CARIBBEAN FOOD CROPS SOCIETY

Thirty Ninth
Annual Meeting 2003

Grenada

Vol. XXXIX Number 1
ABSTRACT: The Caribbean *Amblyomma* Program is a multi-donor funded activity that involves both national governments and several technical organizations for the eradication of *Amblyomma variegatum*, the tropical Bont tick, from the Caribbean. The European Union and the United States Department of Agriculture are the major donors. The Food and Agriculture Organization is the lead technical agency, providing both technical and administrative support to the Caribbean *Amblyomma* Program Regional Coordination Unit. All collaborating agencies, donors, and national representatives are members of the *Amblyomma* Program Council, the overall governing body of the Caribbean *Amblyomma* Program. Historical aspects of the program are reviewed briefly, including the introduction of the tick from Africa in the 18th century, its subsequent spread during the 1970s, and the development of the concept of eradication. Conceptual characteristics for tick eradication programs are outlined using two brief case studies, one from Africa and one from the USA. The paper then focuses on the development of the model adopted for the eradication program, the achievements accomplished, and the constraints that the program faced during implementation.

KEY WORDS: tropical bont tick, acaricide, eradication, cowdriosis, dermatophilosis

INTRODUCTION

*Amblyomma variegatum*, the tropical Bont tick (TBT), became established on three islands in the Caribbean between 150 and 200 years ago. From the late 1960s, when it was first identified in St Croix (1967), and later in Puerto Rico (1974), it caused increasing concern (Pegram et al., 1997). The TBT gradually became widely dispersed over a period of 15 years causing devastation in St Kitts and Nevis, among other islands, in association with dermatophilosis (Pegram et al., 1996). In 1980, heartwater was reported in the Caribbean, and in 1984 the association between *A. variegatum* and the epidemiology of dermatophilosis was demonstrated (Jongejan and Uilenberg, 1994).

The Third Food and Agriculture Organization (FAO) Expert Consultation on Tick-Borne Diseases and their Vectors, held in 1983, made a recommendation urging Caribbean governments to cooperate and support the proposal to eradicate heartwater from Guadeloupe and Antigua. The First CARICOM Chief Veterinary Officers Meeting in Kingston, Jamaica, in May 1985 recommended a regional approach to eradication and encouraged countries to undertake a pilot project to test the feasibility of eradication. A “Technical Workshop on *Amblyomma variegatum* Eradication” was then convened in Barbados in 1987. Subsequently, a feasibility proposal, “Management of the Tropical Bont Tick (*A. variegatum*) and Associated Diseases in the Caribbean”, was presented. The proposal included the creation of an *Amblyomma* Program Council (APC) to provide oversight to the program and to develop an eradication policy.
Several preparatory activities were initiated by FAO:

i. A Technical Cooperation Program (TCP) project, “Control of the Tropical Bont Tick in St Lucia” in 1986.

ii. A regional TCP project, “Eradication of the Tropical Bont Tick, Heartwater, and Dermatophilosis”, based in St Lucia (1988). The project was responsible for the organization of a regional eradication proposal and for establishing the *Amblyomma* Steering Committee, the predecessor to the APC.

iii. Two further regional TCP projects: the first based in St Lucia, the then designated headquarters of the Regional Coordination Unit (RCU), “Surveillance and Prevention of the *Amblyomma variegatum* Tick”, and the second relocated to Barbados, “Surveillance and Control of *Amblyomma variegatum*”.

In 1990, a joint seminar on “Cowdriosis and Dermatophilosis of Livestock in the Caribbean Region” was sponsored by the Caribbean Agricultural Research and Development Institute (CARDI) and the Technical Centre for Agricultural and Rural Cooperation (CTA) in Antigua. In the proceedings, reference is made to the joint USAID/USDA pilot project in Antigua for US$ 4.8 million that could not be implemented because of the lack of agreement on the use of Bayticol, the acaricide used to control the tick.

During the early 1990s, a series of donor consultations were organized:

i. CARICOM – St Lucia, June 1991.


