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ARTHROPODS AND MEDICAL ENTOMOLOGY - ORIGINAL PAPER

Alternative applications of the strategic control against the cattle tick *Rhipicephalus* (*Boophilus*) *microplus* in a subtropical area

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Abstract

Although different evaluations on the efficacy of the strategic control against *Rhipicephalus microplus* have been performed, the effects of successive applications of these schemes on the abundance of cattle ticks have not been evaluated. The aim of this work was to analyse the long-term effect of strategic applications of chemical acaricides on the *R. microplus* infestation in cattle in a subtropical area. These schemes are based on the application of three annual treatments between late winter and late spring. Additionally, a trial to evaluate the efficacy of the strategic control by deferring the first treatment from late winter to spring and the third treatment from late spring to summer was also carried out. The efficacy of the strategic control applied on 3 consecutive years was significant. The tick infestation in the treated group always remained at low levels, because mean number of ticks was almost never higher than 20. Regarding the trial where the third application of acaricide was deferred from spring to summer, and the first one from late winter to spring, the differences between treated and control group were significant in all post-treatment counts. The results of this study add evidence that support the sustainability of the strategic control in subtropical areas where the population dynamics of *R. microplus* is characterized by a well-marked seasonal pattern. Three relevant aspects were determined: (i) the feasibility and efficacy of successive applications of the strategic control in consecutive years; (ii) the time window to start the sequence of treatments is from late winter to mid-spring; (iii) it is achievable deferring the last treatment from late spring to summer if the tick infestation levels on cattle are low enough to allow it.

Keywords *Rhipicephalus microplus* · Control · Chemical acaricides · Argentina

Introduction

The cattle tick *Rhipicephalus* (*Boophilus*) *microplus* is one of the most important parasites affecting livestock production in tropical and subtropical areas of the world. The deleterious effects of this tick on cattle include reduction of weight gain and milk production, hide damage, mortality, morbidity, transmission of haemoparasites (i.e. *Babesia bovis, Babesia bigemina* and *Anaplasma marginale*) and a higher probability of screwworm myiasis occurrence (Späth et al. 1994; Reck et al. 2014). The control of *R. microplus* is mainly achieved with synthetic chemical acaricides. But the intensive use of chemical acaricides can lead to problems such as the rise of drug resistance and accumulation of chemical residues in meat or milk (George et al. 2008; Nari Henrioud 2011; Klafke et al. 2017).

The counterproductive effects associated to the use of chemical acaricides can be avoided or minimized through the use of strategic control methods. They are based on the application of few treatments in the season when the tick population is less numerous and most vulnerable (Norris 1957; Barnett 1961). In subtropical latitudes of northern Argentina, the dynamics of the infestation level of *R. microplus* on cattle is characterized by an increase in abundance from mid- or late spring to autumn and

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then a marked decrease through winter and early spring (Guglielmone et al. 1981; Canevari et al. 2017; Nava et al. 2020). This seasonal pattern is similar to that found in subtropical latitudes of other South American countries as Brazil and Uruguay (Evans 1992; Nari 1995; Martins et al. 2002). Strategic control methods based on three annual applications of chemical acaricides between late winter and late spring were applied and evaluated with positive results in northwestern and northeastern regions of Argentina with different habitat suitability conditions for *R. microplus* (Nava et al. 2015, 2019, 2020; Morel et al. 2017). These three treatments between late winter and late spring are not enough for an absolute control of ticks but they prevent the development of the larger generations on late summer and autumn, maintaining the tick population at low abundance levels. Moreover, the application of strategic treatment schemes to control infestation with *R. microplus* in northeastern Argentina enables to obtain better body weight gains in growing cattle by preventing high levels of tick parasitism on animals (Rossner et al. 2021).

Although different evaluations on the efficacy of the strategic control against *R. microplus* were performed in Argentina (Nava et al. 2015, 2019, 2020; Morel et al. 2017), all of them comprised a limited temporal period (i.e. 10 months). It was not evaluated how the successive applications of the strategic control in consecutive years affects the abundance of cattle ticks. Also, the above-mentioned schemes of strategic control were based on three treatments from late winter to late spring, where the first treatment was always applied at the end of winter. But the robustness of these schemes in the face of modifications in the date of the acaricide applications that may be imposed by the dynamics of cattle farms management was not evaluated. In order to provide information to sustain the practical applicability of the strategic control against *R. microplus* in subtropical latitudes, the present study was performed to analyse the long-term effect of strategic applications of synthetic chemical acaricides on the infestation patterns of *R. microplus* in cattle. Additionally, two alternative schemes of treatment were evaluated to assess whether deferring the third application of acaricide from late spring to late summer, and the first application from late winter to spring, affects the efficacy of strategic control.

