SOUTHERN OSCILLATION TELECONNECTIONS IN THE POPULATION DYNAMICS OF BERNE, LARVA OF *DERMATOBIA HOMINIS*, IN BRAZIL.

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SUMMARY: Variations in the counts of berne (tropical warbles of *Dermatobia hominis)* between and within years during the 1980s , for three long-term observational experiments in Campo Grande, have been corroborated with independent experiments in different parts of Brazil. These observations have been correlated with the Southern Oscillation event, as measured by the SOI or Southern Oscillation Index and known to have significant effects on Neotropical meteorological systems. More data on the life-cycle of berne and of its porters is required to define this correlation and design adequate control programmes.

KEY WORDS: *Dermatobia hominis*, tropical warble fly, population dynamics, Southern Oscillation, teleconnections, field observations, Brazil.

INTRODUCTION

Berne, or tropical warble, is the larva of the cuterebrid bot fly *Dermatobia hominis* (L., 1781) a species unique to the Neotropical Region, where it is a costly ectoparasite of cattle (HONER & GOMES, 1990), causing physical damage and discomfort to its hosts. Much of the biology of this species is still in doubt, but it has long been noticed that its populations tend to have an accentuated temporal pattern, berne being very common at one time and then pratically, or actually, disappearing for periods of one or more years. Farmers do, in fact, recognize " berne years" when the parasite is especially common.

One of the principal explanations for this erratic aspect of its dynamics has been to postulate similar variations in the populations of the adult fly *D. hominis* or, especially, in those of its egg porters. This begs the principal question, since it does not identify a broader underlying pattern, which could account for possible variations in those populations as well.

At the National Centre for Beef Cattle Research (CNPGC), a unit of the Brazilian Corporation for Agricultural Research (EMBRAPA), three long-term experiments, involving berne counts, were carried out during the decade of the 1980s, which covered periods of relative abundance and scarcity of the larvae.

It is suggested in this paper that these berne counts are related to teleconnected events (as defined by WRIGHT, 1985), linked to the Southern Oscillation, and expressed by the Southern Oscillation Index (SOI), known to reflect large-scale climatic conditions and changes in Brazil, and whose influence on parasite population dynamics is being studied at the CNPGC.

MATERIALS AND METHODS

Berne Counts: Three separate counting experiments, with identical methodology, were carried out during the period of 1980 - 1989. These cover: 1) September 1980 to September 1981; 2) February 1983 to September 1985 and 3) November 1986 to October 1989.

In this paper, monthly counts from untreated groups of animals have been used. In two experiments (1 and 3), the animals were *Bos indicus* (Nellore breed), and in the other (experiment 2) *Bos indicus* x *B. taurus* crossbreds (Ibagé with 3/8 Nellore). Berne counts were normalized using a square root transformation ($\sqrt{x}+1$) and processed with the MSTATC programme (Michigan State University).

Southern Oscillation Index (SOI): Values, both historical and realtime, for the SOI are available from several sources. In the CNPGC study, those of the US Department of Commerce, TAO Project Office (**nic. fba. noaa. gov**) and the Pacific ENSO Application Centre of the University of Hawaii (**naulu. soest. hawaii. edu**), were used. The former provides useful plots of Pacific island rainfall events during El Niño and La Niña periods, which can be correlated with the SOI and with South American conditions. In the present work, SOI anomaly values have been used, which are of the same sign and order as standardized data, but usually one unit larger, for facility in plotting results. SOI values are expressed as deviations from zero, and usually range from about +5 (strongly positive), to -5 (strongly negative) although values in excess of these can occur.

Published results: Published results of experiments involving berne counts during the decade of the 1980s have been examined; for those employing similar methodology, counts were normalized by the same transformation and replotted for camparison with the Campo Grande observations.

RESULTS

The distribution, and counts, of the three Campo Grande experiments and corresponding SOI events are presented in Fig. 1, where normalized berne counts are plotted against SOI anomaly values. Monthly rainfall distributions for the three counting periods, compared to a runnning (n=60 year) smoothed average for Campo Grande, are given in Fig. 2. The relationship between SOI anomaly values and rainfall during the period of 1983 - 1989 is given in Fig. 3, and, in more details, berne counts during the first experiment (1980-1981) and the associated SOI values are shown in Fig. 4, and for the third, in Fig. 5.

