The concept of eradication represents a unique alternative to the continual control of livestock ectoparasites, especially when economic losses due to the parasite or compounded by the transmission of diseases. A successful eradication program depends on detailed knowledge of the biology and ecology of the targeted ectoparasite. Without this information, weak points in the life cycle cannot be determined and exploited. We present in this paper a review of the biology and ecology of *Amblyomma variegatum* (Fabricius), a vector of heartwater in the Caribbean, and discuss the implications of this information for development of a regional eradication program.

Key Words: Review, regional eradication program, international cooperation, heartwater disease.

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Since 1948, *A. variegatum* has migrated from Guadeloupe, Marie Galante, and Antigua to at least 17 of the 35 islands of the Lesser Antilles and to Puerto Rico (Fig. 1). There will always be a threat of immigration of the tick and its associated diseases, heartwater, and especially dermatophilosis, as long as there are established tick populations in the Caribbean (Barre et al. 1987). It is estimated that at least one island will become infested with *A. variegatum* each year (Alderink and McCauley 1988). The recent reintroduction of *A. variegatum* in St. Croix, U.S. Virgin Islands, in July 1987, after it had been eradicated in 1970 (Graham and Hourrigan 1977), and the subsequent economic losses due to dermatophilosis in a dairy herd, emphasize this point. Concern among governments and other interested organizations has prompted much debate and as a result, a regional eradication program has been proposed (Anonymous 1986, 1987).

To establish appropriate eradication strategies based on application of acaricides to hosts, basic knowledge describing the life history of *A. variegatum* is essential (Bram 1975, Graham 1975). We present in this paper a review of the available information on the biology, ecology and survivorship both on and off the host of *A. variegatum* in the Caribbean. The importance of this information to the development and implementation of a regional eradication program is emphasized and discussed in light of two eradication strategies.

**BIOLOGY AND ECOLOGY**

*Feeding period of adults and acaricide treatment periods.* Acaricide treatment intervals must coincide with the length of the feeding period of the female tick. Each subsequent treatment must be applied before the female mates, completes the engorgement process, and detaches from its host.

In Africa (Rechav et al. 1982) female *A. variegatum* do not attach to hosts unless there are attached males present. On Puerto Rico, females did attach to goats in the absence of males and the timing of male feeding resulted in changes in the length of the female engorgement period. When males and females were placed on goats at the same time, engorgement of mated females ranged from 11 to 16 days. If males placed in cells on goats were allowed to feed for 10 days or more before females were introduced into the cells, females engorged in a minimum of 8 days (Garris 1984, G.L.G., unpublished data).

Experiments conducted in Guadeloupe with adult ticks placed on goats have shown that males must be attached for at least 3 days before females will attach (N. B., unpublished data). In other experiments, if males are attached and sexually receptive, newly introduced females will readily attach, feed, and detach in a minimum of 7 days and on the average, in 10.6 days (N.B., unpublished data).

Acaricide applied to the host animal at intervals within the minimum engorgement period for adult ticks would ensure exposure of the female. The resultant control would depend on the efficacy of the acaricide used. For *A. variegatum* on Guadeloupe, a 10-day treatment interval (7 + 3 = 10) should be established.

On Puerto Rico, the engorgement period for female ticks averaged 13.5 days in the laboratory (Garris 1984). This observation was incorporated into a successful eradication program against *A. variegatum* where a treatment interval of 14 days was used (Garris 1987, Garris et al. 1989).
Fig. 1. A map of the Caribbean region showing the distribution of *A. variegatum* and the disease, heartwater. The tick is found on at least 17 islands in the Caribbean. Heartwater is endemic on only three of those islands.
Distribution of adult ticks on the host: special acaricide application consideration. On Guadeloupe, eleven tick-infested cattle were anesthetized, and all ticks attached were grouped according to the area of the body found and then counted. Most ticks were found on the lower extremities; 16.5% of all ticks were found attached on the dewlap, 25% in the axillary areas, 13.6% in the mammary gland - scrotal areas, and 24% in the perineum (includes the vulva and anal areas). On goats, adult ticks are frequently found attached between the digits of the feet. No adults were found attached to sides or back of goats and only four males and two females were found attached to one animal’s ears. Surveys conducted in Africa have shown the same preference of attachment sites (Yeoman & Walker 1967, MacLeod et al. 1977).