Materials and methods

Two of the three field assays of this work were carried out in El Colorado (26°19′S, 59°21′W), Formosa Province, Argentina. This site belongs to an area ecologically characterized by a mosaic of xerophytic forest, mesophyte plants, savannahs and "Albardón" Forests (Oyarzabal et al. 2018). The third assay was performed in Colonia Tabay (28°18′S 58°17′W), Corrientes Province, Argentina, where savannahs of *Andropogon lateralis* and *Paspalum notatum* prevail (Oyarzabal et al. 2018). Both localities are representatives of the area defined as ecologically most favourable for *R. microplus* in Argentina by Guglielmone (1992). The climate in the study area is humid subtropical with an average annual rainfall of 1100–1300 mm with no dry season, although precipitation is lower during winter.

Two groups of ten bovines each were included in the assay performed to evaluate the effect of strategic control in a 3-year period in El Colorado. One group of bovines was treated with synthetic chemical acaricides (Group I) and the second one remained as control group (Group II). A tick-infested pasture composed mainly of *Dichanthium aristatum* was divided into two paddocks of 5 ha each in order to maintain the two groups. The stocking rate was 2.0 cattle units/ha. 1-year-old Criollo heifers and steers and their crosses formed the two groups in the first year, 1-year Braford heifers were used in the second year, and 1-year Braford steers formed the treated and control groups in the third year. At the beginning of the trial, 20 bovines naturally infested with *R. microplus* were divided on day 0 into two homogeneous groups of 10 animals each according to the level of tick infestation (Kruskal–Wallis test, $P > 0.05$). When the trial of the first year was completed, the new animals that entered each of the two paddocks in the second year (Braford heifers) were free of ticks, and the same procedure was employed when the animals used in the trial of the third year (Braford steers) replaced the bovines used in the trial of the second year. In this way, the annual replacement of animals did not affect the level of tick infestation that each paddock previously carried. In the first year, bovines belonging to Group I were treated with an injectable formulation of ivermectin 3.15% (IVOMEC GOLD®, Boehringer Ingelheim Animal Health) at a rate of 1 ml/50 kg of body weight on day 0 (30th August 2017, late winter), with 1 ml/10 kg of a pour-on formulation of fluazuron (ACATAK®, Elanco Animal Health) on day 34 post first treatment (3rd October 2017, early spring), and with 5 ml/50 kg of a pour-on formulation of flumethrin (BAYTICOL®, Bayer) on day 85 post first treatment (23th November 2017, late spring). The intervals between treatments were determined by adding the number of days of residual effectiveness for absolute tick control of each formulation (as indicated by the manufacturer) plus a period of 10–12 days. The same commercial formulations of chemical acaricides, and in the same sequence, were applied to animals belonging to Group I in the second year. Treatments with ivermectin 3.15%, fluazuron and flumethrin were applied on 23rd August 2018 (day 0, late winter), 27th September 2018 (day 35 post first treatment, early spring) and 15th November 2018 (day 84 post first treatment, late spring), respectively. In the third year, the animals of Group I were subjected to treatments with fluazuron and flumethrin on 27th September 2019 (day 0, early spring) and 14th November 2019 (day 48 post first treatment, late spring), respectively, as described above. But unlike the previous 2 years, the third treatment was not applied in late spring, instead it was deferred to summer. This third treatment consisted of an application of a commercial pour-on formulation of fipronil 1% (ECTOLINE®, Boehringer Ingelheim Animal Health) at a rate of 1 ml/10 kg on 4th March 2020. The animals from the control group were submitted to a palliative treatment with fipronil (ECTOLINE®) and deltamethrin 1% (BUTOX®POUR-ON, MSD Animal Health) during the second annual period at December 2018 and April 2019, respectively, in order to avoid severe infestation drawbacks.