After several years of negotiations, the impasse was eventually broken at the 1994 FAO-convened donor meeting, when USDA reconfirmed its commitment with an initial contribution of US$ 550,000 (Over the five years this was gradually reduced to about US$ 300,000) and a pledge for US$ 500,000 per year for 5 years. The British and German Governments agreed that residual SECNA funds (US$ 750,000) could be used for the Caribbean *Amblyomma* Program (CAP). Thus, the program started in late 1994 with about 10% of the required funding committed.

**PROGRAM IMPLEMENTATION**

*Administrative Issues.* There were numerous, complex international collaborative financing agreements, and several Memoranda of Understanding and Contractual Agreements. However, each institution managed its funds independently:


ii. FAO Government Cooperative Program Trust Fund Agreements (UK/ODA and GER/GTZ).

iii. IFAD/FAO (Technical Assistance Grant Agreement), the adaptive research component “Environmentally sustainable strategies for the control of the Tropical Bont Tick from the Caribbean” mainly investigated possible biological control methods using a juvenile growth inhibitor (Akatak) or myco-acaricides.

iv. FAO/TF Associate Professional Officer Agreements (Belgium, Italy, Netherlands).

v. FAO/TCP (FAO Management).

vi. EU (Direct purchasing via EU).
In addition to the financing agreements, there were also several agreements relating to coordination, management, and implementation:

i. USDA – IICA: Cooperative Agreement.
ii. FAO – IICA: Memorandum of Understanding.
iii. CARICOM – FAO – IICA: Memorandum of Understanding.
iv. FAO – EU: Memorandum of Understanding.

Unfortunately the various agreements were not always mutually compatible as they did not relate directly to each other, nor were they referred to in the overall program document that envisaged the APC as the overall management authority. There were two main areas of discrepancy. Firstly, there was generally no reference to the executive powers formally assigned to the Amblyomma Program Council. Secondly, funds were managed independently by the respective funding and implementing agencies (i.e., EU, FAO, IICA), and therefore, the clauses relating to collective management of funds were effectively meaningless. Consequently, the Regional Coordination Unit of the CAP often had little executive responsibility for management and disbursement of program funds, especially during the early years.

**Technical Issues.** It was realized at the onset of the program that there was a major defect in the design in relation to the proposed technical implementation of the field activities. It was stated that “… the acaricide will be applied in appropriate handling facilities for livestock. Accordingly, the animal handling facilities will be either permanent or mobile and will be distributed at strategic locations on each island.” The proposal seemed illogical, as most livestock owners in the Caribbean are landless and only raise animals on a part-time basis.

There were several issues related to the handling facilities:

i. Just who was going to construct them?

ii. Where would they be located?

iii. Who would bring the livestock to them?

It was also apparent during the initial internal program review that inadequate attention had been given to the donor concerns relating to the calculations for operational costs for vehicles, for treatment teams, and costs for Bayticol. Notably, in the final version of the program document, external donor costs for the Antigua eradication program were estimated at less than US$ 0.5 million. This is in marked contrast to the estimated costs of the proposed USAID/USDA pilot project with an estimated budget of US$ 4.8 million.

Thus, in 1995, the program approach was reformulated. The new approach envisaged that the tick control treatments would be carried out by the livestock owners themselves at an opportunity cost, that is, the estimated monetary value of the time taken for treating their animals, of about US$ 8 million. The revised strategy, with devolution of responsibility for mandatory treatment to livestock owners, was in line with the global trend of privatization of government services. Government teams would then monitor farmers to ensure compliance with treatment schedules.

The “pour-on” technology using Bayticol is simple to transfer, but there remained considerable concern regarding compliance as it had been noted that, “whilst the technology was available and eradication was considered to be feasible, the most important obstacle in attempts to eradicate the Tropical Bont Tick would be the human factor” (Barre and Garris, 1989; Wilson, 1995). Thus, the strategy was to be reinforced through an intensive public information program directed to livestock owners and the general public. A communications and public information program was designed taking into account experiences from other large-scale animal disease-
eradication programs (African swine fever, rinderpest, and screwworm). Supportive legislation was revised and enacted making it illegal for farmers to be in possession of tick-infested animals.

