

THE PREHATCH PERIOD AND LARVAL SURVIVAL OF *BOOPHILUS DECOLORATUS* (KOCH, 1844) (ACARINA: IXODIDAE) UNDER NATURAL CONDITIONS IN THE TRANSVAAL, SOUTH AFRICA

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ABSTRACT

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Studies were made on the duration of the pre-hatch period of *Boophilus decoloratus* and on the subsequent survival and viability of larvae under natural conditions. The length of the pre-hatch and larval survival periods was found to be inversely dependent on increased temperature. A high initial temperature at the time of female drop decreased the pre-hatch period further, resulting in synchronous hatching of eggs laid at different times. Oviposition occurred but no eggs hatched during mid-winter months with mean temperatures below 10 °C. Eggs laid after mid-winter hatched because of the higher temperatures during subsequent months. Diapause occurs at the egg stage in areas with mean winter temperatures below 10 °C.

Larvae survived for 10 - 35 weeks during periods of high and low seasonal temperatures respectively. Larval viability decreased concomitantly with larval survival.

The results suggest that pasture spelling alone would be impractical as a control measure for this tick species.

INTRODUCTION

Boophilus decoloratus remains on its host throughout the larval nymphal and adult stages of its 3 week parasitic cycle (Arthur & Londt, 1973). The short-interval dipping employed in South Africa, mainly to contain the multi-host tick species, has apparently placed the 1-host *B. decoloratus* under severe acaricide pressure (Paterson, Schumacher & Stenson, 1986). This has resulted in certain strains developing resistance sequentially to arsenic, the chlorinated hydrocarbons, BHC and DDT and to organophosphate compounds (Baker, 1982). More recently resistance to a synthetic pyrethroid has also been cited (Coetzee, Stanford & Davis, 1987). Although excessive reliance is placed on chemical control, the effective integration of 2 or more methods may be employed, where feasible, to conserve existing chemicals (Sutherst, Norton, Barlow, Conway, Birley & Commins, 1979).

In Australia, much information concerning the ecology of the 1-host *Boophilus microplus*, in relation to pasture spelling and controlled dipping is available (Wilkinson, 1957; Hall & Wilkinson, 1960). This information has been implemented with some measure of success (Harley & Wilkinson, 1964). In South Africa biological data on the parasitic phase of *B. decoloratus* (Arthur & Londt, 1973), as well as on the preoviposition and oviposition periods (Londt, 1977) relate mostly to laboratory studies.

This study was undertaken to determine the practicality of pasture spelling as a possible means of control of *B. decoloratus* and to gain ecological data relating to the distribution and seasonality of this tick.

MATERIALS AND METHODS

Engorged female *B. decoloratus* fed to repletion on bovines housed in tick-free stables were collected and individually confined in containers 100 mm high and 20 mm in diameter. The containers were constructed primarily of gauze with thin plastic supports to provide maximum exposure to existing environmental conditions. Twenty engorged females were positioned in groups once monthly over a period of 16 months, from January, 1982, at the base of grass

stems in a field plot approximately 1 h after detachment from the host. The field plot is situated at Onderstepoort (25° 41'; 28° 11') in the Transvaal, Republic of South Africa. The field plot (700 m²), fenced to prevent intrusion by large mammals, was densely covered by 0.5 - 1 m high veld grass throughout the duration of the experiment.

Daily maximum and minimum temperatures were recorded at the tick placement sites by means of temperature probes¹ and in a Stevenson screen situated in the field plot. Daily observations of the vials were conducted to accurately determine the duration of the pre-hatch period (from female drop to larval hatch). Larval survival was monitored by periodic observation of larval aggregation at the top of each vial.

Larval viability was determined by progressively placing groups of larvae from the field plot onto confined bovines at 3 week intervals during the experiment. Percentage mortality of larvae was determined by counts prior to infestation and viability by counting the engorged females resulting from the infestation.

RESULTS AND DISCUSSION

Daily temperatures (max. + min./2) recorded at the tick placement sites are plotted as accumulated temperature. Accumulated temperature is mean daily temperature measured at tick placement sites, accumulated daily for the pre-hatch and larval survival periods. These accumulated temperatures were plotted against the longest pre-hatch and larval survival periods of each month for a 1 year period (Fig. 1). Daily temperatures (max. + min./2) recorded in the Stevenson screen were averaged to reflect the monthly temperatures illustrated in Fig. 1.

