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HOST RESISTANCE-INTEGRATED TICK PROJECT

EVALUATION

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THE INTERNATIONAL CENTRE OF
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REVIEW OF THE LIVESTOCK TICKS RESEARCH PROGRAMME

February, 15 - 24 1988

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HOST RESISTANCE-INTEGRATED TICK PROJECT

EVALUATION

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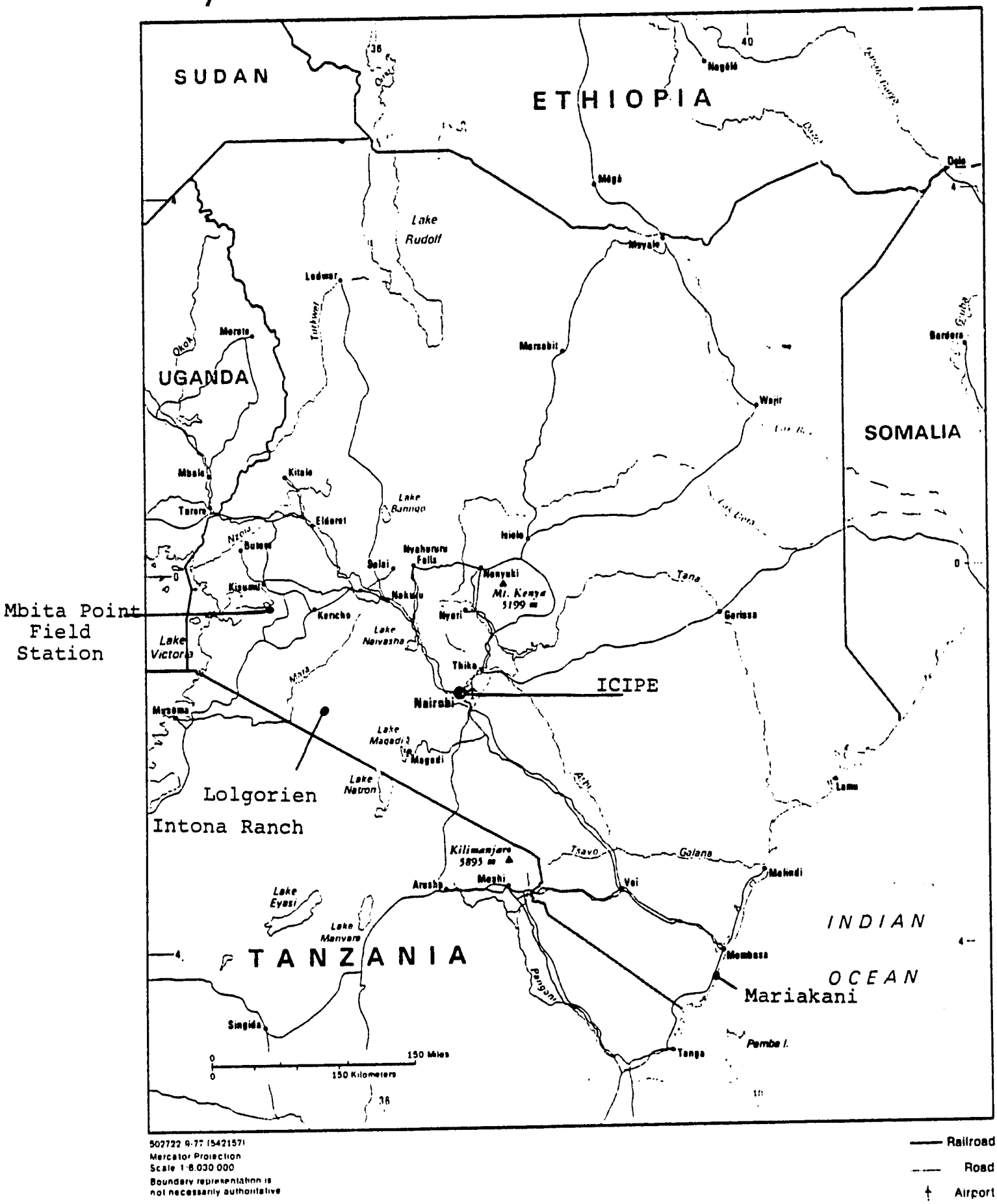
Kenya



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HOST RESISTANCE-INTEGRATED TICK PROJECT EVALUATION

EXECUTIVE SUMMARY

A. Development Objectives

The development objectives as stated in the logframe (updated October 1987) are to: (1) develop an anti-tick vaccine for cattle, sheep and goats; (2) develop reduced or zero acaricide use regimens; (3i) develop methods of assessing tick resistance that can be used by National Programs for culling tick susceptible cattle by 1991; (3ii) determine mode of inheritance of tick resistance and identify specific genes and gene marketrs associated with resistance; (3iii) develop field probes for identification of resistance gene carrying cattle; and (4) define data base and control tick population on Rusinga Island and increase productivity.

B. Purpose of Evaluation

The purpose of this evaluation is to assess progress made in: (1) improving techniques for integrated tick control; (2) evaluating the extent of tick damage to cattle and the extent to which tick resistant cattle reduce the population of ticks in the field; and (3) transferring technology to national and international institutions.