The affinity of *A. variegatum* for protected areas on the body of the host requires special care in the application of acaricides. In an eradication program where hosts are sprayed with a non-systemic acaricide, considerable effort by the applicator must be given to treat those areas of the host body where ticks are found.

Hosts used by *A. variegatum*. To succeed in eradication, all potential hosts of the adult stages of the tick must be treated. Secondary hosts may represent reservoirs of ticks and may hamper the eradication process. For example, on St. Croix, deer were responsible for preventing the successful completion of eradication programs against *Boophilus microplus* (Canestrini) (Graham & Hourrigan 1977).

The hosts of *A. variegatum* in Guadeloupe have been identified (Barre et al. 1988). Five percent of all nymphs and 3% of all larvae found infesting the animals surveyed fed on wild animals (Table 1). In their survey, no adult *A. variegatum* were found on dogs, but of 56 dogs examined by local veterinarians, six were infested with adult ticks and three of these had females attached. The preference of adult *A. variegatum* for large animals, and the high percentage of immature ticks found on domestic livestock in Guadeloupe (Table 1) is consistent with *A. variegatum* in Africa (MacLeod 1970, Morel 1980) and in Puerto Rico (Garris 1987). The knowledge that few immature ticks parasitize wild or feral animals and that larger domestic animals are preferred hosts for adults, favors an eradication approach. This knowledge contributed to the successful eradication of *A. variegatum* from Puerto Rico (Garris et al. 1989).

Because mongooses and birds are infested with some *A. variegatum* immatures (Barre et al. 1988), the movement of these hosts increases the risk of tick immigration from an infested area to an area where an eradication program has eliminated the tick. In an eradication program, only those ticks on treated hosts would be exposed to acaricides. Wild secondary hosts may then temporarily isolate *A. variegatum* in marginal habitats away from exposure to acaricides. But since *A. variegatum* adult ticks prefer to feed on domestic cattle, treatment of the domestic host will result in eradication (Garris et al. 1989).

Secondary host reinfestation problems were addressed in Puerto Rico by simultaneously treating large blocks of adjacent herds of cattle and releasing them at the same time (Garris et al. 1989). A similar approach may be successful on other *A. variegatum*-infested islands.

Geographical distribution of *A. variegatum* on some islands in the Caribbean. In Guadeloupe, the majority of livestock are produced in dry pasture habitats along the shore to well-drained sloping pastures below about 200 m on the mountains. This area averages between 1000 - 2800 mm of rainfall annually and has temperatures...
Barre and Garris: Eradication of *Amblyomma variegatum* (Fabricius) in Guadeloupe

### Table 1. The role of secondary hosts in the life cycle of *Amblyomma variegatum* (Fabricius) in Guadeloupe.

<table>
<thead>
<tr>
<th>Ticks</th>
<th>Percentage of total on wild animals</th>
<th>Percentage of total on domestic animals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adults</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>Nymphs</td>
<td>3.3</td>
<td>96.6</td>
</tr>
<tr>
<td>Larvae</td>
<td>5.1</td>
<td>94.9</td>
</tr>
</tbody>
</table>

* Adapted from Barre et al. 1988.

ranging from 22 to 25°C. All stages of *A. variegatum* have been collected from domestic livestock throughout Guadeloupe year-round in these environments except in pastures higher than 200 m. In these high elevation pastures, where temperatures fall below 22°C and rainfall ranges between 1000-8000 mm annually, *A. variegatum* is not found attached to cattle during the cooler, wet months of the year. In laboratory studies on Guadeloupe, *A. variegatum* can complete its life cycle in a minimum of 132 days (N. B., unpublished data) and on Puerto Rico in 142 days (Garris 1984). Apparently in suitable habitat and climate in the Caribbean, there can be at least two generations per year (N. B., unpublished data, Garris 1987).