CONCEPTUALIZATION OF THE TICK ERADICATION MODEL

There are few, if any, global possibilities for tick eradication programs on which to base and develop a strategic model. Most countries in Africa, for example, remain dependent on tick control, although it is very expensive and generally considered to be unsustainable. Moreover, epidemiological and economic justification for intensive control remains questionable.

Pegram and colleagues formulated a comprehensive list of essential pre-requisites for pest eradication programs based on a literature review and the FAO/IAEA joint symposium on area wide eradication and control programs (Pegram et al., 2000a, 2000b; Tan, 2000). The essential components identified are as follows:

i. An economically viable livestock industry.
ii. Benefit-cost analysis to justify eradication and public conviction of the justification.
iii. Appropriate legislation.
iv. Adequate government, donor and/or industry finance for uninterrupted progression.
v. Scientifically based tick control/eradication strategies.
vi. An effective acaricide with no evidence of resistance to target species.
vii. Geographically defined distribution and host/habitat specificity.
viii. Adequate livestock handling facilities and infrastructure.
ix. Effective education programs, acceptance of the strategy, and farmer co-operation.
x. Adequate quarantine to prevent re-infestation.
xi. A statistically sound practical surveillance system for the tick.

The fundamental requirements were, in part, based on two brief case studies, one for eradication of the cattle tick in the southern USA, and a second for the eradication of a tick-borne disease, bovine theileriosis, in Zimbabwe.

Wilson (1995) concluded: "... Zimbabwe probably had the most intensive, legally enforced, and best supervised dipping system in the world." It had been introduced in the early 1900s to control and subsequently eradicate theileriosis. Over a period of 90 years, the number of tick control facilities increased to 6,000 and the national cattle herd increased from 20,000 to 6 million. Regular tick control was compulsory; it was an offence to own tick-infested cattle.

Civil disturbances in 1975 – 1980 led to the cessation of dipping and to unauthorized cattle movements. Following independence in 1980, there was a gradual transition from intensive tick control to a strategic integrated approach.

Was the Zimbabwe national tick control program a success or failure? Our conclusion is that the Zimbabwe model was highly successful. Although the program broke down during the civil disruptions in the late 1970s, it seems futile to speculate that it was a failure on those grounds. Who would plan a disease control strategy based on the prospects of a civil war 75 years later?

In the southern USA, cattle tick fever was recognized as a major problem in the early 1700s and by the mid 1800s, cattle fever was identified as an important barrier to livestock development. In 1894, the authorities initiated a study on the distribution of the cattle tick and implemented research on the feasibility of tick eradication. Dipping was accepted as the most efficient and economical control method. Also exclusion of host animals from fenced pastures until all ticks had died of starvation was found to be effective.
In 1889, quarantine measures were implemented and the quarantine line extended from the Atlantic coast to the Pacific Ocean. When the eradication program began in 1906, it was estimated that *Boophilus annulatus* cost the cattle industry over US$ 130 million per year. The plan was for the eradication to progress from north to south. By 1909, cattle producers began reporting increased productivity in tick-free areas, but it was not until 1943 that the eradication of the tick was deemed to be complete except for a quarantine area along the Mexican border. Even today, 60 years later, problems of re-infestation still occur and acaricide resistance in Mexico continues to be a major challenge.

One can draw two conclusions from these two brief reviews:

i. Both efforts took an exceedingly long time (more than 30 years) to attain their respective goals.

ii. Governments, both of which showed long-term vision and financial commitment, administered the programs.

In contrast, in the Caribbean *Amblyomma* Program, there are ten national governments and several international agencies involved in the implementation of the program. There was also constant uncertainty over long-term financial assurances for the continuity of the program.