C. Study Method

The evaluation was conducted through presentations, round table discussions, and meetings with individual scientists at ICIPE headquarters in Nairobi and during the site visit to the ICIPE field station at Mbita Point on Lake Victoria. The evaluation team also visited the new laboratories (still under construction) at Duduville, 12 kms. N.E. from downtown Nairobi and the International Laboratory for Research on Animal Diseases (ILRAD) at Kabete. Logistical impediments prevented visits to the Intona and Mutara ranches where field work has been conducted also.

D. Findings, Conclusions and Recommendations

The overall assessment of the ICIPE Livestock Tick Research Program (LTRP) was quite favorable. Its goal to devise cost effective methods of tick control based upon reduced or zero use of acaricides is appropriate and relevant to all of Africa.

The evaluation team was impressed by the quality of research being performed in a severely inadequate laboratory in Nairobi. Limits of space for scientists, equipment, and animals has constrained more rapid achievement of program goals, yet the methodology being employed is appropriate, up-to-date and competently applied. Several constraints on progress in the development of a vaccine will be relieved by the new facilities at Duduville.

Although there is an expressed interest in developing molecular biotechnology for use in the vaccine program, the evaluation team does not recommend the development of a molecular biotechology effort within the LTRP at the present time. There is no doubt that molecular biotechnology capability should be developed at ICIPE but it is a very expensive technology and should be developed as a separately funded research project.

The current biochemical techniques employed have identified some potential vaccine anitigens which appear very promising based on preliminary studies. Studies on host resistance, cattle productivity, tick ecology, modelling, and socio-economic conditions were considered to be soundly conducted and relevant to the problems identified in the program design.

The LTRP is contibuting significant scientific information in the areas of tick ecology and host resistance to tick infestation which can be applied in other African countries where ticks and tick-borne diseases cause significant economic losses. The socio-economic study is providing essential insights into the complex process of incorporating scientific discoveries into current farming practices.

The LTRP is very relevant to the practical problems of pest management in Kenya and other African countries. The evaluation team commends the research program and the use of the socio-economic study to ensure that the experimental results are relevant and applicable in practice. The expertise developed in this program will have benefits far beyond that of tick control.

Future areas of concentration should be in the collection of ecological and socio-economic data in other Kenyan locales in order to develop a comprehensive national tick control program. The tick vaccine program should consider the work done on other tick genera and make use of that material to ensure that the ICIPE developments are not made redundant by more advanced efforts on other tick species overseas. Studies on host resistance and the impact of ticks on cattle productivity should encompass all the major indigenous breeds and derived crosses of importance to the livestock industry. The influences of nutrition and other factors on the expression of host resistance to ticks and the ability of cattle to withstand tick infestation need to be investigated.

The balance between laboratory research and field experimentation is considered to be appropriate to the problems and LTRP goals.

The quality and mix of the LTRP staff is good. One concern of the evaluation team is the seeming lack of continuity of professional staffing which is essential for such a large, long-term project. Loss of experienced staff will reduce the ability of the program to be coherent and scientifically competitive. The combining of chemistry efforts by placing the LTRP immunochemistry in the core program should be strongly considered.

The most glaring deficiency is laboratory and animal space for tick rearing, immunology, immunochemistry and field stations for animal experimentation. The laboratory space problem will be remedied by the move to Duduville. Specific funding proposals will be needed to fully equip the laboratories.

The evaluation team recommends that it is esential for the LTRP personnel to have substantial international contacts and exchange of information. This can be accomplished by attending appropriate international conferences, sabbatical study leaves, and a program for visiting international scientists to work in each of the LTRP research areas (vaccines, tick ecology, modelling, host-resistance, etc.) for periods of 6-12 months.

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ICIPE LIVESTOCK TICK PROGRAMME - IN DEPTH EXTERNAL REVIEW FEBRUARY, 1988

The review team recommends with enthusiasm the funding of the I C I P E Livestock Tick Research Program grant request to U S A I D at the requested level. The requested funding is reasonable for the proposed research. The team strongly recommends against any cuts in funding. If any cuts in requested funding are deemed necessary for budgetary reasons, it is recommended that it be made in one project of the LTRP rather than a general reduction of each project. This recommendation is based on the opinion of the review team that the LTRP is minimally funded. The project which is recommended for cutting, if funding is reduced, is the vaccine project. The reason for this is that vaccines are being developed for other tick species in other countries which might be effective against African tick species. However the team believes that a specific effort should be mounted against African tick species. The LTRP proposal has the added important benefit of providing a vehicle for the traing of African Scientists in the latest techniques in biotechnology. The review team emphasises that the LTRP would be greatly hampered if the vaccine program were not funded and Africa may be severely disadvantaged by such a decision. Additionally, it is the decided opinion of the review team that the cancellation of the vaccine program would have disastrous effects on the continued development of modern laboratory Science at I C I P E.

Dr. A. R. Njogu [signature] 23rd Feb 1988

Dr. William Ruesink [signature]

Dr. Robert Sutherst [signature] 23/2/88

Dr. Joe Templeton Joe W. Templeton February 23, 1988

SUMMARY OF REVIEW TEAM RECOMMENDATIONS

Vaccine

1. The effort to produce a cattle tick vaccine should be continued.

2. The vaccine chemistry and especially the immunochemistry effort needs to become more focused.

3. The cattle tick vaccine experiments should be conducted in cattle.

4. Better adjuvants for the potential tick vaccines should be acquired.

5. The characterization of the tick SMP as a vaccine should be pursued vigorously in terms of optimal dose and delivery systems (adjuvant) and cross-protection to other tick genera.