In 1975, *A. variegatum* was found infesting cattle in 23 herds in the central mountain region of Puerto Rico near Cidra and Cayey. By 1985, 188 farms on Puerto Rico and surrounding islands were found infested with *A. variegatum* (Garris et al. 1989). Although environmental conditions throughout Puerto Rico were suitable for *A. variegatum* survival, the rate of spread of this tick on the main island was slow when compared to *B. microplus* (Alderink and McCauley 1989).

Survival of *A. variegatum* off the host. A long-term research project to determine the maximum longevity of all stages of *A. variegatum* off the hosts has been completed on Guadeloupe (N. Barre, G. I. Garris, & R. Bonhomme, unpublished data). In each of two different climatic zones, one area with 1200 mm rainfall, and one area with 2800 mm rainfall per year, all stages of *A. variegatum* were released in plastic containers covered with nylon mesh cloth. Ticks were released four times per year from December 1983 until March 1987 at two locations in each climatic zone; one in open pasture and one in a wooded area (shade) bordering the pasture.

Among eleven releases in both low and high rainfall climatic zones, the maximum longevity was as follows: oviposition and egg incubation were completed in a maximum of 1.5 months. Larvae survived up to 9.5 months; nymphs and flat adults survived 15 and 20 months, respectively (N. Barre, G. I. Garris, & R. Bonhomme, unpublished data). Environmental conditions in open pastures were less favorable for survival than those found in wooded areas.

**Eradication strategies.** In an eradication program based only on acaricide applications to domestic hosts, there are two possible ways to establish the duration of treatment. One method involves treatment of all potential hosts for maximum period of survivorship of the target ectoparasite (Fig. 2). For *A. variegatum* on Guadeloupe, this period of time would be 46 months (1.5 + 9.5 + 15 + 20 = 46, Fig. 2). Vacated pastures become an important issue in this approach to eradication. If all hosts are removed and kept from a given area for less than the 46 months required for the natural death of the ticks present when the pasture was vacated, animals upon return may become infested with ticks that have survived.
Fig. 2. An eradication strategy based on a model of the life cycle of *A. variegatum* in Guadeloupe based on the maximum period of survival for all stages.

Another approach relies on the ability of the acaricide-treatment host to collect and concentrate ticks. This method requires information on host finding rates and will depend on the parasite's host specificity. Since domestic livestock are the primary hosts for *A. variegatum* in the Caribbean (Garris 1987, Barre et al. 1988), this strategy could reduce the duration of an eradication program from 46 months to about 20 months (Fig. 3). A strategy of this type was successful on Puerto Rico.
Fig. 3. An eradication strategy based on a model of the life cycle of *A. variegatum* in Guadeloupe as affected by host finding rates and control with acaricides applied to domestic livestock.

When domestic livestock and dogs were treated with an acaricide for 18 months (Garris et al. 1989). Observations on the infestation rates of secondary hosts such as dogs, mongooses, and birds become an important issue in this approach to eradication. On Puerto Rico, an additional 6-month surveillance program was followed after stoppage of acaricide treatments (Garris et al. 1989).

**CONCLUSION**

From the data presented in this paper on the biology and ecology of *A. variegatum*, it is reasonable to assume that if all livestock and dogs are treated
systematically with a suitable acaricide over a given time period (Figures 2 and 3), the eradication of *A. variegatum* from the Caribbean is possible. Obviously, each island infested with *A. variegatum* presents a different challenge and thus, requires a different approach to eradication. Further research is needed to develop information on effectiveness of new and more economical acaricides and application techniques, and on the application of these to the unique conditions which exist on each island.

In this paper, we have not addressed the most important questions that will ensure success of an eradication program. Those questions involve the perception of the need for a program by the livestock producers and consumers in the Caribbean region. It will be difficult and costly to develop the needed producer support but without that support, it will be impossible to gather 100% of the domestic hosts of *A. variegatum* for treatment with acaricides.

**REFERENCES CITED**