Rapid temperature accumulation and high initial temperature at the onset of oviposition during the summer months result in a relatively short pre-hatch period (e.g. 40 days for eggs laid in December). Slow temperature accumulation and low initial temperature cause considerable lengthening of the pre-hatch period (e.g. 138 days for eggs laid in August). This inverse relationship of pre-hatch period to daily temperature accumulation showed a coefficient of

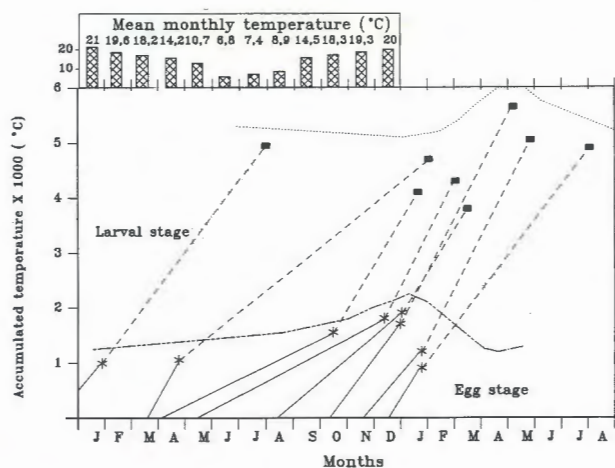


FIG. 1 Prehatch period (—*) and larval longevity (—■) of *Boophilus decoloratus* plotted against accumulated temperature showing maximum accumulated temperatures for egg hatch (---) and larval survival (....). Mean monthly environmental temperatures are given for each month

determination of 0,9913 (Fig. 2). Eggs laid at low initial temperature tended to hatch synchronously with eggs laid later in the year at higher initial temperature and more rapid temperature accumulation (Fig. 1. Compare eggs laid in August at 8,9 °C and eggs laid in October at 18,3 °C). This dependence on temperature is also strongly reflected in the work of Robertson (1981), who showed the development periods of successive egg batches to become progressively shorter as more favourable conditions occurred, resulting in a convergence of hatch.

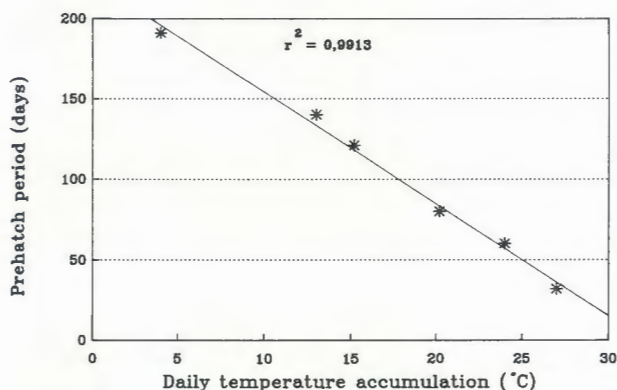


FIG. 2 Linear correlation of daily temperature accumulation and prehatch period. Coefficient of determination $r^2=0,9913$

Critical minimum temperature below which hatching does not take place appears to be 10 °C, unless daily temperature accumulation increases by at least 5 °C within 13 – 15 days of female detachment. This is shown by females, placed during the second week of May (mean 10,7 °C) through to the second week of August (mean 8,9 °C), ovipositing without subsequent hatching of eggs. Females placed after the second week of August start accumulating temperature at a higher rate during September (mean 14,5 °C), which apparently allows oviposition, embryonic development and subsequent larval hatch to occur (Fig. 1). This is consistent with the laboratory results of Londt (1977), who found no oviposition by female *B. decoloratus* at a constant temperature of 10 °C while females kept at 15 °C oviposited with an extension of the oviposition period over females kept at

higher constant temperatures. Robertson (1981) also records very few egg batches hatching from May to September because of the slow development of ticks exposed from May to August, probably as a result of low temperatures during June and July. These results suggest successful, but prolonged, oviposition and hatching of *B. decoloratus* in areas where the winter temperatures exceed a mean of 10 °C.