Ecology

1. The precise questions to be answered and the ultimate use of the models should be defined in detail first.

2. Develop, initially, a simple life-cycle model

3. Develop a deterministic simulation model based on population dynamics.

4. Acquire and dissect appropriate existing models - especially the T3Host model from Australia.

5. Begin descriptive phase of the ecological programme in other major habitats at Mariakani and Mutara ranches and complete ecological descriptions at Muguga, Ukunda, and the Transmara.

6. The data from Rusinga Island should not be used both to build and to validate the same model.

7. There is a need to collect further data on survival and particularly on behaviour of the important tick species in relation to climate and range of vegetation type at each location.

8. Also use truly natural populations in collecting data about population dynamics.

9. Continue seeking better ways to quantify mortality rates.

10. Convene a monthly meeting of modellers and ecologists to define goals and review progress.

11. Ecological studies should be performed on ticks no more than one generation removed from the field whenever possible.

Productivity

1. Involve the socio-economist in a totally pastoral system (Maasai).

2. Careful planning should be used in large-scaled field experiments to ensure that every possible piece of information will be gathered.

3. It is vital to define experimentally the effects of tick-borne diseases on the subsequent productivity of surviving animals. Factors which should be included in this study are nutrition and vaccination against East Coast fever.

Host Resistance/Genetics

1. Pursue the different diurnal rhythms of detachment from their hosts observed on Rusinga Island.

2. Use greater numbers of tick-naive animals for study of numbers of ticks picked up by their hosts.

3. Repeat the experiments at Intona with Borans. The study should additionally include Maasai cattle and intensive measurement of all ecological factors that might affect the results.

4. Study in detail the resistance levels of the Boran cattle.

5. Use the largest engorged females collected from resistant host cattle for tick challenge experiments.

6. Further study the intradermal skin test for identifying tick-exposed or resistant cattle.

7. Be cautious in applying discriminant analysis to susceptible versus resistant hosts.

Socio-Economics

1. Complete socio-economic study of Rusinga.

2. Perform socio-economic study in a totally pastoral setting and a mixed farming system elsewhere in Kenya.

Staffing

1. Efforts should be made to improve communication between scientists and between staff and management in areas of salaries, freedom to set goals, and logistical support.

Training

1. Develop a list of potential research areas consistant with the programme's goals to be publicized for recruitment of graduate students.

Management

1. Goals of the LTRP should be made more clear by using project management tools such as Gannt charts.

2. Delegate more responsibility to the senior scientists in each area to develop individual scientific inputs.

3. Encourage regular sharing of research plans, experimental design and preliminary results.

E. Lessons Learned

ICIPE is one of 11 organizations in Kenya whose mission involves research on animal diseases, disease vectors and their effect on livestock productivity. The Host Resistance-Integrated Tick Control project combines research on the role of acquired tick-resistance in the management of ticks with the use of immunological methods for controlling this parasite. ICIPE's total operating budget was $8,904,300 in 1987. The Livestock Tick Research Program garners $615,000 or 6.9% of the core budget. Of this amount, AID has funded 32% . Other donor support includes 37% ($228,000) from the Switzerland Directorate for Development Cooperation and Humanitarian AID (DDA). The EEC abstained from funding for 1987. The portion of the program funded by the Government of Switzerland emphasizes the development of a vaccine for the artificial immunization of cattle against ticks. This research effort appears to be very active and innovative.

Attention should be given to the fact that ICIPE is the only International Agricultural Research Center (IARC) with an objective of training only Africans within Africa and staffing its programs primarily with African scientists and administrators. Unlike the other IARCs, ICIPE is developing its credibility as an African institution by utilizing the capabilities and skills of indigenous human resources. It is in this regard that AID and other donor funding is most well spent.

The EEC is not expected to support ICIPE in 1988 and DDA has yet to renew its grant. Reduction in AID funding or worse yet, termination of the project, would weaken severely the fundamental groundwork in reduced acaricidal tick control that the Host Resistance-Integrated Tick Project has accomplished.

Past history of the Livestock Tick Research Program indicates that ICIPE received AID funding on a cash grant basis with good faith that program goals and objectives were being attained. Less attention was given by AID to careful monitoring of project activities in order to learn how funds were being expended. It is therefore essential that careful project monitoring by REDSO-ESA and AID/W project managers be complementary and cooperative should the project grant be renewed.

Concerns were raised regarding the ability of ICIPE to produce a tick vaccine without commercial support and the short timeframe expectations of the Director. There is a need to work with the Kenya Veterinary Laboratories at Kabete for alternative methods of tick control other than acaricide dipping which has been estimated to cost the GOK roughly $27.5 million annually.

It is therefore of primary importance to the GOK that a vaccine be developed yet collaboration is not as strong as expected due to the way in which the GOK has organized its ministries and laboratories which produce vaccines for the livestock sector. Nor has ILRAD been a strong partner in collaboration since it perceived that research at ICIPE had not provided -- until now -- enough of the type of research results they require to work.

There has always been a need to develop integrated systems of tick control to provide methods that minimize or eliminate excessive dependence on acaricides. ICIPE recognizes that possible alternative approaches are limited. Past experience and present knowledge do not indicate that biological control using tick parasitoids, pathogens or predators is likely to offer a solution. Similarly, the prospects of using pheromones, kariomones, or arthropod growth regulators as tools in new tick control technology are minimal. These methods need further investigation before their potential can be assessed properly.

