ADJUSTMENT OF SIMULATIONS OF CATTLE TICK *(BOOPHILUS MICROPLUS)* POPULATIONS AND FIELD OBSERVATIONS IN THE PLANALTO REGION OF BRASÍLIA (DF)

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SUMMARY: The adjustment of simulations to correlate with real-time observations of cattle tick (*Boophilus microplus*) populations, under varying local conditions, permits the identification of key-factors, reliable mapping of the distribution of this parasite, and the designing appropriate local control programmes. The CLIMEX programme was used in the present study to compare 24 months of actual counts of standard female ticks, at the high (> 1000m) Planaltina site in the central region of Brazil, with local ecoparasitological simulations, with the Campo Grande site (>550m) and with others previously studied, where tick-counts are available. A meaningful relationship exists between the various components analysed; future control programmes, especially under conditions of tick resistance, can be developed using data of this type.

KEY WORDS: Cattle tick (*Boophilus microplus*), simulations, population dynamics, key factors, Brazil.

INTRODUCTION

Studies have been carried out to identify *key factors* in the population dynamics of cattle tick (*Boophilus microplus*) at several sites in Brazil, and include the application of simulation techniques to emulate observed real-time field patterns (HONER & GOMES, 1990; HONER *et alii*, 1993; SAUERESSIG & HONER, 1993). Each site was studied because of the recognition of particular, local, factors in the distribution and dynamics of the tick: Lages, (Santa Catarina State - SC), for example, is the least favourable site studied in detail in Brazil (HONER *et alii* 1993) while Bagé (Rio Grande do Sul State - RS), and Campo Grande (Mato Grosso do Sul State - MS) represent distinct degrees of favourability for this parasite for different reasons (SAUERESSIG & HONER, 1993). Within a given region marked differences may occur, resulting in important variations in disease transmission rates, (HONER, 1993; MADRUGA *et alii.*, 1993a, 1993b). The necessity for adjusting simulation scales in space and time, a process which may be referred to as *fine-tuning* and which permits the identification of key population processes on a very local scale (site-oriented), has become clear, and applications are being developed which permit this type of simulation for both ecto- and endoparasites.

The Central Brazilian Plateau (*Planalto Central*) where the Federal District (DF) is situated, combines altitude (>1000m) and latitude (15°S) in a region which, although not unfavourable for the cattle tick, is characterized normally by an annual dry-stress factor during the "winter", or dry season. The experiment reported here was designed to identify key factors in the population dynamics of *Boophilus microplus* under local conditions and to fine-tune and scale up simulation techniques with the CLIMEX model (SUTHERST & MAYWALD, 1985), to give continuous weekly population Growth Index (GI) readings and annual Ecological Index (EI) values which can be related directly to on-site field observations, and to other sites in Brazil, with a view to the development of a generalized model.

MATERIALS AND METHODS

Field observations were carried out on the premises of the Centre for Agricultural Research in the Cerrados

(EMBRAPA-CPAC), Planaltina, at an altitude of 1175 m, whose synoptic weather station in situated at 15°35'S and 47° 42'W, hereafter referred to as the CPAC site. Meteorological data from this, and other stations in the DF area, was used to: a) calculate weekly Growth Rates (GIs) during the experimental period and, b) calculate long-term local Ecological Indices (EIs, n=30 years), using the CLIMEX programme available at the National Centre for Beef Cattle Research (EMBRAPA-CNPGC), Campo Grande, MS (hereafter CNPGC) and also the Agro_Degree_Day programme (DD) developed there (HONER *et alii*, 1993).

From June 1989 and during the following 24 months, standard engorged female *B. microplus* were counted on seven untreated Holsteins x Zebu crosses, every 14 days, using the methodology described by WHARTON & UTECH (1970). The animals were kept together on native pasture at the CPAC, and subjected to all local management programmes, with the exception of tickicide treatments.

Counts obtained at 14-day intervals, were normalized by the square root transformation ($\sqrt{n}+1$) and used either directly as mean 14-day counts, or as mean monthly values for analysis and correlation with meteorological and simulation data.

RESULTS

The mean (n=30 years) CLIMEX characterization of the CPAC site is presented in Figure 1. The original 14-day standard female counts (seven animals/mean) are given in Figure 2. The graphical relationship between weekly GI values and the 14-day standard female counts, converted to monthly means (two counts x seven animals/month), is shown in Figure 3. Statistical correlations between meteorological data and population levels are given in Table 1. The relationship between the CPAC site and the Campo Grande (MS) site is depicted in Figure 4; the interrelationship of a number of critical tick sites in Brazil is given in Figure 5.