A critical analysis of the literature on both successful and unsuccessful tick control/eradication programs was then applied to the Caribbean *Amblyomma* Program countries to determine the parameters likely to impact on its success. The status of the key essential requirements for some of the islands is summarized in Table 1.

The basic field model. The application of the model in the field was dynamic for a number of reasons. It had been envisaged from the conceptual stages that the eradication effort must start simultaneously on all TBT infested islands. However, financial constraints prevented this from the beginning, and starting dates on individual islands were based more-or-less haphazardly, from north to south, on the temporal availability of funding.

It was further anticipated that all animals would be tagged prior to implementation of treatment, but this proved to be very time-consuming, especially to keep up-to-date with the prolific reproductive capacity of small ruminants, and proved to be expensive relative to the very limited funding available. Subsequently, tagging was discontinued in favor of animal owner registration and head counts of animals owned.

A further constraint was that on some islands there was no up-to-date livestock census. Antigua was the worst-case scenario. As the registration of livestock continued it was realized that animal populations had been seriously underestimated: cattle by 25% (16,000 compared to 12,000), and small ruminants showed a disparity of 400% (60,000 as opposed to 15,000 previously recorded).

The general model planned for implementation consisted of the following sequential activities:

i. Registration of livestock owners.

ii. Tagging of all livestock with specific color and number sequences.

iii. Data recording using the databases CAPstat and CAPdat specifically designed for the program, primarily for monitoring purposes. The second database made provision for subsequent TBT surveillance but proved unwieldy in that all negative findings had to be recorded individually.

iv. Treatment of all livestock every two weeks, for at least two years, by the livestock owners. The treatment schedule was based on a simulation model of tick survival, host preferences, and climatic data.
Quantitative, statistically validated surveillance for TBT was introduced after the first year of mandatory treatment. A user-friendly database “TickINFO” was then developed with user involvement for the TBT surveillance component.

Quarantine and livestock movement restrictions as areas or islands were certified provisionally free from the tick.

Each stage of the cycle was introduced and reinforced through an intensive public education and social marketing program. This input was continued throughout the program and included media (TV, radio, printed materials including posters, and calendars), signboards, promotional materials (including T-shirts, caps, key rings, calculators, pens, pencils, mugs, clocks, watches, and fanny packs), and sponsorship (softball, cricket, and football) as well as more traditional extension and field training for farmers and technical training for animal health staff.

Assessment of progress in the eradication was based mainly on analysis of quantitative surveillance for the TBT and associated diseases at the parish level on each island. In the initial stages of the program, the sampling strategy was based on a statistically representative sample of livestock throughout the island. The sampling design was reviewed after one year and the strategy changed to sample far more properties or premises, but fewer animals on each property. This design strategy was deemed necessary because of the diversity of the animal husbandry practices among the community.

Island wide treatment could be terminated only after at least 24 months of continuous application of the pour-on, and two consecutive surveillance cycles in which no TBT were observed. After the cessation of island wide treatment, certification of provisional freedom from the tick was dependent on no ticks being found on a statistically representative sample of properties during a further consecutive six-month period. Again, this scheme was modified in 2000 on the basis of USDA experiences in Puerto Rico, where it had been assumed that individual male ticks did not constitute an active infestation. Whilst there may have been some validity in this assumption under Puerto Rican conditions, post-factum assessment of the TBT simulation model that was used as a basis for the two-year treatment schedule (based on Puerto Rico data and experiences) is believed to be flawed.

RESULTS

During 2001-2003, six islands, St Kitts, St Lucia (November 2001), Anguilla, Montserrat (February 2002), and Barbados and Dominica (February 2003) were certified as provisionally free from *A. variegatum*. There are various administrative and technical reasons why the national eradication campaigns took much longer than the original model had projected. Thus, the final stages of eradication on most islands were “vague” and elimination of the residual infestations in hot-spot areas took a further 15 - 30 months, although TBT prevalence rates were maintained at very low levels.