A trial to evaluate the efficacy of the strategic control by deferring the first treatment from late winter to spring and the third treatment from late spring to summer was carried out in Colonia Tabay. Twenty-four Braford heifers naturally infested with *R. microplus* were arranged to constitute two groups of 12 animals each, one subjected to treatments against ticks (Group I) and the other as a control without treatments (Group II). Animals were also divided into two homogeneous groups according to tick infestations and kept in a paddock of 5 ha with a pasture of *Brachiaria brizantha* naturally infested with *R. microplus*. Heifers of Group I were treated with a commercial pour-on formulation of fluazuron (ACATAK®, Elanco Animal Health) at a rate of 1 ml/10 kg of body weight on day 0 (8th October 2019, spring), with 5 ml/50 kg of a pour-on formulation of flumethrin (BAYTICOL®, Bayer) on day 54 post first treatment (1st December 2019, spring), and with a commercial pour-on formulation of fipronil 1% (ECTOLINE®, Boehringer Ingelheim Animal Health) at a rate of 1 ml/10 kg on day 99 post first treatment (15th January 2020, summer).

The quantification of tick infestation on cattle was made by monthly counts of the *R. microplus* females (4.5–8.0 mm long) on the left side of the bovines. The number of ticks counted was multiplied by two for statistical analyses. Prevalence (number of hosts infested/number of hosts examined), mean number of ticks (number of ticks/number of hosts examined, including both infested and non-infested hosts) and median with first and third quartiles (1Q–3Q) were calculated. Because the Shapiro–Wilk test (Zar 1999) indicates that the data are not normally distributed ($P < 0.05$), statistically significant differences in the distributions of *R. microplus* numbers between treated and control groups were analysed by using the non-parametric Mann–Whitney test. Differences were considered significant at $P < 0.01$. The therapeutic efficacy of the treatments was determined by calculating the corrected efficacy percentage (EP) with the modified Abbot's formula by using the mean number of ticks (Henderson and Tilton 1955):

$$\mathrm{EP\%} = \left(1 - \frac{n \text{ in Co before treatment} \times n \text{ in T after treatment}}{n \text{ in Co after treatment} \times n \text{ in T before treatment}}\right) \times 100,$$

where n is the mean number of ticks, T is the treated group and Co is the untreated group. The efficacy percentage was calculated by using arithmetic means because in the presence of aggregation the efficacy estimated from the arithmetic mean has provided unbiased results, whereas geometric means often yield skewed outputs (McKenna 1998; Dobson et al. 2009).

Monthly differences in tick distributions on hosts within the same year and among years were tested by using the Kruskal–Wallis test with a posterior Dunn's multiple comparison (Zar 1999). Tick susceptibility to chemical groups applied during this study was evaluated with the larval immersion test, larval packet test and adult immersion test described in Klafke et al. (2017) and Torrents et al. (2020a, b), and by observing the efficacy of the acaricides after each treatment under field conditions. Handling of animals was made in accordance with the institutional guide for the care and use of experimental animals (resolution number P21–025), with the approval of the Institutional Committee for Care and Use of Experimental Animals, CICUAE-INTA, Argentina.

Results

The results of the trials performed in El Colorado during the annual periods August 2017–May 2018, August 2018–May 2019 and September 2019–May 2020 are presented in Tables 1, 2 and 3, respectively. In this locality, a scheme of winter-spring strategic control was applied during the first two annual periods, while the third treatment was deferred from late spring to late summer in the last period (2019–2020) (Fig. 1). Differences in tick infestation level between treated and control group of bovines were significant in all post-treatment counts, regardless of the annual period, although the values of efficacy percentage were highly variable among months within a year, and among years for a same period (Tables 1, 2, 3). These significant differences can be visualized in Fig. 1, where the dynamic of tick infestation level in both treated and control group of bovines during the 3 years is shown. The mean number of ticks and the median values in the group of bovines subjected to the strategic control were never higher than 20.5 and 15, respectively, with the only exceptions of the counts of March (mean: 58.1; median: 49) and May (mean: 28.2; median: 31) in the second annual period (2018–2019) (Tables 1, 2, 3). The mean value of the efficacy percentage for the 3-year period was 77.7. As can be observed in the dispersion graph

Table 1 Strategic control trial for the 2017–2018 period in El Colorado, Formosa Province