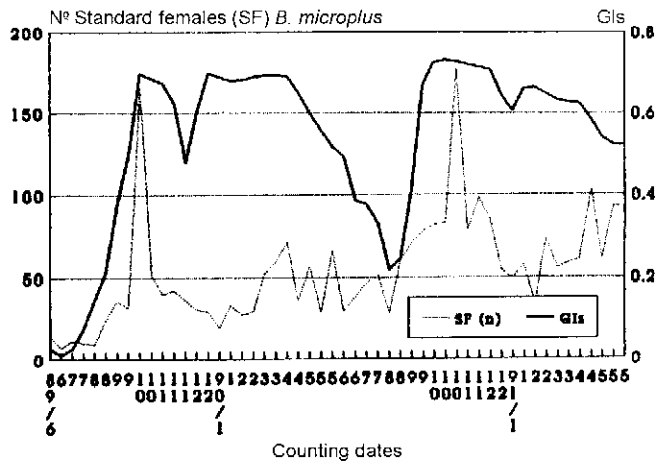

Fig. 2 - Counts of standard females (SF), means of seven animals, carried out at 14-day intervals. Since the animals were maintained on the same native pasture without tickicide treatments, the general increase in tick-counts may be due to this only, or in combination with increased favourability factors for the ticks, as indicated by calculated weekly GI values. Peak counts can be seen after the dry season, when hosts are in poor condition, and lower counts during the rainy season when hosts are less susceptible.

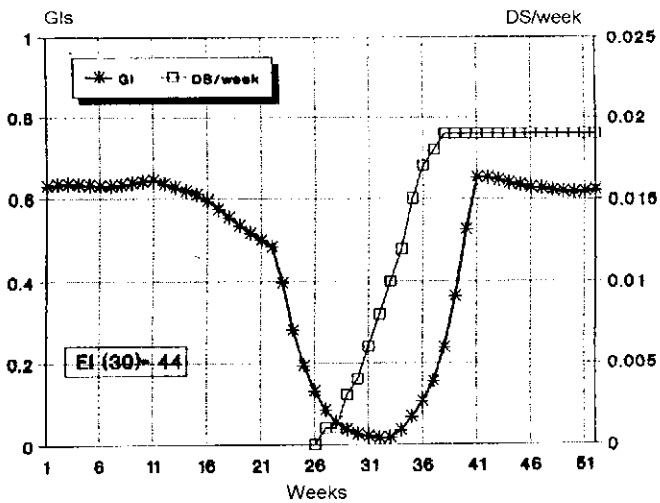

Fig. 1 - Simulation of mean favourability conditions (n=30 years) for the CPAC site, Brazilian Planalto. The annual mean Ecological Index = 44. The simulation identifies a Dry Stress (DS) factor, which accumulates after week # 26, reaching a final value of <0.02. Simulation carried out with CLIMEX programme.

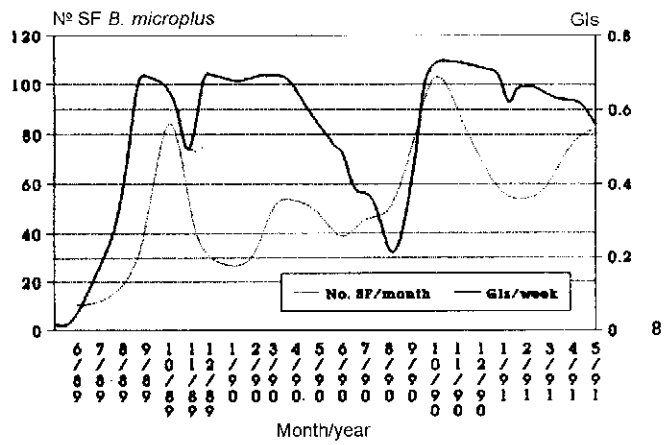

Fig. 3 - Relationship between counts of standard females (means of seven animals on >100 native pasture at 14-day intervals), recalculated as monthly means, and GI values indicating weekly favourability, for the CPAC site. The calculated GI graph indicates general favourability, without identifying small-scale population changes.

Table 1 - Statistical analysis of the correlations between three principal meteorological factors and cattle tick populations at the CPAC site. Analysis by Pearson's Coefficient of Correlation.