Genetic methods for controlling tick populations are a possibility. Researchers in the United States have successfully produced a "sterile hybrid" cattle fever tick with possible application for the control of either Boophilus microplus or Boophilus annulatus. A variety of other genetic approaches may be possible with other species of ticks. Acquired resistance from cattle to particular tick species can interfere with engorgement and appreciably limit the degree to which livestock are parasitized. This knowledge is presently being exploited by ICIPE scientists; it is a field which is attracting interest at an accelerating rate.

The research being conducted by the ICIPE Livestock Tick Research Program includes elements relating to livestock management practices and tick ecology, in addition to the application of knowledge of tick resistance in cattle to the problems of controlling ticks affecting livestock.

Tick-resistant cattle are being successfully used in Australia against a one-host tick species and the technique has potential value in Africa particularly against tick species with limited host ranges. ICIPE is selecting and utlizing cattle with the ability to acquire resistance to ticks. The eventual development of an anti-tick vaccine has future promise.

ICIPE has laid a good research foundation in determining tick resistance in cattle. ICIPE has also demonstrated a capability for cooperating with others in addressing a complex research problem. This project extends the basic research generated by ICIPE to the development of tick management systems. Investigations involve indigenous cattle as well as improved breeds with the objective of improved productivity and to gain information for use by farmers in upgrading their herds with an improved indigenous breed. The returns from this research should be significantly higher than those cited prviously due to the current low producitivity of the indigenous cattle.

SECTION TWO -- DISCUSSION

A. PURPOSE AND STUDY QUESTIONS OF THE EVALUATION

The purpose of this evaluation is to assess progress made in: (1) improving techniques for integrated tick control; (2) evaluating the extent of tick damage to cattle and the extent to which tick resistant cattle reduce the population of ticks in the field; and (3) transferring technology to national and international institutions.

The Host Resistance-Integrated Tick Control Project includes three main areas of work, namely inducement of immunity in the host by vaccination with tick antigens, the use of much reduced or zero-dipping regimens to control ticks, and the selection of cattle with inherited tick resistance characteristics. The evaluation was to address the following specific questions.

Area One: Inducement of Immunity--

- What animal species have been vaccinated?
- What antigens and adjuvant systems were used?
- What was the state of purification of the antigens and what methods were used to purify?
- How was the biological response to vaccinations assessed?
- Has any estimate of effect on tick pasture populations been made?
- What are the time scales to : field trial of a purified antigen; large scale production of the selected purified antigen; general availability of a vaccine?

Area Two: Reduced or Zero Dipping Regimens--

- What type of model will be used to predict the effects of altered dipping regimens?
- From what range of climatic biotypes is data being gathered?
- Have existing models been examined? Why is a new model necessary?
- What data is being collected and for how long?
- Where will field trials of new regimens be carried out?
- Will the model and the regimens have any value outside of Kenya?
- What are the external factors influencing the success of reduced dipping regimens?

Area Three: Selection of Tick Resistant Cattle--
Where is this work being carried out and what data is being collected?
What are the significant results to date?
Have any heritable tick resistance factors been demonstrated?
How will this work relate to the other areas of activity within the program?
What is the projected use of the breeding herd now being established?
How can this breeding process be speeded up?
What are the time scales of this work?

B. ECONOMIC, POLITICAL AND SOCIAL CONTEXT

Tick-borne diseases and debility caused by tick infestations are major inhibiting factors in livestock production throughout the world but particularly in tropical regions and especially in Africa. Tick-borne diseases are prevalent all over the African continent, including an estimated 10 million square kilometers (Young, 1981, Adv. Cont.Theileriosis, Martinus Nijho - p.38-55) across Central Africa where livestock production is impossible or severely limited because of the presence of trypanosomiasis. Throughout this area and the rest of the continent, diseases transmitted by ticks to domestic animals include anaplasmosis, babesiosis, cowdriosis, and theileriosis. The most notorious of these diseases, and the most difficult to contain is East Coast Fever (ECF). ECF is caused by Theileria parva and is transmitted by the tick Rhipicephalus appendiculatus (Irvin and Cunningham, 1980, Trop. Dis. Cattle, Martinus Nijhoff, p.393-410). It occurs throughout East and Central Africa, involving Angola, Burundi, Kenya, Malawi, Mozambique, Rwanda, Uganda, Tanzania, Zaire, Zambia and Zimbabwe. The magnitude of tick losses can be illustrated by examining those which occur annually in the western hemisphere (U.S. dollars): Argentina - 88 million, Colombia - 66 million, Mexico - 287 million, USA - 100 million, and Venezuela - 16 million (Masiga, 1981, Pro. Conf. Ani. Dis. Res. Livestock Prod. Afr., 175-176). It is estimated that in Kenya 50,000 to 70,000 improved cattle die each year from ECF.

In susceptible cattle exposed to ECF, and this includes both exotic breeds and improved Zebu or Zebu from non-enzootic areas, morbidity and mortality approach 100%. In the case of the indigenous cattle in enzootic areas, mortality is low and generally confined to calves. Calves that survive exposure become immune and remain completely resistant to subsequent challenge.

