THE EFFECT OF DIPPING ON PARASITIC AND FREE-LIVING POPULATIONS OF *AMBLYOMMA HEBRAEUM* ON A FARM AND ON AN ADJACENT NATURE RESERVE

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ABSTRACT

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Domestic stock on a farm 30 km north of Grahamstown were treated with an acaricide at regular intervals over a period of several years. This resulted in a marked reduction in all stages of development of *Amblyomma hebraeum* on kudu *(Tragelaphus strepsiceros)*, scrub hares *(Lepus saxatilis)* and helmeted guinea fowl *(Numida meleagris)* which were on the farm compared with the burdens of similar animals in an adjacent nature reserve. The populations of free-living larvae of *A. hebraeum* on this farm and on another farm 10 km south of Grahamstown, on which the domestic stock were also regularly treated with acaricides, were markedly reduced when a comparison was made with the free-living populations in the adjoining nature reserves.

INTRODUCTION

Heartwater *(Cowdria ruminantium)* in domestic livestock in South Africa can be controlled in 2 ways. Firstly, by means of a live vaccine developed by the Veterinary Research Institute, Onderstepoort, which can effectively immunize cattle, sheep, and goats for periods of up to 12 months. However, the vaccine has the disadvantage of being expensive to produce, labile, and highly pathogenic, and it has to be administered intravenously (Bezuidenhout, 1985). The second and more usual form of control is through vectors. This aims at reducing the populations of the principal vector, *Amblyomma hebraeum,* to a point at which the chance of a host contracting the disease is at an acceptable level. Vector control is accomplished by dipping in or spraying with an acaricide at regular intervals. Both forms of control may be applied simultaneously and the intention is to develop a stable enzootic disease focus (Bezuidenhout, 1985).

Before the best strategy for acaricidal application can be developed, information on the effect of this procedure on normal population levels of larvae, nymphae and adults of *A. hebraeum* is necessary. Preliminary results indicate that the population size of *A. hebraeum* has been drastically reduced on wild hosts on a farm on which the domestic stock are treated with an acaricide, compared with the tick burdens of similar wild hosts in an adjacent nature reserve (Horak & Knight, 1986). In this paper we give a detailed seasonal comparison of the larval, nymphal and adult populations parasitizing 3 common wild hosts, the kudu *(Tragelaphus strepsiceros),* scrub hare *(Lepus saxatilis)* and helmeted guinea fowl *(Numida meleagris),* as well as the free-living larval populations of *A. hebraeum* on the farm and the contiguous nature reserve.

MATERIALS AND METHODS

Survey localities

The farm "Bucklands" is 5 480 ha in extent and shares a common 11 km boundary with the Andries Vosloo Kudu Reserve. The farm is stocked with some 300 Dorper sheep, 4 000 Angora goats, 185 cattle, 300 kudu and 80 bushbuck *(Tragelaphus scriptus).* The cattle are dipped or sprayed at 2–4 weekly intervals with the acaricide fenvalarate[1], while the sheep and goats are treated with the same compound at 4-weekly intervals. This practice has been followed for several years. The Andries Vosloo Kudu Reserve comprises an area of 6 497 ha. It contains approximately 450 kudu, 140 eland *(Taurotragus oryx),* 100 buffalo *(Syncerus caffer),* 54 red hartebeest *(Alcelaphus buselaphus),* 80 bushbuck and 18 springbok *(Antidorcas marsupialis).*

The 2 properties are located at approximately 33° 06′ S, 26° 41′ E and their altitudes range from 300–450 m above sea level. The vegetation of each is classified as Valley Bushveld (Acocks, 1975).

The farm "Orange Grove" comprises 800 ha and shares a common boundary of 3,5 km with the Thomas Baines Nature Reserve. Chicory, maize and sunflower are planted as crops on the farm, and 240 Merino sheep, 420 Boer goats and 23 cattle graze an area of 386 ha. The cattle are dipped in cyhalothrin[2] at intervals of 8–10 days and the sheep and goats at the same intervals in chlorfenvinphos[3]. No large wild ungulates occur on the farm.