Chronological, quantitative TBT surveillance data from 1998 to 2003, based on an analysis using the TickINFO database, are shown in Table 2 and Figures 1, 2, 3, and 4. It should be noted that data for several countries is not complete, especially in terms of infested farm prevalence rate. This is primarily due to the fact that earlier databases that were adopted under the program did not allow easy generation of this information.

Although all countries under CAP, except Nevis, Antigua, and St Maarten, have attained provisional freedom from TBT infestation, several countries continue to report the presence of ticks, both males and females. However, under the current protocol, they will maintain their provisional free status as long as extensive surveillance and appropriate control measures in the surrounding areas are carried out.
Farmers themselves have reported many of the recent sightings of ticks in several countries. The active participation of farmers in surveillance activities is of paramount importance if adequate levels of animal inspection are to be maintained.

DISCUSSION AND CONCLUSIONS

Constraints. The pour-on technology and the pyrethroid acaricide selected for the program were known to be the best technically available. The distribution of the tick was known. The legislation was in place but, unfortunately, not always enforced in a timely manner. On most islands, the animal handling facilities and quarantine measures were deemed to be adequate, but again they were not always effectively applied and some of the authorities were unable to pay adequate attention to important issues such as land ownership and lack of grazing rights. In the dry season and periods of prolonged drought particularly, there were serious problems when livestock owners either abandoned their livestock or let them wander anywhere in search of grazing. Antigua and Nevis were the two worst cases and this undoubtedly was one of the major constraints leading to inadequate progress.

It is doubtful in the overall context of the world economy in agricultural production that any of the countries had an internationally competitive, or viable, livestock industry, mainly because of cheaper imports of meat and dairy products. However, opportunities existed for niche markets, and prior to the devastation caused by the TBT, most islands had reasonably viable local and regional markets. The USDA benefit-cost analysis (Gersabeck, 1994) certainly justified the intervention at the wider continental level, but public-owner conviction was marginal on several of the islands because livestock owners were invariably only part-time. The regional approach to provide an effective education program was deemed to be effective although some countries did not sustain it consistently.

Funding. An overall problem was the uncertainty of continuity of funding for the regional inputs. Moreover, most countries found it difficult to maintain the long-term national annual inputs for staff and local operational costs. There were also several periodical donor-funding crises throughout the program. In late 1996, the EU released € 0.740 million (= US$ 850,000) for the purchase of Bayticol, and in 1997 the International Fund for Agricultural Development (IFAD) approved a Technical Assistance Grant for US$ 1 million for support of the adaptive research component. A constructive mid-term review (MTR) in 1997 concluded that the program had achieved substantial progress towards eradication, despite administrative, resource, technical, and personnel constraints.

The participatory approach, supported by a public information and communications strategy was highly commended. The MTR stressed that progress could be sustained only if additional funding were urgently secured to finance the eradication of the TBT from the entire Caribbean.

In mid-1998, the CAP again faced an acute funding problem. At that time the US Treasury had identified US$ 1.94 million originally committed to the SECNA program, and USDA approved these funds for the CAP. The EU/CARIFORUM provided a further € 1.5 million for the period 2000-2003.

Progress. Although there were constraints and complications, there was sufficient good will among most of the main collaborating agencies and the participating Governments to ensure substantial technical progress. Moreover, at the national level, there was generally a positive commitment and determination to succeed.

There are several lessons to be learnt from this program, although they are not necessarily new. Most of them were included in overview presentations at the IAEA/FAO Conference in Malaysia on “Area-wide Control of Pests” in June 1998 (Tan, 2000). These include:
i. Programmes should be independent of political and institutional bodies, i.e., managed by an autonomous body (It was noted that some programmes failed not because of inappropriate technologies, but because of conflicting political and institutional agendas). It was further noted, however, that independent management of eradication programs rarely, if ever, occurs. As outlined above, in this program there were no fewer than 10 international inter-agency agreements (excluding the French West Indies program) and 10 national governments involved in the implementation. Frequently, implementation delays occurred, and unilateral decisions on procedures and funding priorities were sometimes made without consultation with the technical managers. These led to inter-agency disagreements and lack of harmonization.

ii. Full support of producers and producer associations is essential.

iii. Appropriate legislation must be in place and agreed upon by all parties.

iv. Education and communication are very important.

v. Use only “proven” technical methods within the eradication areas. Applied or adaptive research should be carried out before the implementation of the eradication process (or in areas outside the eradication zone).

vi. Defined goals are also essential as well as standard systems to verify status.

vii. Research that could jeopardize success should not be carried out within the area of eradication or control.