DISCUSSION

Campo Grande observations: The SOI is expressed as differences in barometric pressure between Darwin (Australia) and Tahiti (French Polynesia), in the Pacific Ocean. Past values have been tabulated, and are available from 1851 to the present

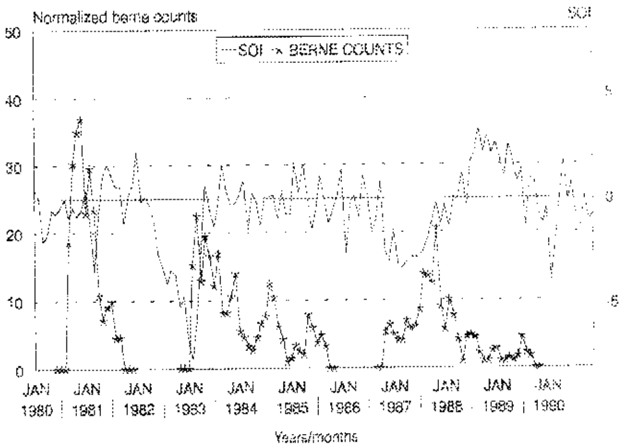

Fig. 1 - Distribution of three berne counting experiments (marked 1, 2 and 3) during the period of 1980-1990 at Campo Grande, Mato Grosso do Sul, Brazil, and the course of the Southern Oscillation Index (SOI) during the same period. The berne counts have been normalized ($\sqrt{x}+1$), and the SOI is presented as non-standardized anomalies.

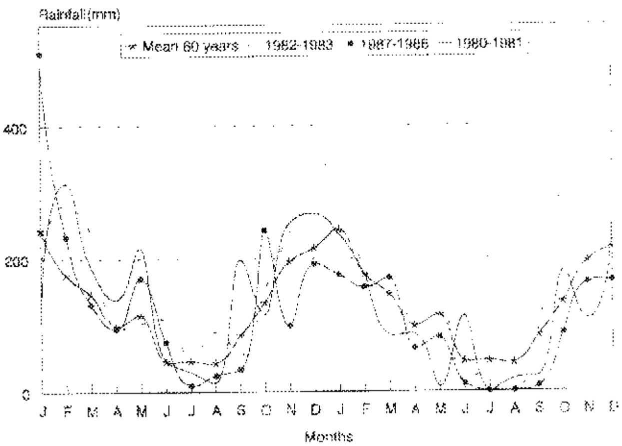

Fig. 2 - Deviations in observed rainfall (mm) during the three counting periods identified in Fig. 1, compared to a smoothed, repeated, 60-year mean, for Campo Grande, MS. The three periods show accentuations of the dry-wet seasons during the Southern Oscillation event.

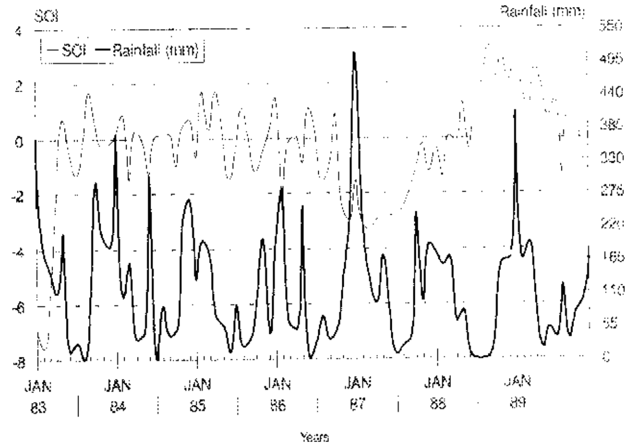

Fig. 3 - General relationship between total monthly rainfall (mm) and the SOI for the period 1983-1989 for Campo Grande, MS. Deviations from the zero value of the SOI are accompanied by deviations in rainfall, with lag periods differing from episode to episode.

