.03	0.62	0.16	0.03	0.56	0.42	0.14	1.01
	C	0.03	0.00	0.29	1.20	0.60	2.13	0.13	0.02	0.49	1.34	0.70	2.28
	D	0.13	0.02	0.51	0.15	0.02	0.56	0.37	0.11	0.90	0.63	0.24	1.31
	E	34.21	30.41	38.49	33.92	30.03	38.17	3.90	2.66	5.41	72.38	66.56	78.46
	F	0.84	0.36	1.63	6.20	4.62	8.14	0.78	0.33	1.55	2.42	1.51	3.68
2017	A	0.05	0.00	0.41	0.00	0.00	0.30	0.11	0.00	0.55	0.13	0.00	0.59
	B	0.03	0.00	0.37	0.00	0.00	0.30	0.07	0.00	0.48	0.09	0.00	0.52
	C	0.02	0.00	0.32	0.00	0.00	0.27	0.29	0.05	0.94	0.32	0.06	1.01
	D	0.02	0.00	0.32	0.00	0.00	0.26	0.22	0.03	0.84	0.21	0.03	0.78
	E	0.20	0.02	0.82	0.00	0.00	0.29	0.70	0.22	1.65	0.96	0.36	2.08
	F	0.19	0.02	0.78	0.00	0.00	0.16	0.23	0.03	0.82	0.47	0.11	1.29

pasture and grassland areas, in line with the reports of Labruna et al. (2001, 2004). From these studies, it was reported that there was a strong relationship between “dirty” pastures (i.e. pastures in which plant growth was unchecked) and favorable microclimate conditions that contributed to survival and development of these ticks in the environment.

From the time of the initial data-gathering on the farm Fazenda da Ponte, high numbers of capybaras were observed along the riverbanks. Consequently, higher numbers of ticks were found in this sampling location (F), while the number of ticks caught was usually a little lower in the other sampling areas. This area was characterized by high vegetation and the presence of several species of domestic and wild animals, especially horses and capybaras.

During the first year of the experiment, a flaw in the management proposed for the farm was identified. During one of the monitoring visits, horses were once more found along the riverbanks. This possibly caused an increase in the infestation observed in 2016 in the area to which the horses were allocated (E). This suggests that horses were responsible for tick dispersion to other areas of the farm with limited access to the capybaras.

Another similar situation was described by Siqueira (2017), who found an abundance of *A. sculptum* in a forest area and identified horses as the source of infestation. That author found that animals that visited this area were responsible for carrying parasites to locations that were more distant from the infestation source. In addition, the reintroduction of horses to the river banks, an area also visited by capybaras,

seems to be similar to what was described by Labruna et al. (2004). Those authors stated that, even when ticks were controlled intensively through strategic baths for horses, favorable conditions for development of ticks would allow their perpetuation in the environment. Thus, part of the population could be maintained through feeding off a few species of wild animals, thereby ensuring their survival such that they would never be eliminated from the area.

Only one individual of the species *A. dubitatum* was found, which was caught at location “E”. Siqueira (2017) also found this species in low numbers in pastures, and in significantly lower numbers than *A. sculptum*. The primary host for *A. dubitatum* Neumann, 1899 (= *Amblyomma cooperi* Nuttall and Warbuton, 1908) is capybaras (VIEIRA et al., 2004), which were constantly observed on the farm of the present study. This tick species is associated with damper and more floodable environments (SZABÓ et al., 2007; QUEIROGAS et al., 2012). However, in the sampling of the present study, over the course of two years, no other individual was caught, even in areas that theoretically would be preferred by *A. dubitatum*.

Although the model was not specifically designed to measure the role of the interaction between horses and capybaras in intensification of infestation by *A. sculptum*, the results obtained strongly suggest that segregation of these species is an important and necessary measure within integrated tick management programs in rural areas.