Parameters	Mean Temperature (°C)	Rainfall (mm)	Relative Humidity %
Nº Standard Females	0.5199	-0.0105	0.0981
Probability	0.0092	0.9610	0.6484

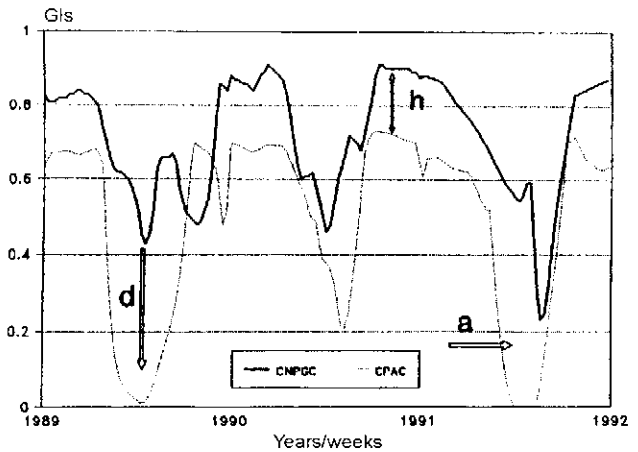

Fig. 4 - Similarities and differences in the relationship between calculated GIs for the CPAC (.....) and the CNPGC (__) sites for *Boophilus microplus* during the years 1989 to 1992. The overall pattern is clearly similar; differences in the depths of the troughs [d] and the peaks [h] of the graphs are reflected in the final annual EI values. Due to local conditions the graphs may be out of step, troughs being advanced [a] or delayed.

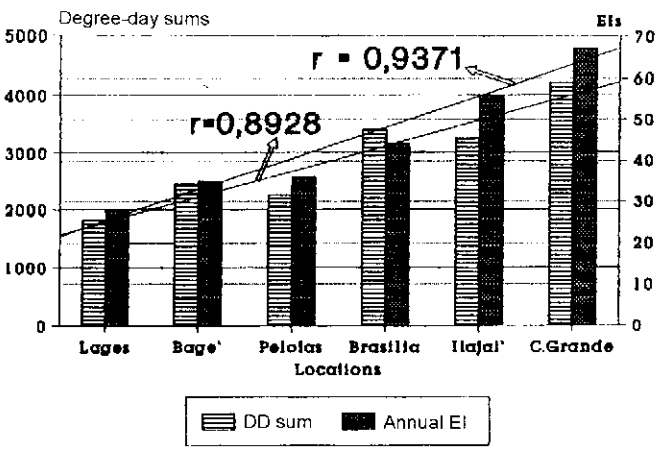

Fig. 5 - Relationship between Degree Day (DD) sums, annual EIs and geographical location for six key locations (experimental sites) in Brazil. The EI values generated by the CLIMEX programme show a stronger correlation than the values of the DD programme (r=0.9371 and r=0.8928, respectively).

DISCUSSION

The calculated (n=30) Ecological Index (EI) for the CPAC site is 44. This situates the Planalto area in an intermediate position between Bagé (RS; EI=35) and Itajaí (SC; EI=56) as shown in Figure 5, where the EI values for several key tick study sites are given, as well as the simpler Degree-Day model (DD) which produces values permitting a similar site ranking, although with a weaker correlation coefficient (r=0.8928 for the DD model as against r=0.9371 for the CLIMEX ranking: Figure 5). Lages (SC), although at an altitude similar to that of the Planalto site (997m and 1175m, respectively), is situated at a latitude which lowers both DD and EI values.

The 30-year mean characterization of the CPAC study site, (Figure 1), indicates that the cumulative effect of dry-stress (DS, maximum cumulative value = 0.019) commences at week # 26. During weeks # 26 to #33, mean GI values fall to nearly zero, favourable conditions returning during weeks #38-39. This DS cannot be seen, however, as a dominant (limiting) factor, as cold stress (CS) certainly is at the São Joaquim (SC) site, Figure 6, where maximum cumulative CS values reach 0.90.

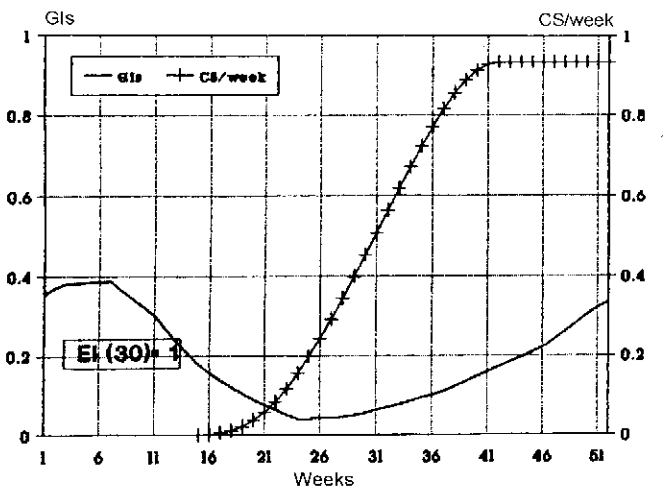

Fig. 6 - CLIMEX Simulation for the São Joaquim site in Santa Catarina State. The Cold Stress index (CS/week) is marked and accumulates after week # 16, reaching a value [>0.9] which can inhibit the survival and development of the cattle tick in many years. This value should be compared to that of the DS index in Figure 1.