However, different circumstances, such as a prolonged drought that severely lowers population densities of R. appendiculatus, may result in the failure of a calf crop to be appropriately challenged and therefore lower immunity. At a later time exposure to T.parva of such non-immune indigenous cattle may cause enormous losses (Radley et al. 1975a, Vet. Parasitol. 1: 35-41).

Cattle mortality is a serious factor in the losses attributable to ECF, but it is probable that the greatest losses in indigenous cattle in enzootic areas are caused by the stunted growth of surviving animals as a result of continuous tick challenge during calfhood. These effects are manifested in decreased production of calves, milk, and beef. For example, in the Mbita Point area in southwestern Kenya, where ICIPE has a field station, and where ECF is enzootic, adult Zebu cows commonly produce no more than 1 liter of milk a day, beef steers take 6-8 years to reach a live-weight of 350 kilograms, and heifers do not mature to the calf-bearing stage until they are bout 4 years of age. Obviously, other factors are involved in the low productivity of such cattle, but undoubtedly tick infestation and ECF play an important role in this problem.

In addition, to the livestock losses the cost of controlling ticks is significant. In Kenya, for example, there are about 4,500 dip facilities (Masiga, 1981). These cost about $6,000 per unit to construct. The annual cost of acaricides for dipping cattle in Kenya are estimated to range from $8 to 9 million. Maintenance and the supply of water must be added to the above costs. Total costs in Kenya are roughly $27.5 million and even this figure is reputed to be low.

Reducing tick and tick-borne disease losses is an important consideration in African agricultural production. Cattle numbers in Africa have increased from 150 million head in 1969-71 to 170 million head in 1980 (FAO, Vol. 34, 1980). Carcass weight has remained constant at 138 kg/animal in 1969-71 and 139 kg/animal in 1980. Therefore, productivity per animal on the average has not changed. Total beef and veal slaughter in Africa increased from 2,339 thousand metric tons in 1969-71 to 2,909 thousand metric tons in 1980. During the same period, population rose from 354 million to 470 million. As a result, beef availability declined from 6.6 kg per capita to 6.2 per capita. The foregoing analysis excludes beef that was consumed on the farms.

The above data indicate the need to improve livestock production in Africa. Therefore, research to reduce livestock losses due to ticks and tick-borne diseases is important not only to individual farmers but to the economy of Africa as a whole.

Because one infected tick feeding on an animal for less than 2 days can transmit a fatal infection, the only method presently available for the control of the disease is close interval (3-4 days) application of acaricides in dips or sprays. This procedure has obvious disadvantages including cost, danger of toxicosis in livestock and humans handling and applying the acaricides, unacceptable pesticide residues in meat and milk, and dangers of environmental contamination. However, there are few alternatives to acaricides for tick control at present. Under some circumstances pasture-spelling is effective against host-specific ticks, but the method is difficult to implement and under some conditions ticks such as R.appendiculatus could survive in a vacated pasture as long as two years. Biological control with parasitoid wasps has been unsuccessful and this approach to tick control appears to have very little potential. An experimental genetic control procedure has been developed for use against B.microplus and B.annulatus, but the development of additional genetic control methods in the near future is unlikely.

The new technology for ECF management will appreciably alter the necessity of depending excessively on the application of acaricides to cattle. Two other important limitations of excessive dependence on acaricides are:

1. Acaricide resistant tick populations are widespread. This necessitates the development of new products. Companies must account for the risk that acaricide resistance will affect sales before a reasonable profit occurs. This has made companies cautious about the development of new acaricides.

2. The unremitting and close interval application of acaricides to cattle at 3-4 day intervals necessitated in East and Central Africa for the control of ECF, produces an inherently unstable situation where cattle are completely susceptible to tick-borne diseases, and naive to tick infestation. If for any reason acaricide control breaks down, catastrophies can occur, and large numbers of cattle may die of disease and debility caused by massive tick infestations. Such a situation recently arose in Zimbabwe where acaricide control failed during the liberation wars, and more than a million cattle were lost. (Norval, 1978, Rhod. Vet. J.9: 9; Lawrence et al, 1980, Vet. Record 107: 82).

C. TEAM COMPOSITION AND STUDY METHODS

The evaluation team was composed of Dr. Joe Templeton, genetist, Texas A&M University; Dr. Robert Sutherst, entomologist (tick specialist), CSIRO, Australia; Dr. William Ruesink, ecologist and population modeller, University of Illinois; and Dr. Adriel Njogu, Director, Kenya Trypanosomiasis Research Institute (KETRI), Kikuyu. Kenya. Ms. Joyce Turk, animal scientist, Science and Technology Bureau, AID/W, acted as Team Leader.

The study methods employed by the evaluation team included meetings and interviews with individual scientists, formal review and examination of research data presented by each scientist, round table discussions, and site visits to ICIPE headquarters in Nairobi, the new laboratory facilities under construction at Duduville 12 km. N.E. of Nairobi, the field station at Mbita Point on Lake Victoria, Rusinga Island, and the International Laboratory for Research on Animal Diseases (ILRAD), Kabete.

In an effort to satisfy both AID and ICIPE evaluation requirements, the evaluators divided review information into four primary categories, i.e., vaccine production, tick ecology and population dynamics, host resistance/genetics, and animal productivity. Socio-economic data was considered an essential and integral part of the animal productivity category although the studies conducted by the social scientist impact fully on the entire program.