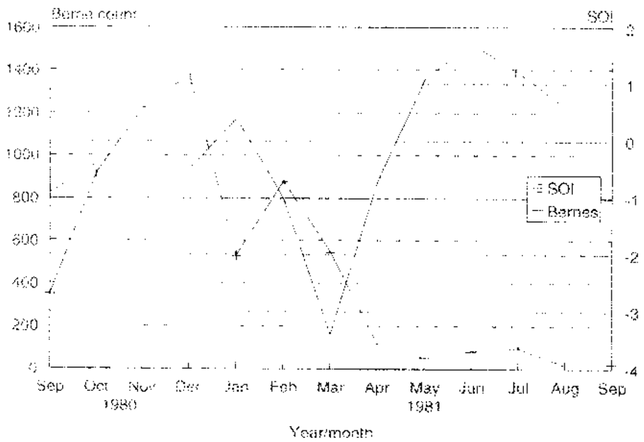

Fig 4 - Normalized berne counts and corresponding SOI values for the first Campo Grande experiment (1980-1981). Changes in polarity in the SOI are accompanied by abrupt changes in berne counts.

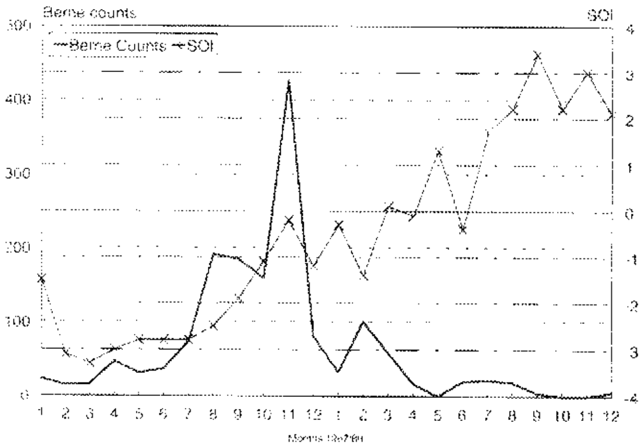

Fig. 5 - Normalized berne counts (for the *Sede* site at the CNPGC), and corresponding SOI values for the third Campo Grande experiment, the two components again showing opposed polarity.

day. A correlation is known to exist between meteorological conditions in Brazil and the state of the SOI, described as "the single most prominent signal in year-to-year climate variability" (RASMUSSON & WALLACE, 1983), or as "the dominant pattern of short-term climatic variation over the globe" (WRIGHT, 1985). Variations in the SOI are associated with the phenomenon known as El Niño, of irregular occurrence, but which is usually followed by a reverse phenomenon, identified as La Niña. The 1982-1983 El Niño was one of the strongest on record (CANE, 1983, PICAUT *et alii*, 1996), causing worldwide meteorological phenomena from the US to Africa, Asia and Australia (RASSMUSON & WALLACE, 1983), hence the usual terminology "teleconnections". In Brazil, (KOUSKY & CAVALCANTI, 1984), there were widespread weather changes during this period, including marked shifts in rainfall patterns, and extensive flooding in the centre and south of the country.

During the aftermath of this El Niño episode, berne were being counted in Campo Grande in experiment 2. The shape of the graph of these counts - the reverse of the SOI graph - first drew attention to a possible inverse relationship between SOI values and berne counts. This can be seen clearly, on a different scale, (Fig. 4), for the 1980-1981 counts. Here the inverse polarity is clearly seen and, this is further confirmed in Fig. 5, which shows the experiment 3 counts.

Fig. 1 portrays the entire period for which berne count data are available, indicating that there is a distinct, and repeated, inverse relationship between these two factors and it is also possible to see that the changes in SOI polarity are reflected in similar berne population changes throughout the series. As a general rule, it can be stated that positive anomalies in the SOI lead to a fall in berne populations and *vice versa*.

One of the principal effects of the Southern Oscillation is to alter rainfall patterns and totals in central and southern Brazil and Fig. 2 presents the differences between the mean (n=60 year) smoothed rainfall curve and curves for the experimental periods. The effect on rainfall deviation is seen to be more drastic during experiment 2 than 3, confirming the pattern shown in Figs. 1 and 3. In the latter Fig., although the height of the rainfall peak is greater in the rainy-period of 1986-1987, the duration and total mass of precipitation is greater in that of 1983-1984. This is reflected in Fig. 1, where the changes in berne counts are greater and more abrupt.