The Thomas Baines Nature Reserve is 875 ha in extent. It contains 30 mountain reedbuck *(Redunca fulvorufula),* 20 bushbuck, 24 bontebok *(Damaliscus dorcas dorcas),* 78 impala *(Aepyceros melampus),* 4 black wildebeest *(Connochaetes gnou),* 23 kudu, 19 eland and 23 buffalo.

The farm and the reserve are located at approximately 32° 23′ S, 26° 28′ E with altitudes ranging from 335–518 m. Their vegetation is classified as comprising False Macchia, Eastern Province Thornveld and Valley Bushveld (Acocks, 1975).

Host sampling

Except in June 1985, when 2 animals were shot, a single adult male kudu was shot on the farm "Bucklands" every 3rd month from March 1985 and to June 1986. On the Kudu Reserve a single adult male kudu was shot every month from February 1985 to January 1986, and thereafter in March and in June 1986. On both the farm and the reserve an attempt was made to shoot 2 helmeted guinea fowl and 2 scrub hares monthly from February 1985 to July 1986. This was not always possible and the 1st guinea fowl were only shot on the farm during May 1985.

The dead animals were returned to the laboratory of the Tick Research Unit as soon as possible and processed for tick recovery as described by Horak, Meltzer & De Vos (1982), Horak & Williams (1986) and Horak & Fourie (1986). The ticks were counted as described by Horak, Potgieter, Walker, De Vos & Boomker (1983).

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[1] Sumitik Cattle Dip: Shell SA (Pty) Ltd

[2] Piredip: Vetsak Co-operative Ltd

[3] Multidip: Vetsak Co-operative Ltd

Sampling of free-living larvae

Free-living larvae were collected by dragging (Rechav, 1982). Nine strips of cloth, each 100 mm wide and 1 m long, were attached by 1 end, and side by side, to a 910 mm long rounded wooden pole. This apparatus was dragged over the vegetation for a distance of 250 m for each sampling replicate. At monthly intervals at each of the 4 localities 3 replicate samples were taken in each of the following 3 habitat types: open grassland; thick bush with abundant shade, and a gully which could contain water after heavy rainfall. Thus, compared with Rechav (1982), we reduced the number of replicates but increased the total area sampled per drag. After each drag ticks were removed from the cloth strips and placed in 70 % alcohol prior to identification and counting.

Sampling commenced during August 1985 at "Bucklands", the Kudu Reserve and the Thomas Baines Nature Reserve, and during October 1985 at "Orange Grove".

As larvae are unlikely to be randomly distributed and probably occur in clumps near the deposition site of egg batches (Rechav, 1979) large variances can be expected in the mean number of ticks recovered per unit area. Very high variances have precluded accurate statistical comparison of many data collected in the past for free-living larvae. The variance of the estimate of mean larval density for a clumped distribution, in a given habitat, is proportional to $1/A^2$ where A is the total area sampled per replicate (see Appendix 1 for a formal analysis). Hence by increasing the area dragged variance of the estimate of mean larval density can be reduced, thus increasing the likelihood of valid statistical analysis.

RESULTS

Parasitic ticks

The numbers of ticks recovered from the animals on "Bucklands" and in the Kudu Reserve are graphically illustrated in Fig 1–3.

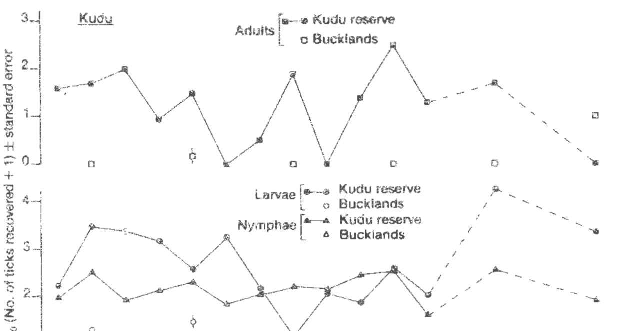

FIG. 1 The numbers of *Amblyomma hebraeum* recovered from kudu on the farm "Bucklands" and in the Andries Vosloo Kudu Reserve

Except in June 1986, when more adult ticks were recovered from the kudu on "Bucklands" than from the animal examined at the same time in the Kudu Reserve, the kudu on the farm always harboured considerably smaller numbers of larvae, nymphae and adults than those on the reserve.