The key issues leading to eventual success can be summarized as follows:

i. The important role played by the APC as an independent body, assisted in harmonizing the earlier differences among some agencies and governments.

ii. The flexibility of “informal ad hoc working groups” as defined and agreed on by the APC.

iii. The continuous informal contact and meetings particularly between the main technical and donor institutions (for example the USDA and the CAP-RCU).

iv. The gradual increase in confidence of, and flexibility on the part of FAO-HQ to decentralize operational and technical responsibilities more directly to the RCU.

v. The gradual trend towards more independent management of project funds.

vi. The commitment and support of the Ministries of Agriculture of the participating governments.

vii. The public information/social marketing aspects of the program.

viii. The positive response and compliance of the target livestock owners.

Ecological and Biological Factors. Simulation models were developed, using biological and ecological data for *A. variegatum*, to estimate the duration of the required treatment periods for the elimination of the tick in the Caribbean environment.

Key bio-ecological factors, including development and survival periods for *Amblyomma variegatum*, are summarized in Table 3. With the favorable climatic conditions in the Caribbean, the adult ticks may be present year round, although they are far more prevalent between July and September.

The tick usually completes its life cycle in one year, but with the long survival periods, the life cycle could be extended to up to four years. In contrast, in the more arid and harsh conditions in central Africa, the synchronization of various stages of the life cycle, and the much shorter periods of survival for all free-living stages, the cycle is usually completed in one year.
even though development periods are longer (Pegram et al., 1998; Pegram and Banda, 1990).

In the Caribbean, the only hosts for the tick other than domestic livestock, and rarely dogs, are the cattle egret and the mongoose. Studies in Guadeloupe showed that almost 95% larvae, 97% nymphs, and 100% adults feed on domestic hosts (Barre and Garris, 1989; FAO, 1993).

The two simulation scenarios developed were based on the following criteria:

i. The total accumulated maximum survival period for eggs, larvae, nymphs, and adults is 46 months.

ii. The survival period of adults only is 20 months.

This second scenario made two assumptions:

i. A concentration of all tick stages within the host grazing area or range.

ii. All livestock would be treated every two weeks.

The latter strategy was based on experiences in Puerto Rico for a successful intensive treatment duration of two years. It had been assumed that it would work throughout the Caribbean, but there are at least two reasons why this may not be so.

Firstly A. variegatum had not become well established in Puerto Rico by the time intensive treatment programs were implemented. It was most unlikely, therefore, that A. variegatum immatures had become adapted to feral hosts. In contrast, in most other Caribbean islands the tick had been present at least 10-15 years before the intensive treatment programs were implemented and the tick was well established.

Secondly a further factor influencing the widespread dispersion of the tick is related to livestock management systems. In Puerto Rico, most livestock are kept commercially and maintained in enclosed or fenced commercial properties. Thus, all stages of ticks would be “exposed” to hosts that have been treated with acaricide. In the other Caribbean islands, there are very few livestock managed commercially except on Government farms, and the majority of livestock are free ranging. Moreover, on some islands, for example Antigua and Nevis, there is a high proportion of feral or free-ranging livestock. In these situations, there could be small pockets of residual infestations of A. variegatum that are not exposed to acaricide-treated animals, because of larvae and nymphs feeding on non-domestic small ruminant hosts for periods of up to 2 years.