Independent Corroborations of Teleconnections : Within the period covered, three other experiments were carried out in different regions of Brazil. These were: a) BELLATO *et alii*., (1986) for the period of January 1982 to December 1984 in the municipality of Lages, Santa Catarina State, latitude ~27°S, altitude aprox. 937 m above sea level (asl); b) MAGALHÃES & LIMA (1988) for the period of May 1984 to November of 1986 in the municipality of Coronel Pacheco, Minas Gerais State, latitude ~21° S, altitude aprox 436 m asl and c), RIBEIRO *et alii*., (1989) for the period of June 1984 to May 1987 in the muncipality of Pelotas, Rio Grande do Sul State, latitude~31°S, altitude aprox. 13m asl. A fourth study, by MAIA & GUIMARÃES (1985), for the period of July 1983 to July of 1984 from another area of Minas Gerais State, appears to confirm the other studies, but there is some difficulty in identifying the graphs published.

The counts recorded in the experiments a) to c) above have been recalculated from the published data and normalized by the square-root transformation. The results of experiments a), b) and c) are now included separately in Figure 6 for clarity, but also together with the Campo Grande experiments in Figure 7, which therefore represents six berne counting experiments throughout the 1980s, distributed through southern and central regions of Brazil

The authors cited in the first paragraph above, generally relate (but without statistical analyses) berne peaks to favourable temperatures and rainfall, since bernes are more frequently observed during the rainy season, and are much less common in the June, July and August dry period, which is valid for about 65% of the entire Brazilian territory.

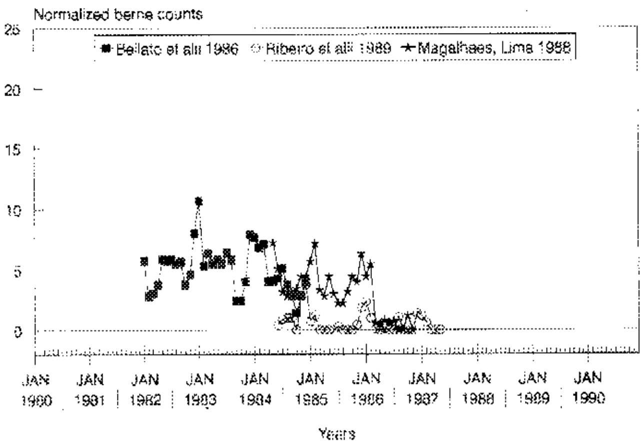

Fig. 6 - Normalized berne counts for the three independent observational berne experiments identified in the text, all plotted on the same scale, and showing similar fluctuations in counts.

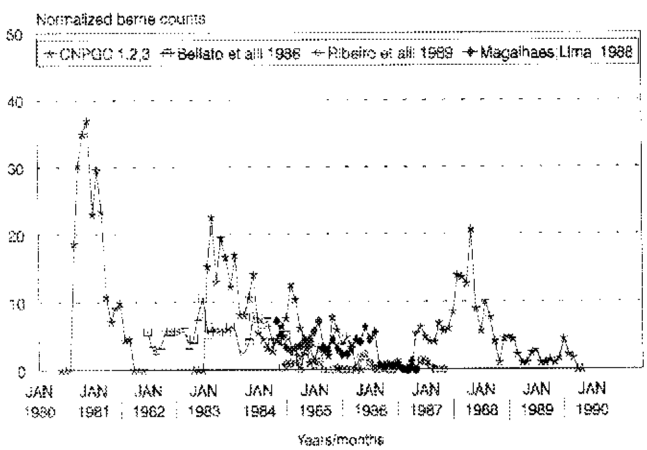

Fig. 7 - Composite graph showing all berne counts made during the 1980s and included in this article. The counts are on the same scale, so that overall similarities between the independent berne counts can be observed.