No adult ticks were recovered from the scrub hares or guinea fowl, and the number of nymphae recovered never exceeded 100. With rare exceptions, and those only when the nymphal numbers recovered from animals on the Kudu Reserve were low, were the numbers of nymphae recovered from the scrub hares and guinea fowl

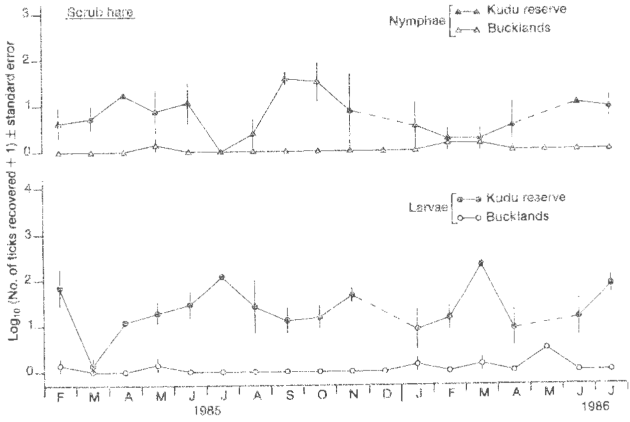

FIG. 2 The numbers of *Amblyomma hebraeum* recovered from scrub hares on the farm "Bucklands" and in the Andries Vosloo Kudu Reserve

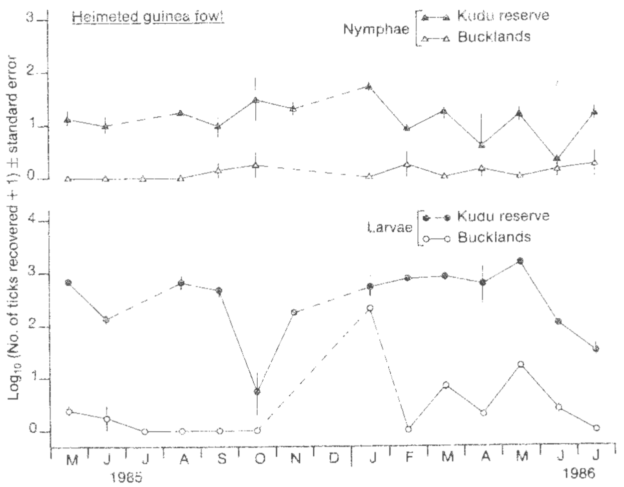

FIG. 3 The numbers of *Amblyomma hebraeum* recovered from helmeted guinea fowl on the farm "Bucklands" and in the Andries Vosloo Kudu Reserve

on the 2 properties similar. On all other occasions the animals on the reserve harboured more nymphae than those on the farm.

The numbers of *A. hebraeum* larvae recovered from the scrub hares and guinea fowl on the Kudu Reserve always exceeded those from the same host species on "Bucklands".

On the Kudu Reserve the larvae reached peak levels on the 3 host species at some time during the period February–July or August and the nymphae during the period September–December or January. Peak nymphal burdens were, however, also recovered from the kudu during March 1985 and March 1986. The largest numbers of adults were recovered from the kudu shot during December 1985.

Because of the small numbers of ticks recovered from the animals on "Bucklands" no pattern of seasonal abundance could be determined.

Free-living larvae

With the exception of the period of minimum abundance, which generally occurred from October–February, the numbers of free-living larvae collected in the 3 habitats sampled in the Kudu Reserve were generally 10–100 times higher than in similar habitats on "Bucklands" (Fig 4).