	P (%)	Group I			*P* (%)	Group II (control)	
		Mean	*M* (1Q-3Q)	EP (G1 vs G2)		Mean	*M* (1Q-3Q)
August	100	6.6[a]	5 (4–10)	NA	100	7.5[a]	6 (4–12)
September	10.0	0.2[a]	0 (0–0)	98.1	100	11.7[b]	9 (7–18)
October	0.0	0.0[a]	0 (0–0)	100	100	8.2[b]	4 (4–12)
November	50.0	2.4[a]	1 (0–4)	38.2	80.0	4.4[b]	4 (1–6)
December	0.0	0.0[a]	0 (0–0)	100	90.0	6.2[b]	6 (2–11)
January	0.0	0.0[a]	0 (0–0)	100	80.0	6.4[b]	6 (1–6)
February	0.0	0.0[a]	0 (0–0)	100	100	69.1[b]	62 (12–122)
March	80.0	13.6[a]	13 (4–22)	22.8	100	20.0[b]	18 (9–32)
April	40.0	7.6[a]	2 (0–4)	92.9	100	121.5[b]	50 (32–233)
May	90	16.0[a]	15 (10–24)	70.0	100	59.3[b]	38 (18–115)

Prevalence, mean number, median (*M*) and first and third quartiles (1Q-3Q) of *Rhipicephalus* (*Boophilus*) *microplus* females 4.5–8.0 mm long of the treated (Group I) and untreated (Group II) bovines. The efficacy percentage (EP) is also indicated. *NA* not applicable

Mann–Whitney *U* test. Numbers not sharing superscripts are significantly different at $P < 0.01$

Table 2 Strategic control trial for the 2018–2019 period in El Colorado, Formosa Province

	P (%)	Group I			*P* (%)	Group II (control)	
		Mean	*M* (1Q-3Q)	EP (G1 vs G2)		Mean	*M* (1Q-3Q)
August	100	10.9[a]	11 (6–15)	NA	90	10.2[a]	10 (6–14)
September	30	0.9[a]	0 (0–1)	87.2	70	6.6[b]	5 (4–8)
October	100	20.5[a]	12 (7–38)	59.8	100	47.7[b]	49.5 (24–59)
November	70	2.1[a]	2 (0–4)	91.8	100	22.9[b]	20 (15–24)
December	30	0.5[a]	0 (0–1)	99.8	100	274.8[b]	280 (265–340)
January	90	6.5[a]	6 (3–10)	63.4	100	16.6[b]	16 (14–18)*
February	80	2.8[a]	1.5 (1–5)	95.2	100	54.6[b]	53 (48–62)
March	100	58.1[a]	49 (35–74)	55.8	100	123.6[b]	118 (33–145)
April	100	14.5[a]	12 (9–20)	83.6	100	82.7[b]	79 (56–100)
May	100	28.2[a]	31 (20–40)	42.8	100	46.2[b]	42 (35–48)**

Prevalence, mean number, median (*M*) and first and third quartiles (1Q-3Q) of *Rhipicephalus* (*Boophilus*) *microplus* females 4.5–8.0 mm long of the treated (Group I) and untreated (Group II) bovines. The efficacy percentage (EP) is also indicated. *NA* not applicable

Mann–Whitney *U* test. Numbers not sharing superscripts are significantly different at $P < 0.01$

*A palliative treatment with fipronil (ECTOLINE®, Boehringer Ingelheim Animal Health) was applied to the untreated group of bovines 26 days before the tick count of January

**A palliative treatment with deltamethrin (BUTOX® POUR-ON, MSD Animal Health) was applied to the untreated group of bovines 24 days before the tick count of May

shown in Fig. 2, most of the months presented low level of tick infestation (mean number of ticks ≤ 20) with no statistical differences among each other. Only 2 months presented mean values higher than 20, namely March (58.1) and May (28.2) of the 2018–2019 period, and they were statistically different in the comparison with the remaining months (Fig. 2).

The results of the trial performed in Colonia Tabay are shown in Table 4 and Fig. 3. Tick counts were made from September 2019 to May 2020. Differences between treated and control group were significant in all post-treatment counts. Values of efficacy percentage were always higher than 88.1, with the only exception of the count of April where a value of 79% was obtained. The level of *R. microplus* infestation in the group formed by the treated bovines was characterized by mean and median values that never exceeded 10.8 and 9, respectively. The mean value of the efficacy percentage for the period October 2019–May 2020 was 89.8.