An analysis of berne counts and their correlations with weather conditions at the CNPGC site during 1987 and 1988, given in Table 1, suggests that - in 1987 at least - relative humidity may have been more important than temperature.

Table 1 - Total berne counts in 1987 and 1988 at Campo Grande, Mato Grosso do Sul State, Brazil and correlation coefficients between these counts and meteorological values.

Year	Tberne	Max.temp	Min. temp	Rain	Train	RH%
1987	1284	0.481	0.150	-0.313	1805.3	-0.552*
1988	277	-0.037	0.228	0.363	1150.2	0.362

* = significant at the 0.10 level
Legend: Tberne = total berne counts; Train = total rainfall (mm); RH% = relative humidity (%)

CATTS (1982) emphasized the preference of *D. hominis* for "moist, cool tropic highlands like those of coffee-growing areas" and for being a species found at the edge of tropical forests. In the literature, (NEEL *et alii.*, 1955) berne is said to occur most commonly between 400m e 1500 m above sea-level, becoming less frequent, and finally disappearing, after either of the limits has been passed, but RIBEIRO *et alii* (1989) studied berne in animals in the region of Pelotas, at a latitude of ~31°S and about 13 m above sea-level, encountering restricted populations of berne (mean monthly counts of 0 - 14.7 bernes/animal), which nevertheless exhibited peaks similar to those encountred in other experiments recorded in this paper.

BATES (1943) characterized the porter species as being diurnal, zoophilous, moderately small and moderately active. There are many of these: GUIMARÃES & PAPAVERO (1966) list 49 different insect porters, but not all are likely to be equally important. Local lists of functional porters are necesssary to complete studies on *D. hominis* ecology. Additionally, the ecology of a greater part of the porter species is not known in detail, and at times, not at all. Further studies are required to quantify the importance of the porters.

With these data, it cannot be demonstrated inequivocally whether SO events are acting primarily on the life-cycle of *D. hominis*, or on the porter populations, about which too little is known to generate a functional model of the population dynamics of berne as an ectoparasite.

An examination of the form of the graphs for simultaneous observations including all experiments, suggests a progression from higher to lower latitudes with peaks occuring slightly earlier in the south than in the central and more northern parts of the country. This would be in accordance with observations on other parasite populations, where latitude and altitude are responsible for inter-site lags (HONER *et alii.*, 1993; SAUERESSIG & HONER, 1995). KOUSKY & CAVALCANTI (1984), however, analysing the 1983 El Niño event, have emphasized local differences, for example, between Campos Novos (Santa Catarina State) and São Paulo, as to the frequency, intensity and timing of rainfall. If atmospheric pressure is a key-factor in *D. hominis* population dynamics, then the progression of an El Niño event across the country could be important in causing asynchronous dynamics between separate, regional, populations.

Two other aspects of the lifecycle of *D. hominis*, still remain without quantification: the rates and conditions for larval development, and the interpretation of the populations of porters found positive in any given area. The latter are so low, that in any mathematical model, the species *D. hominis* is apparently doomed to extinction, which is obviously not happening. It would appear the there must exist undescribed refuges or mechanisms permitting the persistence of tropical warble populations. Due to the great damage caused by this ectoparasite and the existence of plans for increased exports of hides from the central region of Brazil, it is necessary to carry out further controlled experiments on berne with a view to developing strategic control programmes.

SUMÁRIO

Variações nas contagens do berne (larva da mosca *Dermatobia hominis)* dentre e entre anos na década de 1980 para três experimentos observacionais de longa duração em Campo Grande, MS, foram confirmados por experimentos independentes de diferentes regiões do Brasil. Estas observações foram correlacionadas por sua vez com os eventos da Oscilação Sul, expresso pelo SOI, (Índice da Oscilação Sul), os quais são conhecidos como tendo um efeito marcante sobre o sistema meteorológico da área neotropical. Mais dados são necessários sobre o ciclo biológico da mosca do berne e dos seus vetores, para que seja possível definir esta correlação e delinear programas adequados de controle.

PALAVRAS - CHAVE: *Dermatobia hominis*, mosca do berne, dinâmica populacional, Oscilação do Sul, teleconexões, observações de campo, Brasil.

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