Drought and other factors influence the grazing areas of domestic animals, especially goats, and as such, untreated, or infrequently treated hosts may pick-up residual adults some 24-48 months after the original depositing of eggs. It is also known that immature stages of A. variegatum are known to survive longer in bush scrublands than on well-managed pastures.

These rather complex and varied management factors have undoubtedly contributed to the prolonged persistence of infestations of TBT in the Caribbean islands.

At the administrative and political management level, the main conclusion drawn from these experiences is that international collaboration is a valuable tool in the implementation of such a multi-donor funded, and multi-institutionally managed program. It was stressed earlier in this paper that eradication programs should be independent of political and institutional bodies; i.e., managed by an autonomous body. Thus, rather than a multitude of individual, and possibly incompatible agreements being made, a single multi-organizational agreement must be considered essential to harmonize and coordinate operations under the leadership of a single technical, preferably independent, implementing agency. Democracy can be ensured through a body such as the Amblyomma Program Council, but it must be empowered with some legally binding and acceptable authority.
Further application of the model. The activities of CAP, in addition to controlling *Amblyomma variegatum* in member countries, have helped to foster a strong link between the farming communities and national veterinary services. Furthermore, under CAP the capabilities of veterinary services for data collection and analysis have been enhanced; a culture of livestock data management has started on many islands where before none existed. CAP hopes to build upon this and, using lessons learnt from the program, act as a model for widening and further strengthening animal disease surveillance in the region to include diseases other than just that of the Tropical Bont Tick.

REFERENCES


* Many of the literature citations used in this paper are in the form of unpublished documents, institutional reports, project proposals, legal agreements, etc. Consequently, they cannot be

Table 1. Identification of potential constraints in Caribbean territories.

<table>
<thead>
<tr>
<th>Pre-requisite/Factors</th>
<th>Anguilla</th>
<th>Antigua</th>
<th>Barbados</th>
<th>St Kitts</th>
<th>Nevis</th>
<th>St Lucia</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appropriate Legislation</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>Legislation and</td>
</tr>
<tr>
<td>Geographically defined distribution</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>methodology</td>
</tr>
<tr>
<td>Known effective acaricide</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>common to all islands</td>
</tr>
<tr>
<td>Scientifically based strategies</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Adequate quarantine measures</td>
<td>+</td>
<td>±</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Adequate, un-interrupted finance</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Adequate livestock handling facilities</td>
<td>±</td>
<td>±</td>
<td>+</td>
<td>±</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>A viable livestock industry</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Benefit-cost analysis / justification</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Effective education program</td>
<td>±</td>
<td>±</td>
<td>+</td>
<td>±</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Public/owner conviction</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>±</td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>