In both localities, the seasonal dynamic of *R. microplus*, considering only the infestation on the untreated groups, was characterized by an increase of abundance from late

Table 3 Strategic control trial for the 2019–2020 period in El Colorado, Formosa Province

	P (%)	Group I			*P* (%)	Group II (control)	
		Mean	*M* (1Q-3Q)	EP (G1 vs G2)		Mean	*M* (1Q-3Q)
September	100	11.4[a]	9 (8–14)	NA	100	12.4[a]	12 (7–20)
October	0	0.0[a]	0 (0–0)	100	90	14.0[b]	14 (7–24)
November	70	3.8[a]	3 (0–4)	89.4	100	39.1[b]	22 (9–67)
December	80	9.0[a]	9 (4–12)	44.6	100	17.5[b]	12 (12–22)
January	70	4.4[a]	4 (0–8)	70.8	100	16.4[b]	16 (12–20)
February	100	9.4[a]	9 (4–12)	60.8	100	25.1[b]	16 (7–42)
March	80	7.2[a]	8 (6–10)	77.9	100	35.5[b]	24 (14–28)
April	80	6.2[a]	4 (2–8)	78.6	100	31.5[b]	28 (16–44)
May	30	0.6[a]	0 (0–2)	97.3	100	36.6[b]	28 (13–40)

Prevalence, mean number, median (*M*) and first and third quartiles (1Q-3Q) of *Rhipicephalus* (*Boophilus*) *microplus* females 4.5–8.0 mm long of the treated (Group I) and untreated (Group II) bovines. The efficacy percentage (EP) is also indicated. *NA* not applicable

Mann–Whitney *U* test. Numbers not sharing superscripts are significantly different at $P < 0.01$