The evaluation team leader stressed the need for conclusions and recommendations regarding the relevance of research activities to the overall Tick program, quality of experimental design, the significance of research results to date, and continuation or cessation of individual acitivites as well as the program. Evaluators were encouraged to comment on the level and quality of staffing, management and budgetary provisions of the program. The team was also asked to consider what portion of the program could be sacrificed if AID funding were to be severely curtailed.

D. FINDINGS AND CONCLUSIONS:

The goal of the ICIPE Livestock Tick Research Program to devise cost effective methods of tick control based upon reduced or no acaricides is important to reduce recurrent costs in Kenya. The research results can be applied to all areas of Africa where ticks and tick-borne diseases cause significant economic losses.

The overall approach used in collecting ecological data on tick populations is well suited to the achievement of the program's goals. The methodologies employed in all tick activities are current and competently applied.

Molecular biotechnology for use in the vaccine program should be developed as a separately funded research project due to its expense.

The Tick Project is contributing significant scientific information on tick ecology and host resistance to tick infestation.

Future areas of concentration should focus on the collection of ecological and socio-economic data in other Kenyan locales in order to develop a comprehensive national tick control program.

The high rate of staff turnover indicates a need for improved management. The evaluation team identified a need for improved collaboration between chemistry and tick immunochemistry groups.

Insufficient and inadequate laboratory and animal space has constrained more rapid achievement of program goals. Newly constructed facilities will relieve this constraint.

The immunochemistry group is inadequately staffed to achieve its goals in the stated timeframe.

Experiments relating to cattle tick vaccine should be conducted in cattle. Concerns about experimental design are centered about the appropriateness of the rabbit and sheep used as models for tick resistance in cattle.

The use of Toxaphene should be eliminated and replaced by use an acaricide that is not environmentally damaging or hazardous to human health.

Use of greater numbers of tick-naive animals are needed to demonstrate differences with statistical significance.

The ARPPIS progeram contributes greatly to improving the scientific expertise of Africa and should continue to be supported strongly by donor organizations.

The overall assessment of the ICIPE's Livestock Tick Research Programme (LTRP) by the review team is highly favourable. The stated goal of the LTRP is to "devise cost effective methods of tick control based upon much reduced or no acaricides". This goal is relevant and appropriate to Africa.

The LTRP has developed a plan to control ticks by three methods: vaccines, strategic (reduced) dipping and genetically based host resistance to ticks. The LTRP has several projects that involve the collection of ecological data to be used in planning more effective tick control strategies. Mathematic models of tick population dynamics are being developed. These models will be used to design national and hopefully regional policies based on research results of the LTRP and other national and international bodies. The overall approach is well suited to the achievement of the goals of LTRP.

The methodology employed in each of the LTRP projects is appropriate, up-to-date and competently applied. Several constraints on progress in the development of a vaccine will be relieved by the new facilities at Duduville. Although there is an expressed interest in developing molecular biotechnology for use in the vaccine programme, this review team does not recommend the development of a molecular biotechnology effort within the LTRP at the present time. There is no doubt that molecular biotechnology capability should be developed at ICIPE but it is a very expensive technology and should be developed as a separately funded research project. The current biochemical techniques employed have been used to identify some promising vaccine antigens. The studies on host resistance, cattle productivity, tick ecology, modelling, and socio-economic conditions were considered to be soundly conducted and relevant to the problems.

The LTRP is contributing significant scientific information in the areas of tick ecology and host resistance to tick infestation. The socio-economic study is providing significant insights into the complex process of incorporating scientific discoveries into current farming practices.

The LTRP is very relevant to the practical problems of pest management in Kenya and other African countries. The review team commends the ecological

research programme and the efforts to ensure that the experimental results are relevant and applicable in practice. The expertise developed in this programme will have benefits far beyond that of tick control.

Future areas of concentration should be in the collection of ecological and socio-economic data in other Kenyan locales in order to develop a comprehensive national tick control programme. The tick vaccine programme should consider the work done on other tick genera and make use of that material to ensure that the ICIPE developments are not made redundant by more advanced efforts on other tick species overseas. Studies on host resistance and the impact of ticks on cattle productivity should encompass all the major indigenous breeds and derived crosses of importance to the livestock industry. The influences of nutrition and other factors on the expression of host resistance to ticks and the ability of cattle to withstand tick infestation need to be investigated.

The balance between laboratory research and field experimentation is considered to be appropriate to the problems and LTRP goals.

The quality and mixture of the LTRP staff are good. One concern of the review team is the seeming lack of continuity of professional staffing, which is essential for success in such a long-term programme. Loss of experienced staff will reduce the ability of the programme to be coherent and scientifically competitive. The review team identified a need for improved collaboration between the chemistry and LTRP immunochemistry groups.

The most glaring deficiency is laboratory and animal space for tick rearing, immunology, immunochemistry and field stations for animal experimentation. The laboratory space problem will be remedied by the move to Duduville. The review team recommends that each of the laboratories be equipped with the basic items of scientific equipment, to increase the efficiency of each group. Establishment of a molecular biotechnology group will be expensive and will require a specific funding proposal.

The review team recommends that it is essential for the LTRP personnel to have substantial international contacts and exchange of information. This can be accomplished by attending appropriate international conferences, sabbatical study leaves, and a programme for visiting international scientists to work in each of the LTRP research areas (vaccines, tick

ecology, modelling, host-resistance, etc) for periods of 6 to 12 months.