Distinct peaks of larval abundance were evident in the Kudu Reserve. These occurred during August or September 1985 and from March–June 1986. These peaks were not mirrored on "Bucklands" where larval

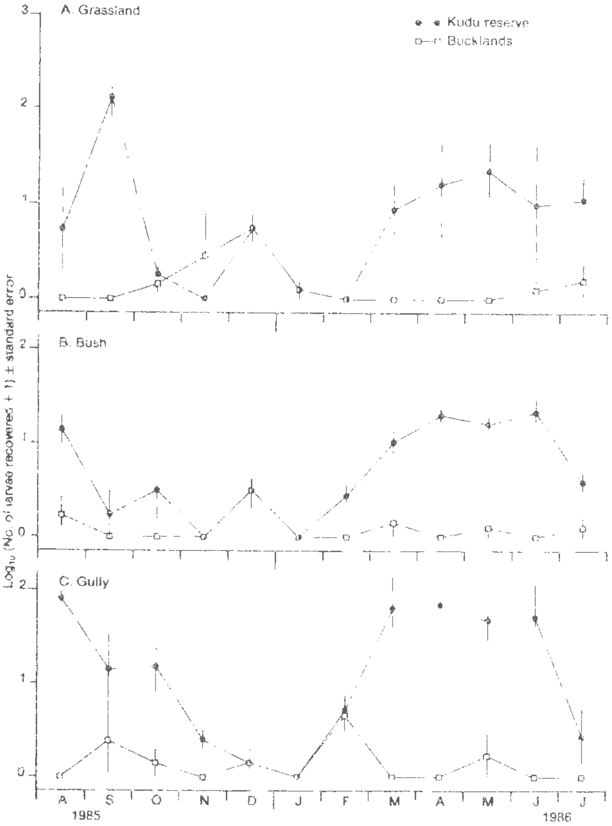

FIG. 4 The numbers of free-living larvae of *Amblyomma hebraeum* recovered from the vegetation of the farm "Bucklands" and of the Andries Vosloo Kudu Reserve

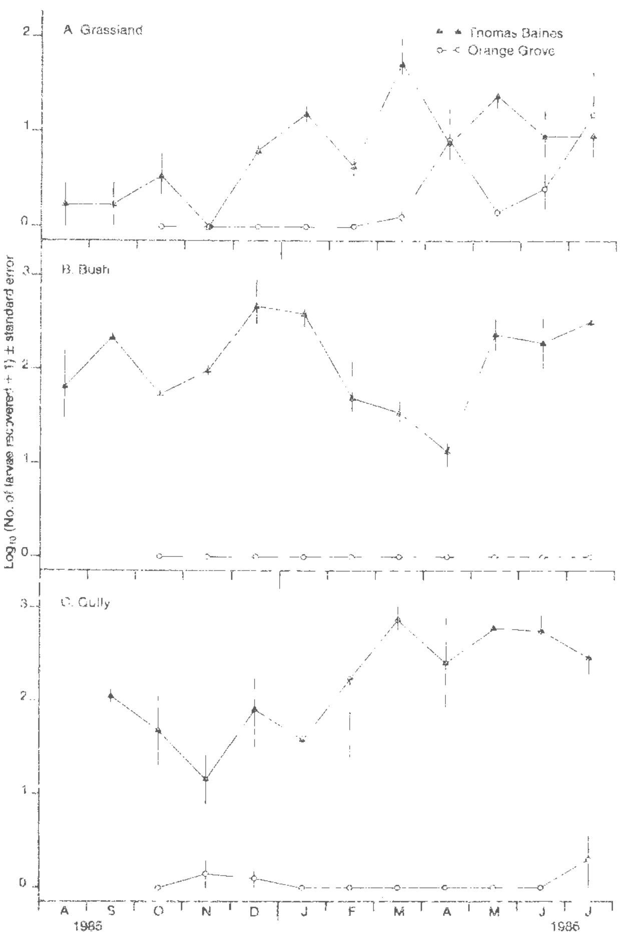

FIG. 5 The numbers of free-living larvae of *Amblyomma hebraeum* recovered from the vegetation of the farm "Orange Grove" and of the Thomas Baines Nature Reserve

populations remained low throughout the sampling period.