40
Table 2. Tropical Bont Tick surveillance data 1998 to 2003.

<table>
<thead>
<tr>
<th></th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>NEVIS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Properties Exam</td>
<td>699</td>
<td>234</td>
<td>231</td>
<td>429</td>
<td>356</td>
<td>355</td>
</tr>
<tr>
<td>Hosts Examined</td>
<td>14952</td>
<td>6938</td>
<td>7016</td>
<td>12478</td>
<td>8417</td>
<td>7163</td>
</tr>
<tr>
<td>No. TBT Positive</td>
<td>74</td>
<td>40</td>
<td>17</td>
<td>10</td>
<td>16</td>
<td>21</td>
</tr>
<tr>
<td>Prevalence (%)</td>
<td>1.80</td>
<td>0.58</td>
<td>0.24</td>
<td>0.08</td>
<td>0.19</td>
<td>0.29</td>
</tr>
<tr>
<td>Male TBT</td>
<td>55</td>
<td>10</td>
<td>0</td>
<td>16</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>Female TBT</td>
<td>15</td>
<td>10</td>
<td>0</td>
<td>1</td>
<td>10</td>
<td>3</td>
</tr>
<tr>
<td>ST KITTS</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Properties Exam</td>
<td>80</td>
<td>90</td>
<td>93</td>
<td>966</td>
<td>916</td>
<td>70</td>
</tr>
<tr>
<td>Hosts Examined</td>
<td>927</td>
<td>984</td>
<td>1015</td>
<td>412</td>
<td>434</td>
<td>390</td>
</tr>
<tr>
<td>No. TBT Positive</td>
<td>3</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Prevalence (%)</td>
<td>0.31</td>
<td>0.11</td>
<td>0.47</td>
<td>0.08</td>
<td>0.20</td>
<td>0.39</td>
</tr>
<tr>
<td>Male TBT</td>
<td>5</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Female TBT</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ST LUCIA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Properties Exam</td>
<td>170</td>
<td>204</td>
<td>111</td>
<td>196</td>
<td>189</td>
<td>158</td>
</tr>
<tr>
<td>Hosts Examined</td>
<td>1101</td>
<td>936</td>
<td>1068</td>
<td>1383</td>
<td>2416</td>
<td>2488</td>
</tr>
<tr>
<td>No. TBT Positive</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>12</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Prevalence (%)</td>
<td>0.47</td>
<td>0.13</td>
<td>0.08</td>
<td>0.10</td>
<td>0.11</td>
<td>0.01</td>
</tr>
<tr>
<td>Male TBT</td>
<td>0</td>
<td>10</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Female TBT</td>
<td>0</td>
<td>5</td>
<td>3</td>
<td>6</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>ANTIGUA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Properties Exam</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hosts Examined</td>
<td>195</td>
<td>280</td>
<td>1037</td>
<td>1578</td>
<td>2378</td>
<td>570</td>
</tr>
<tr>
<td>No. TBT Positive</td>
<td>1</td>
<td>7</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Prevalence (%)</td>
<td>0.51</td>
<td>2.50</td>
<td>0.79</td>
<td>0.66</td>
<td>0.08</td>
<td>0.41</td>
</tr>
<tr>
<td>Male TBT</td>
<td>1</td>
<td>12</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Female TBT</td>
<td>0</td>
<td>4</td>
<td>6</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>
Table 3. Bio-ecological development and survival data for *Amblyomma variegatum* under quasi-natural conditions (in days).

<table>
<thead>
<tr>
<th>Parameter</th>
<th>(FAO, 1993)</th>
<th>(Pegram et al., 1988)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(Pegram and Banda, 1990)</td>
<td></td>
</tr>
<tr>
<td>Adult female feeding period</td>
<td>7 - 15</td>
<td>10 - 19</td>
</tr>
<tr>
<td>Pre-oviposition</td>
<td>9 - 21</td>
<td>10 - 63*</td>
</tr>
<tr>
<td>Oviposition period</td>
<td>17 - 50</td>
<td>56 - 97</td>
</tr>
<tr>
<td>Pre-eclosion (Incubation) period</td>
<td>43 - 62</td>
<td>53 - 111</td>
</tr>
<tr>
<td>Pre-moulting (Larvae to Nymph)</td>
<td>15 - 22</td>
<td>42 - 63</td>
</tr>
<tr>
<td>Pre-moulting (Nymph to Adult)</td>
<td>18 - 28</td>
<td>39 - 60</td>
</tr>
<tr>
<td>Larval survival</td>
<td>285 (max)</td>
<td>96 - 147</td>
</tr>
<tr>
<td>Nymphal survival</td>
<td>450 (max)</td>
<td>98 - 189</td>
</tr>
<tr>
<td>Adult survival</td>
<td>600 (max)</td>
<td>196 - 228</td>
</tr>
<tr>
<td>Total maximum duration</td>
<td>4 years</td>
<td>1 year</td>
</tr>
</tbody>
</table>

*Usually 11 to 21 days. If longer than 21 days, engorged females were considered to undergo morphogenetic diapause.*
Figure 1. Nevis: Prevalence of TBT infested farms and animals.
Figure 2. St Kitts: Prevalence of TBT infested farms and animals.
Figure 3. St Lucia: Prevalence of TBT infested farms and animals.
Figure 4. Antigua: Prevalence of TBT infested farms and animals.