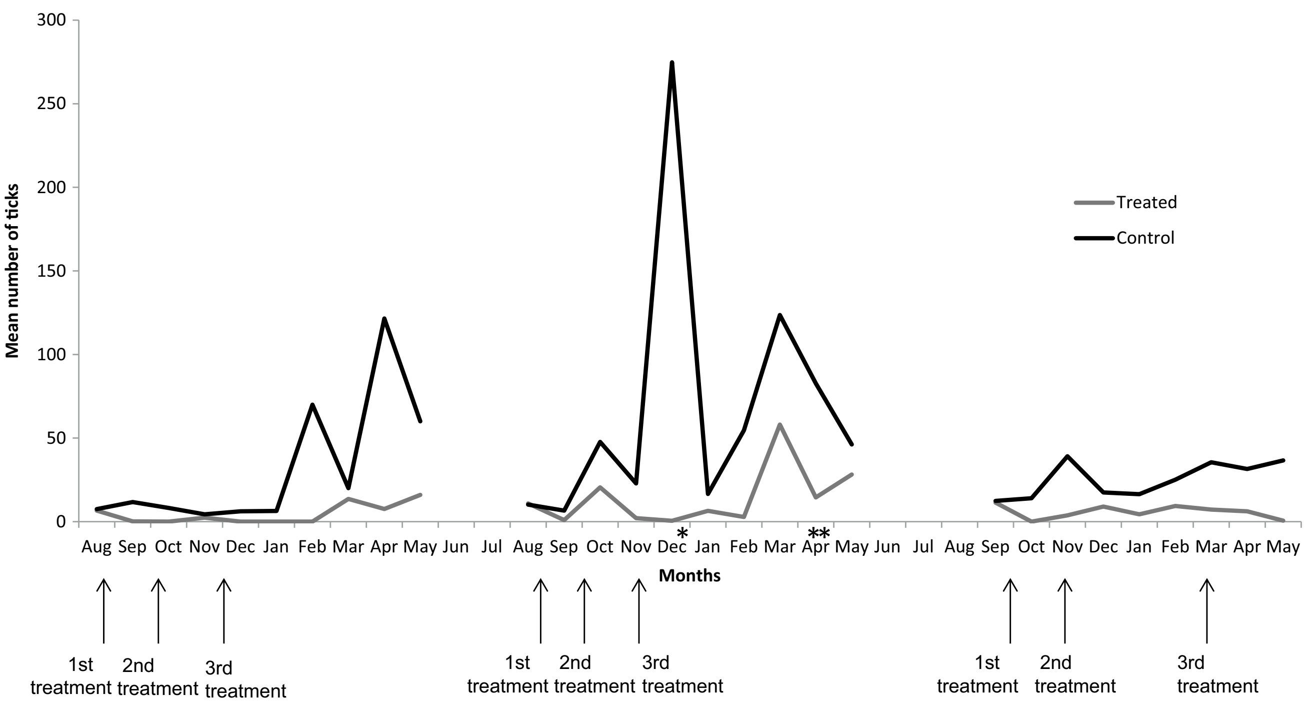

Fig. 1 Mean number of *Rhipicephalus* (*Boophilus*) *microplus* females (4.5–8.0 mm long) on cattle from August 2017 to May 2020 in El Colorado, Formosa Province, Argentina. See details of the treatments in material and methods. Group 1, treated: grey line; Group 1, control without treatments: black line. Animals from the control group were submitted twice to palliative treatments with fipronil (ECTOLINE®) (*) and deltamethrin 1% (BUTOX®) (**)

winter-early spring to autumn and then a decrease towards winter, with the peaks of abundance observed in late spring-early winter and autumn (Figs. 1, 3).

Discussion

This study demonstrates a significant efficacy of the strategic control schemes herein evaluated during a 3-year

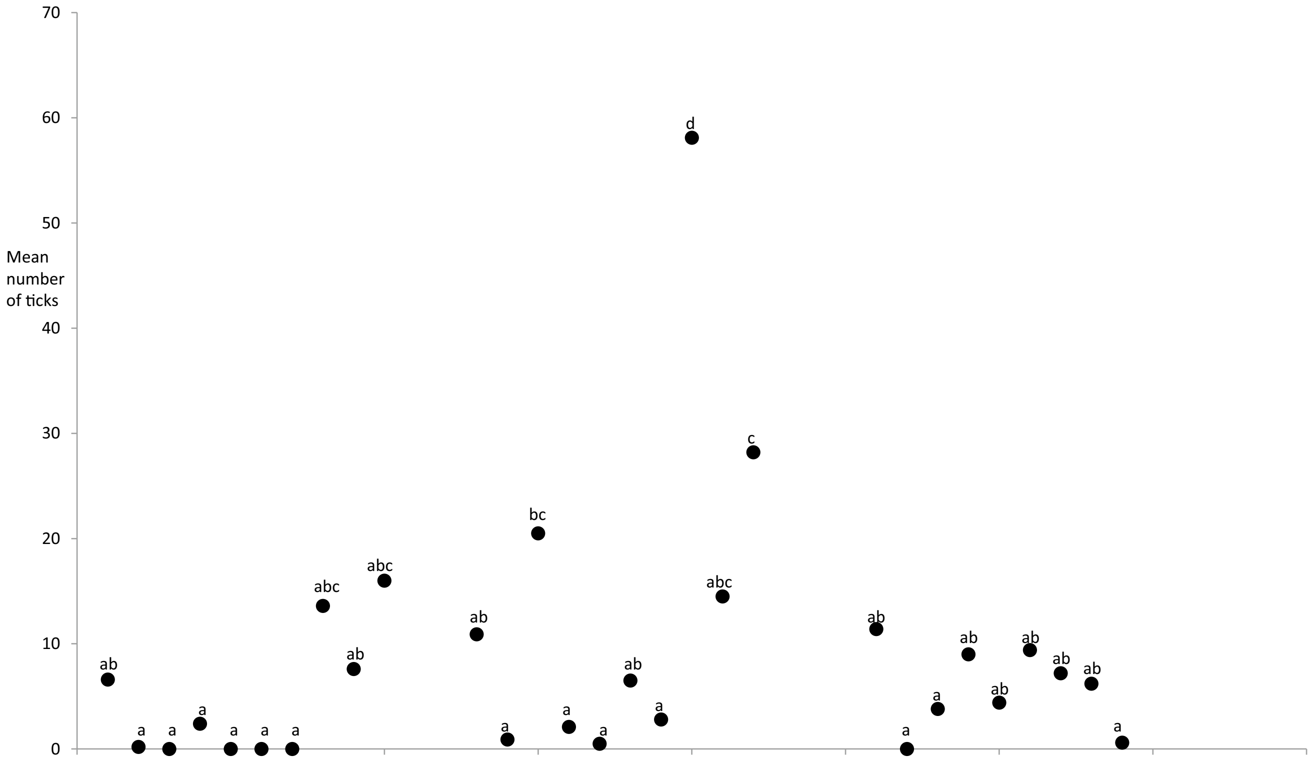

Fig. 2 Dispersion graphs showing the monthly values of mean number of *Rhipicephalus* (*Boophilus*) *microplus* females (4.5–8.0 mm long) on the treated cattle from August 2017 to May 2020. Kruskal–Wallis followed by Dunn's test: points not sharing superscripts are significantly different ($P<0.01$)