On 3 occasions the numbers of larvae recovered from the grassland habitat on "Orange Grove" equalled or exceeded those from a similar habitat in the Thomas Baines Nature Reserve (Fig 5). On all other occasions the numbers of larvae recovered from the 3 habitats in the Thomas Baines Reserve markedly exceeded those recovered on "Orange Grove" (Fig 5).

The numbers of free living larvae recovered in the Thomas Baines Nature Reserve exceeded those recovered in the Kudu Reserve. No pattern of seasonal abundance was obvious for the former reserve.

Comparisons between the larval populations of the 4 properties sampled indicate that grassland habitats tend to have the smallest populations. Moreover the variability between replicates is greater in grassland than in bush habitats.

Discussion

As neither site within each experimental pair is exactly similar to its partner one must first try to assess how each site would be expected to vary before attempting a comparison between sites.

No estimates of guinea fowl or scrub hare populations are available for any of the sites studied. However, as there is no management policy for either of these species and as farming does not disrupt their normal mode of existence, it is assumed that the farm and nature reserve are equivalent in this respect.

The same, however, is not true for ungulate stocking density. "Bucklands" has about 4 850 domestic and wild ungulates compared with about 850 on Kudu Reserve. This suggests that, were dipping not practised, the total *A. hebraeum* population on "Bucklands" could be substantially higher than that on the Kudu Reserve.

"Orange Grove" with approximately 680 ungulates grazing less than 400 ha, also has a much greater host density than the Thomas Baines Reserve, which has only 221 ungulates on 875 ha.

Only the wild hosts on each of the properties are capable of maintaining the *A. hebraeum* populations. Any domestic host represents a 'dead end', with the ticks being killed by acaricide and thus removed from the population. Consequently approximately 92 % of the ungulate hosts on "Bucklands" and 100 % of the ungulate hosts on "Orange Grove" represent 'dead ends' for any *A. hebraeum* which attaches to them.

When wild untreated hosts occur in conjunction with treated domestic hosts, as on "Bucklands", we predict that a stable, but reduced population of *A. hebraeum* would exist dependent on the actual numbers of the 2 host types present (Appendix 2).

Acaricidal treatment clearly depresses the population size of all life history stages of *A. hebraeum*. When very few or no wild hosts for the adult ticks are present, as on "Orange Grove", the free-living larval population is effectively reduced to zero. The single area on "Orange Grove" where *A. hebraeum* larvae were consistently found, the grassland habitat, abutted directly on a heavily bushed area of the Thomas Baines Nature Reserve. We cannot preclude the possibility of movement across the boundary, either by wind (Lewis, 1970) or possibly female ticks carried by tortoises (Dower, Petney & Horak, unpublished data, 1986).

"Bucklands" represents a more complex picture as in addition to the domestic hosts which are dipped and represent a 'dead end' for any attaching tick, a population of wild, undipped hosts also exists. As predicted these clearly maintain a small but seemingly stable population of *A. hebraeum* on the farm. The size of this population is apparently unaffected by the level of control.

In addition to depressing the overall numbers of *A. hebraeum*, acaricidal treatment has also masked changes in the seasonal abundance of the tick. *A. hebraeum* larvae may peak from February–May (Rechav, 1982) or March–June as found in the Kudu Reserve. The absence of this peak on "Bucklands" indicates that dipping had so depressed tick numbers that periods of peak abundance are no longer evident.

The lack of seasonality observed for the free-living larvae on the Thomas Baines Reserve remains unexplained but may be related to th higher stocking rate of buffalo and eland than in the case of the Kudu Reserve. These large bovids are excellent hosts of adult *A. hebraeum* and frequently harbour more than 1 000 adults ticks (Horak, MacIvor, Petney & De Vos, 1987), which consequently may give rise to very large populations of free-living larvae.