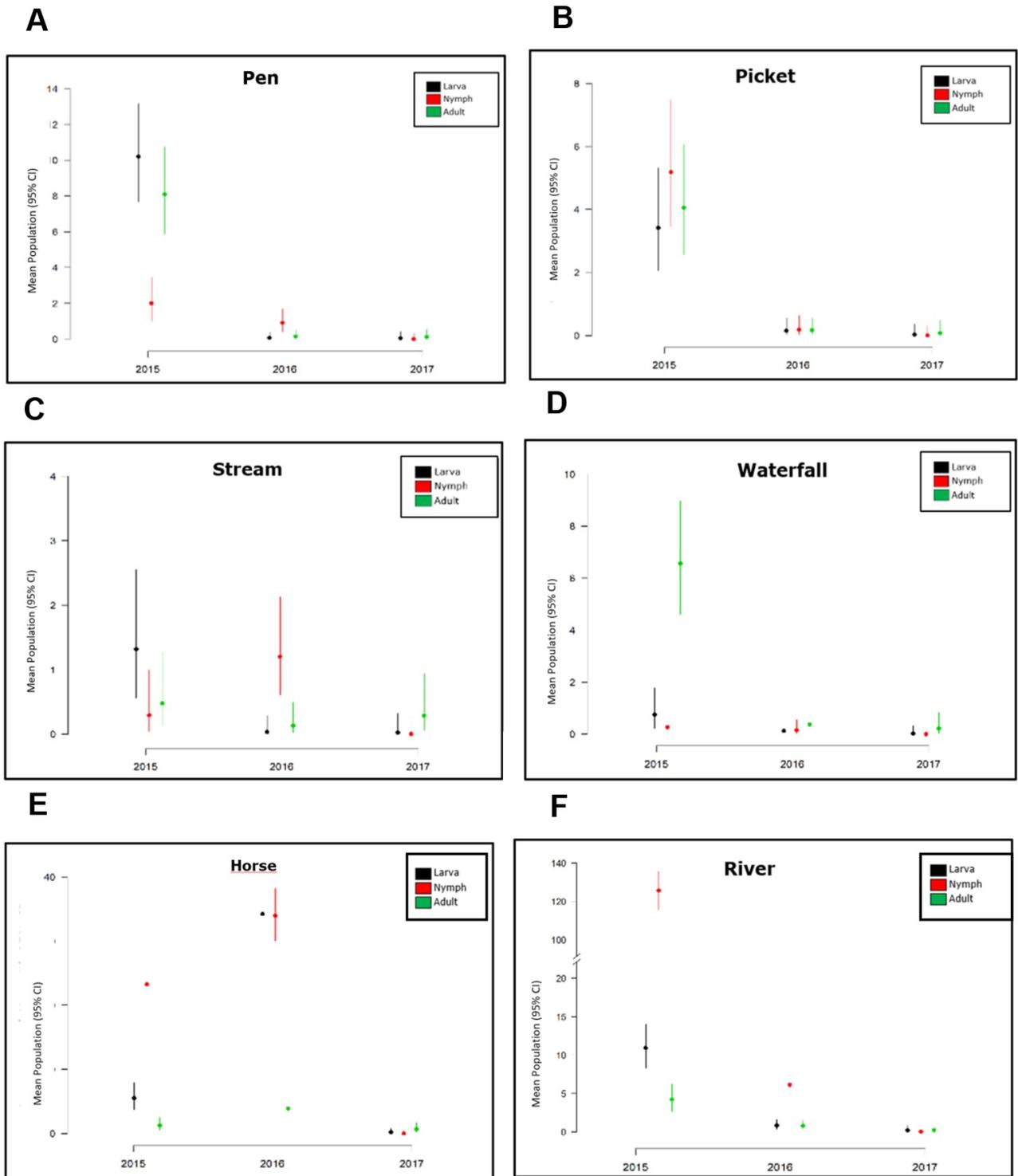


Figure 3. Estimated numbers of larvae, nymphs and adults of the *Amblyomma sculptum* in the locations identified as A to F, between July 2015 and July 2017.

Conclusion

The results obtained in the present study showed that, within two years, a high tick infestation level was effectively reduced, since the data reached values close to zero. Therefore, this study demonstrate

for the first time that uninterrupted use of measures based on the IPM concept (which was called integrated tick control in the present study) and using the association of procedures already developed elsewhere can be a good means for establishing a control protocol on farms, as long as they are conducted by properly trained individuals.

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