TICK VACCINE

The tick vaccine work is particularly relevant and appropriate to Africa and ICIPE's strategy of integrated tick control.

The approach employed to identify tick proteins that might be used as antigens is reasonable. The technical approach for protein isolation utilizes conventional biochemical techniques that have been used successfully to produce vaccines against other pathogens.

The tick proteins isolated and tested to date are: (i) Proteins from tick embryonic cell cultures of Rhipicephalus appendiculatus and Rhipicephalus evertsi, (ii) Vitellin from tick eggs, (iii) soluble and solubilized tick midgut proteins.

The tick cell culture proteins and the vitellins were tested in rabbits as potential vaccines. These proteins were antigenic (induced antibody response) but were not protective, i.e., did not reduce tick infestation. Soluble midgut proteins were also tested in the rabbit but did not induce protection. Whole midgut and solubilized membrane proteins (SMP) induced some protection, as measured by reduction of female engorgement and egg production.

The tick SMP were tested in red Maasai sheep. The results of this experiment indicate that the SMP induced resistance to ticks by killing or reducing the fed weight of larvae, nymphs and adult females of R. appendiculatus.

Utilizing a different detergent system, an additional SMP has been isolated and is being tested in cattle in Switzerland by collaborators at the University of Neuchatel (the Ticks Programme is funded in part by the Swiss donor organization - DDA).

The concerns about the experimental design are centred about the appropriateness of the rabbit and sheep as models for tick resistance in cattle. Furthermore the experiments using rabbits utilized absolute minimal numbers of animals. The review team realize that the constraints on utilizing appropriate numbers and conducting experiments in cattle were the lack of animal facilities. These constraints will be removed by the new facilities at Duduville. The review team recommends that the tick vaccine

experiments relating to cattle tick vaccine be conducted in cattle.

The use of Freund's adjuvants are probably not the best adjuvants to induce protection in cattle using solubilized proteins. There have been several new adjuvants developed in Europe and the USA that are superior to Freund's adjuvants in adjuvanating a protective immune response when solubilized proteins are used as antigens.

The review team thinks that the immunochemistry staff working on the tick vaccine are capable, but barely adequate in number to achieve the goal of isolation and preliminary characterization of potential tick vaccine antigens within the stated time frame. All efforts should be concentrated on characterizing the SMP in terms of dosage, cross- protection to other tick genera, and optimal delivery system (adjuvant).

The preliminary results of the SMP as a potential vaccine in sheep and rabbits are very promising. If the SMP prove to induce host resistance to ticks in cattle, this would be a significant scientific contribution.

ECOLOGY

Understanding the ecology (population dynamics) of key tick species is essential to the development of improved management schemes. Especially important is the definition of the factors causing variation in tick fecundity, survival and feeding rates in the range of conditions in which control is planned.

Deterministic simulation modelling is the most appropriate way to combine diverse knowledge on population dynamics. Such models are well suited to summarising knowledge, identifying information gaps and predicting seasonal variation in population levels. No such model has been built at ICIPE, but the review team is confident that present personnel are competent to do this. While the team recommends that ICIPE acquire and dissect appropriate existing models (especially T3HOST from Australia), it is important that they also build their own version in order to incorporate relevant information specific to African livestock systems. The latter exercise will also increase the ability of African scientists to respond to the continent's needs.

Initially it will be very instructive for the whole group if a simple life-cycle model were

developed. Such a model could be used to manage laboratory cultures and to explore the potential effects of vaccination, diurnal patterns of detachment of ticks from their hosts, predation, and different rates of host-finding, for example. Such a model would avoid the many complications introduced by using climate to drive biological processes.

Once the simple model has been developed and thoroughly understood by the biologists in the group, a more ambitious stochastic simulation model would be more easily produced and comprehended by the whole group.

The review team would like to see a greater effort being put into clarifying the precise requirements for each model, prior to any decision to proceed with construction of that model. As models are simply one of several analytical tools, the precise questions to be answered and the ultimate use of the models should be defined in detail first.

Multivariate statistical approaches and stochastic simulation models are better suited than deterministic models to forecasting actual pest numbers. The review team commends the livestock tick program for recognizing the need for several kinds of models.

The descriptive phase of the ecological programme is well advanced at Rusinga Island in particular. In the other environments, which are representative of the major habitat types in Kenya, the degree of progress is variable. Whilst seasonal variation in tick populations has been defined at Muguga, Ukunda and the Transmara, the physical and management aspects still await description. At Mariakani and Mutara ranches, the entire systems are yet to be described.

The program of regular sampling of 10 farms on Rusinga Island is providing valuable observational data, which highlights the importance of environmental heterogeneity and cattle management practices in the ecology of ticks. The data should prove well suited to building the planned statistical and stochastic simulation models and also to validating the T3HOST simulation model. These data should not be used both to build and to validate the same model as it is inappropriate to use the same data for both purposes.

The multivariate statistical approach to describing the relative importance of tick-borne diseases and other factors on the production of cattle on Rusinga Island likewise seems well conceived. The

review team would have preferred to see a clearer distinction between dependent and independent variables. It was also a little concerned about the potential scale of the proposed data collection, arising from excessive detail in some areas not of prime concern.