Londt (1977) showed the daily mass of eggs produced to be directly related to temperature change and the relation of total mass of eggs to be linear to initial female mass. Rapid daily temperature accumulation would thus have the effect of decreasing the oviposition period. Eggs laid during the warmer months (from November through to March) accumulate from 1 000 – 1 200 °C of effective temperature before hatching occurs. Eggs laid during the rest of the year, however, have to accumulate from 1 300 – 1 800 °C, thus indicating some dependence on initial temperature as well.

Eggs laid during the 3rd week of March are thus able to accumulate sufficient temperature to hatch before the end of April (mean 14,2 °C) and the onset of lower environmental temperatures, whereas eggs laid during the last week of March and during April (14,2 °C) and May (10,7 °C) do not hatch until the onset of higher temperatures from September (14,5 °C) onwards. However, eggs laid from April to May showed a reduction in percentage hatch estimated at less than 29 %, while egg batches of females placed during June and July failed to hatch.

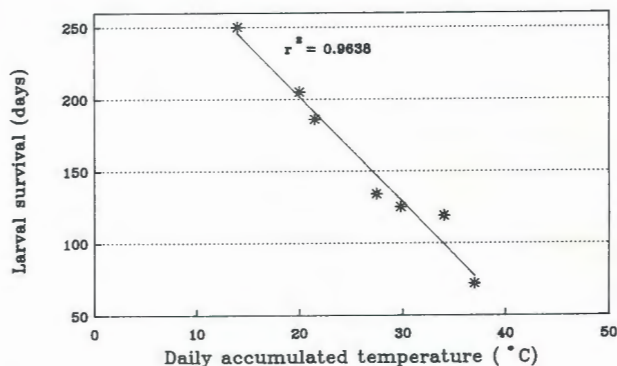


FIG. 3 Linear correlation of daily temperature accumulation and larval survival period. Coefficient of determination $r^2=0,9638$

Larvae survived from approximately 10 – 35 weeks after hatching (Fig. 1), and the survival period was inversely dependent on increased temperature accumulation ($r^2=0,9638$) (Fig.3). Larvae that hatched during the high environmental temperatures of December and January, with a subsequent fast accumulation of daily temperature, experienced short survival times. Larvae that hatched during the third week of April, just prior to the onset of low winter temperatures, survived the longest, probably due to immobility enforced by the colder winter months. Larvae accumulated from 3 800 – 5 800 degrees of temperature, depending on when hatching took place, before total mortality occurred. Robertson (1981) showed no clear pattern of seasonal periodicity in larval survival although maximum survival periods were similar to those reported here. Her placing of ticks in glass tubes in a Stevenson screen may have had a modifying effect on environmental conditions, resulting in a minimum survival

period of 180 days as opposed to 68 days in the present experiments. Larval mortality increased progressively with larval age until approximately 20% had died, thereafter a marked increase in mortality took place (Fig. 4).

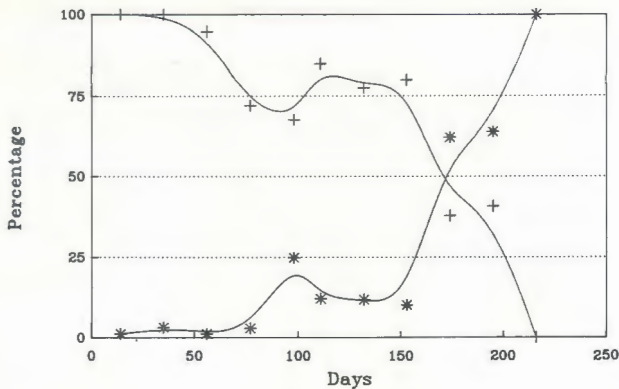


FIG. 4 Percentage mortality (—*) over time in an ungrazed field plot and subsequent percentage attachment (viability) (—+) of larval *Boophilus decoloratus*

The viability of surviving larvae, as portrayed by percentage attachment, was remarkably good (Fig. 4), being almost reciprocal to mortality ($r^2 = 0.9735$) (Fig. 5). The effective survival period is therefore not much shorter than the total survival period found here. Energy loss through host-seeking, as well as the effect of vegetation cover should, however, also be considered in determining more exact survival potential.