Table 4 Strategic control trial for the 2019–2020 period in Colonia Tabay, Corrientes Province

	P (%)	Group I			*P* (%)	Group II (control)	
		Mean	*M* (1Q-3Q)	EP (G1 vs G2)		Mean	*M* (1Q-3Q)
September	33.3	3.0[a]	2 (0–4)	NA	33.3	2.5[a]	2 (0–3)
October	66.6	4.3[a]	3 (0–8)	NA	83.3	5.1[a]	3 (2–8)
November	60	1.6[a]	1 (0–3)	89.7	100	18.5[b]	11 (8–22)
December	100	10.8[a]	7 (4–17)	88.1	100	107.5[b]	79 (50–162)
January	83.3	6.1[a]	6 (3–8)	93.8	100	116[b]	71 (36–224)
February	33.3	1.2[a]	0 (0–3)	98.2	100	78[b]	76 (35–112)
March	83.3	5.5[a]	5 (2–8)	91.2	100	80.2[b]	88 (40–115)
April	83.3	4.6[a]	2 (2–5)	79.0	91.6	26.0[b]	14 (8–42)
May	91.6	8.3[a]	9 (6–10)	88.6	100	86.3[b]	78 (40–142)

Prevalence, mean number, median (*M*) and first and third quartiles (1Q-3Q) of *Rhipicephalus* (*Boophilus*) *microplus* females 4.5–8.0 mm long of the treated (Group I) and untreated (Group II) bovines. The efficacy percentage (EP) is also indicated. *NA* not applicable

Mann–Whitney *U* test. Numbers not sharing superscripts are significantly different at $P<0.01$

period. Although absolute control was never reached, the tick infestation always remained at low levels (Figs. 1, 2). The median and mean number of ticks were almost never higher than 20. However, a single count, in March 2019, reached a value that can be considered high (median: 49, mean: 58.1). All the previous evaluations of similar schemes performed in different subtropical areas from Argentina (three applications of chemical acaricides between late winter and late spring; see Nava et al. 2015, 2019, 2020; Morel et al. 2017) only covered a 1-year period. In the current study, it was demonstrated that the efficiency remains high with just nine treatments in a 3-year period after the successive applications of the strategic control. However, the evolution of the *R. microplus*