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APPENDIX 1: **Sampling technique for clumps of individuals**

Assuming that clumps of larvae are distributed as in a Poisson process within each habitat, with a mean of λ per unit area, then the numbers of clusters in a sample area of area A are Poisson distributed with a mean of λA. If N denotes the number of clusters then $E(N) = \lambda A$ and the variance of N $(\sigma^2)_N$ is the estimator of the mean number of clusters. Suppose now that the numbers of ticks in a cluster is a random variable X_i with $E(X_i) = \mu$ (the estimator of the mean number of larva/ area) and variance $(X_i) = \sigma^2$ (i.e. μ is the expected number of larvae/cluster and σ^2 of the variance of numbers of ticks in cluster). Then $E = (x_1 + x_2 + x_3 + \ldots . x_w)/A = \mu\lambda A/A = \mu\lambda$ is the expected number of ticks/area and Var $(x_1 + x_2 + x_3 + \ldots x_n/A) = 1/A^2(\lambda A^2 \sigma^2 + \lambda A\mu^2) = \lambda (\sigma^2 + \mu^2)/A$.

This means that in order to estimate the number of larvae per area the total number of larvae in the sample is divided by the area sampled. To estimate the variance of this estimator the mean cluster size and the variance of the cluster must be calculated, these being respectively $x = 1/n \sum_{i=1}^{n} x_i$ and $s^2 = 1/n-1 \sum_{i=1}^{n} (x_i - x)^2$ where x_i is the number of larvae in the ith cluster and n is the number of clusters in the sample. The estimated variance of the estimator is $Var = n\,(S^2 + \bar{x}^2)/A^2$.

If we consider $n_1 s^2$ and x constant for a given situation then Var α $1/A^2$. To reduce the variance simply increase the area sampled. This increases the signal to noise ratio of data collected.

APPENDIX 2: **A simple model relating natural and domestic host numbers to the number of ticks on a managed property where dipping is used as a tick contron measure.**

Using a Lotka-Volterra equation:

$dN/dt = r(1-N/K)N$: gives the rate of change of a population given a set carrying capacity (K) of the environment. r is the per capita rate of increase; N the population size at a given time; K the carrying capacity equal to the maximum equilibrium population size. Without other restraints a normal population of ticks would be expected to reach K.

The introduction of domestic hosts which are dipped, and hence act as traps for ticks, resulting in their death, leads to the introduction of a factor changing dN/dt of tick population commensurate with the rate of removal of ticks through dipping $dN/dt = r\,(1-N/K)N-cPN$ where c is a "predation" constant relating to the proportion of ticks attaching to a single domestic host. P is the population size of the domestick host.

An equilibrium value of N can be calculated by setting $dN/dt=0$ then $r(1-N/K)N = cPN$. This is true when $N=0$ (trivial solution) and can be solved for $N \neq 0$ as follows:

$$r(1-N/K) = cP$$
$$N/K = 1-cP/r$$
$$N = K(1-cP/r).$$

Therefore the equilibrium population of ticks (N), when domestic hosts (P) and natural hosts (αK) are present, is defined by the number of domestic and the number of natural hosts. We may assume r and c to be constant for any given environment.

To determine the number of ticks/host: $N = K - KcP/r$ where KcP/r equals the total number of ticks removed by domestic hosts. Therefore Kc/r = number of ticks recovered/host (K can be calculated from a comparison of natural populations on undipped areas; the value of c/r can also be calculated as Kc/r is amenable to determination in the field).

If the proportion of ticks carrying the heartwater organism is q then $Kc/r \times q$ = the number of ticks/host carrying heartwater.

If an enzootic focus is to be established then $Kc/r \times q > 1$ must be true over a suitable time period.

Assuming the above equations to be approximately accurate, the carrying capacity of an environment, supplying enough ticks per domestic host to ensure enzootic stability to heartwater, can be calculated.