Statistical analysis of the meteorological data (mean temperature, rainfall (mm) and % relative humidity) showed that mean daily temperature was significantly correlated with tick population size (P=0.0092; Pearson's Coefficient=0.5100 - Table 1).

Figure 2 indicates that mean (n=7) tick counts increased during the course of the experiment, a fact noted by other workers, especially when the experimental animals in this type of study may not be treated with tickicides. Weekly GI values appear to show, however, that there was also a general trend of increased favourability during the experimental period (Figures 2 and 3); these two factors cannot now be separated. Figure 2 also shows peaks in counts after the dry season, when animals are more susceptible, having been subjected to sub-nutrional conditions, and also the lower counts during favourable environmental conditions, as shown by the GIs, but when the hosts are less susceptible.

Figure 3 shows the relationship between the *a posteriori* simulation of local conditions, and real-time standard female tick counts, a relationship that may be characterized as being satisfactory, especially when the two different sources of data are taken into account. Similar results for nematode parasites have been obtained, and will be reviewed elsewhere; it seems clear that, although there can be no absolute synchronization between calculated and observed data, it may be possible to refine techniques, or design other generalized models, to be used in pinpointing key factors and operations. Although this aspect of the simulation of parasite population dynamics has received less attention, it has a high priority since it may lead to the development of simplified forecasting systems, based on the identification of key factors over long periods of time; such systems will become critical when parasite resistance to control measures becomes widespread.

Figure 4 emphasizes the basic similarity between continuously simulated GI values for the CPAC and CNPGC sites during 1988 to 1991. The fundamental discrepancy is that of the difference in trough depth between the curves, which reflects annual EI values (44 and 69, respectively) and results from differences in meteorological patterns imposed by factors such as altitude (1007m and 530m), latitude (15° 35'S and 20° 27'S), and local topography. At the CPAC site, the unfavourable period of the year is very much more so than at the CNPGC site, and may appear earlier (Figure 4, factor "a").

As can be seen in Figure 5, a satisfactory relationship can been developed between geographical location and site favourability, which will permit a more complete simulated mapping of the distribution of the cattle tick in Brazil (HONER *et alii*, 1993; SAUERESSIG & HONER, 1993), and possible control programmes (HONER & GOMES, 1990).

The CPAC and CNPGC are both three-generation sites; under very favourable conditions, a fourth generation would be possible at the CNPGC, but consistent 4-generation dynamics may be expected further north, and especially at lower altitudes.

A critical factor in the central region of Brazil is the continuous, planned, introduction of *B. taurus* genes into beef cattle populations for economic reasons. Any present equilibrium between cattle and tick populations can be expected to change within a few years, and new evaluations will have to be made continuously as to the means and feasibility of tick control, since Zebu x European crosses support tick populations which may be at the limits of acceptability as far as tick-worry and disease transmission are concerned (GOMES *et alii*, 1989). It can be concluded that the data collected and analysed to date under Brazilian conditions indicates that simulation techniques can offer valuable support for the evaluation of the key factors in the population dynamics of the cattle tick and the development of future control programmes.

SUMÁRIO

O ajuste de programas de simulação, visando à sua correlação com observações reais de populações do carrapato do boi (*Boophilus microplus*) sob diversas condições locais, permitirá a identificação de fatores-chave, um mapeamento fidedigno do parasito e a confecção de programas apropriados de controle local. O programa de simulação CLIMEX foi empregado no presente estudo de comparação de 24 meses de contagens reais de fêmeas-padrão do carrapato no Planalto Central do Brasil (altitude > 1000m) com simulações locais, com os resultados de Campo Grande (MS) (altitude > 550m), e com outras localidades estudadas anteriormente onde contagens são disponíveis. Uma relação significativa existe entre os componentes analisados: programas futuros de controle, especialmente sob condições de resistência, podem ser desenvolvidos utilizando dados desta natureza.

PALAVRAS-CHAVE: Carrapato do boi (*Boophilus microplus*), simulações, dinâmica populacional, fatores-chave, Brasil.

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