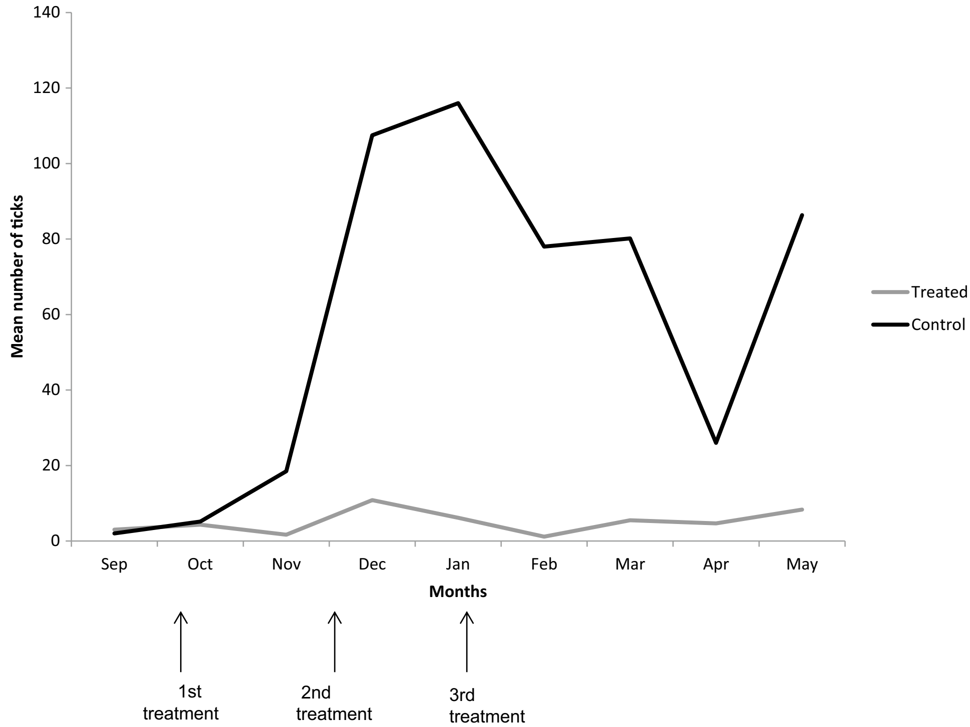

Fig. 3 Mean number of *Rhipicephalus* (*Boophilus*) *microplus* females (4.5–8.0 mm long) on cattle from September 2019 to May 2020 in Colonia Tabay, Corrientes, Argentina. See details of the treatments in material and methods. Group 1, treated: grey line; Group 1, control without treatments: black line

infestation level on cattle through the different years (Fig. 1) shows that there is no additive effect in terms of a decrease in tick abundance over time. The seasonal abundance of *R. microplus* is not only related to the efficacy of a control scheme but also to the susceptibility of a cattle herd to ticks or to the climatic conditions that can favour a tick population exponential growth at certain times of the year, which is a factor only observed in long-term studies.

An additional advantage related to the low number of treatments per year and the alternation of chemical groups is that selection pressure for resistance could be minimized. Alternation of chemical groups was made not only within a year but also among years, as for example between years two and three. In the 3-year period, the tick population was exposed to just three treatments with fluazuron and flumethrin (one per year) and two with ivermectin 3.15% (also one per year), while fipronil was applied only once. Furthermore, these control schemes could allow the maintenance of a refugia of susceptible ticks. In the context of animal parasite control, the term refugia refer to the part of the parasite population untreated and thus free from the selection pressure applied by exposure to drug (Hodgkinson et al. 2019). The long-acting formulations (i.e. IVOMEC GOLD®, ACATAK®) employed in these schemes are applied in a period of the year (late winter, early spring) where the population dynamics of *R. microplus* in its non-parasitic phase is characterized by incubation periods (see Nava et al. 2020) longer (or similar) than the period of residual effectiveness for absolute tick control of the acaricide formulation. Hence, a part of the tick population is not exposed to the treatment and therefore remains as refugia in the pastures in form of eggs or larvae recently hatched, potentially contributing to reduce the probability of resistance growth.

The schemes of strategic control evaluated in subtropical areas of northeastern Argentina, the part of the country ecologically most favourable for *R. microplus* according to Guglielmone (1992), were based on three treatments applied between late winter and late spring (Nava et al. 2019, 2020; annual periods of August 2017–May 2018 and August 2018–May 2019 of this work). But in order to evaluate the adaptability of these schemes to management modifications in a cattle farm, another objective of this study was to determine how the deferral of one of the three treatments affects the efficacy of strategic control. The third treatment was deferred from late spring to summer in the annual period 2019–2020 in El Colorado (Fig. 1), while the first and third treatments were deferred from late winter to early spring and from late spring to summer, respectively, in Colonia Tabay (Fig. 3). The efficacy values reached after these specific modifications are similar to those obtained with the late winter-late spring schemes, as observed in the results presented in Tables 1, 2 and in Figs. 1, 3, being in this way feasible to be applied. These positive results are due to the fact that the main basis of the strategic control is fulfilled, that is, acaricides act primarily in the period of the year (comprised between late winter and spring) when the tick population is less numerous and most vulnerable, preventing the development of the larger generations of late summer and autumn.

The results of this study add evidence that support the sustainability of the strategic control in subtropical areas where the population dynamics of *R. microplus* is characterized by a well-marked seasonal pattern. Although there are previous studies that have evaluated the strategic control against ticks of the subgenus *Boophilus* in subtropical areas (Norris 1957; Barnett 1961; Nava et al. 2015, 2020; Morel et al. 2017), three relevant aspects were determined in the current work with impact on the practical application of strategic control: first, the feasibility and efficacy of successive applications of the strategic control in consecutive years; second, the time window to start the sequence of treatments is from late winter to mid-spring; third, it is achievable deferring the last treatment from late spring to summer if the tick infestation levels on cattle are low enough to allow it. Considering that at present the control of *R. microplus* is almost exclusively performed by the use of synthetic chemical acaricides, the evaluation of different application schemes, for instance those proposed in this study, is necessary to optimize their effectiveness and minimize negative by-products such as resistance and the presence of residues in meat and milk.

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