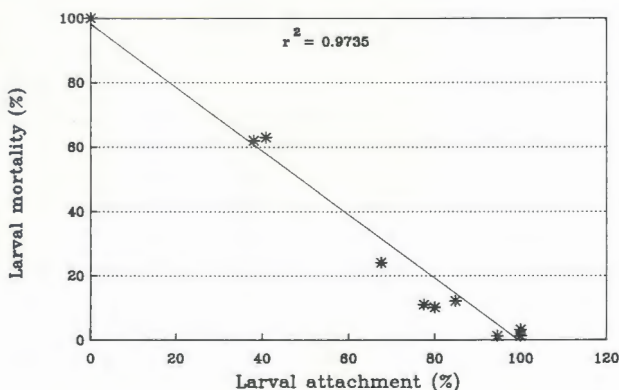


FIG. 5 Linear regression of percentage larval attachment (viability) on larval mortality. Coefficient of determination $r^2=0.9735$

Mean daily temperatures (max. + min. /2) measured in the Stevenson screen are plotted as an accumulated temperature curve for the specific experimental plot in Fig. 6. The maxima necessary for larval hatch and larval survival are 1 800 and 5 800 degrees respectively. Fitting Fig. 6 onto Fig. 1 with abscissa corresponding to female detachment would give the maximum period necessary for hatching/mortality to occur at this site for the respective accumulated temperatures necessary in either event. Plotting similar temperature curves for other sites would give an excellent estimate of pre-hatch period and larval survival.

The long survival period of viable larvae on ungrazed pasture will complicate the integration of

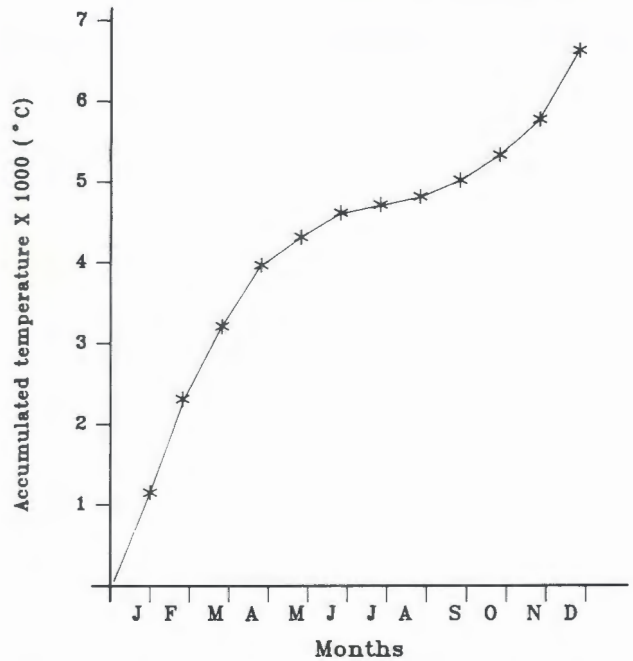


FIG. 6 Macro environmental temperature accumulated over time for the experimental plot

pasture spelling with grazing practices and strategic chemical control. In addition, the dependence of the tick's life processes on temperature indicates that differences will occur in the lengths of the survival period in different climatic zones which will further complicate the integration of pasture spelling practices.

Differences in temperature between climatic zones will also influence the timing of the synchronous hatching of eggs. Horak, De Vos & Brown (1983) showed *B. decoloratus* larvae to be most abundant on blue wildebeest during October in the Kruger National Park which is characterised by higher monthly temperatures than those recorded in this study. Eggs will thus accumulate temperature at a higher rate and subsequently have shorter pre-hatch periods with synchronous hatching yielding peak numbers earlier than in this study. Horak, De Vos & De Klerk (1984) also found peak numbers of all stages of *B. decoloratus* on zebra during September in the Kruger National Park. They attribute this incidence to synchronous hatching of eggs based on the work of Robertson (1981). This study supports their contention and also explains the seasonality of *B. decoloratus* on cattle on climatically different zones shown by Baker, Ducasse, Sutherst & Maywald (1989).

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