The experimental phase has paid particular attention to freeliving stages of ticks, to host resistance and to production losses. These studies have provided vital data for modelling purposes. Further data are required on survival and particularly on behaviour of the important tick species in relation to climate and the range of vegetation types (density, cover and species) at each location. In addition the host-finding rates of ticks need to be estimated in relation to stocking densities and tick behaviour. The effects of the many stressful factors affecting the cattle hosts must be defined as these can explain a large proportion of the variation in size of tick populations. Further, there are some potentially important effects on tick populations of local cattle management practices, such as overnight bomas, seasonal grazing of crop wastes, use of widely separated communal and private grazing areas and mixed herding of different host species, including game. These problems provide numerous opportunities for postgraduate studies, but it is essential that the data collected should be in a form appropriate for incorporation into models.

The review team recognizes that collecting high quality ecological data is very time consuming and at the same time problematic. Generally the best observational data come from field studies using natural populations, but in most cases manipulations and controlled experiments are required to supplement and/or confirm the observational data. This is especially true when and identifying the factors responsible for mortality and quantifying mortality rates. Unfortunately without rather large amounts of high quality mortality data, it is impossible to understand population dynamics or forecast the impact of any control program. The present studies are providing very useful data, but would benefit from greater efforts to use truly natural populations. The review team encourages members of this program to continue seeking better ways to quantify mortality rates. For example the use of gauze enclosures for studies of unfed ticks in pasture could be supplemented by techniques such as destructive sampling of ticks released free into pasture in areas protected from incursion by birds and other animals.

To maximize the benefit of modelling the review team recommends that the program leader meet at least monthly with the modelers and the ecologists to define goals, review progress and help both groups to understand each other's needs and vocabulary. The frequency of these meetings will decline after several months.

Field facilities for observational studies, and computer hardware and software for modelling all seem adequate. We believe that the ecological studies have been greatly hindered by inadequate office and laboratory space, field experimental facilities and cattle holding areas. At Duduville the laboratory facilities will be excellent, but some specialized equipment may be needed (such as environmental chambers to investigate potential diapause/dormancy). In addition substantial areas of grazing land will be needed to enable experimental studies on the factors that affect the expression of host resistance, to quantify host-finding rates and to test the effect of the vaccine on tick populations.

The review team recognizes the difficulties in obtaining disease-free supplies of ticks for experimental purposes, but also suggests that ecological studies should be performed on ticks no more than one generation removed from the field whenever possible. Unbiased samples from field populations should be used. Use of other material must be accompanied by conclusive evidence that the parameters being measured are unaffected by longer maintenance in the lab colony.

The review team commends the recent progress that has been made in the ecological area and is confident that it will provide practical benefits in the area of tick control over a wide area of Africa. Future success will depend greatly on maintaining clear goals and on ensuring that all team members are involved and kept informed of progress with the models.

PRODUCTIVITY

The project has made good progress in defining the response of Maasai cattle to chemical control of mixed tick infestations on the growth in the Transmara, which is climatically very favourable for tick population growth. The experiment was well designed and demonstrated the high level of adaptation of Maasai cattle to ticks and tick-borne diseases. The results obtained are in broad agreement with data from other countries in Africa and are suitable for use in

computer models. The research team is commended on the economic analysis of the results which demonstrates a welcome increase in awareness of biological scientists of the need to relate their research results to the needs of the end users. As the logical next step, the review team recommends the involvement of the socio-economist in order to evaluate the options available to the Maasai in a totally pastoral system, given their goals and constraints.

The above data were complemented by observations on the effects of mixed tick infestations on improved Boran cattle under set-stocking conditions in the Transmara environment. Boran cattle originate from semi-arid areas which are not conducive to the evolution of adaptive characters for defence against parasites. In contrast to the trial using Maasai cattle under traditional management, the trial with Boran cattle showed their inability to control a heavy tick challenge, with consequent anaemia and reduced liveweight gain. Possible explanations include the very favourable environment for tick propogation created in the small, lightly-stocked paddocks and the possible lower host resistance of the Boran's to tick feeding. The heavy infestations of B. decoloratus on the bulls at Mutara Ranch, despite monthly dipping, also suggests a limited degree of adaptation to ticks. While the results were unexpected, they were nonetheless very valuable as they raised important questions for future attention. The difficulties experienced during the trial also highlighted the need to ensure adequate support for such large-scale field experiments. The cost of such trials demands that every possible piece of information should be gathered to ensure that an adequate explanation is obtained for the results. This will require a high degree of alertness to changing situations and willingness to respond accordingly. Such efforts will be cost-effective and scientifically rewarding.

The collection of baseline data on animal productivity and the impact of tick-borne diseases on cattle survival rates in the very poor pastoral environment on Rusinga Island was carried out competently and provided the required data in a suitable form for modelling purposes.

The results illustrated the relatively low incidence of deaths due to tick-borne diseases in this endemically stable environment. They also revealed a very slow rate of growth of the surviving calves, which raises important questions relevant to tick control. The review team believes that it is vital to define experimentally the effects of tick-borne diseases on

the subsequent productivity of surviving animals. These effects must be distinguished from nutritional deficiencies caused by poor dam lactation and diversion of milk for human use. The results should also be related to the use of vaccination strategies against East Coast fever.

The integration of these Rusinga observations with the socio-economic observations will provide a sound basis for the successful implementation of control measures aimed at reducing the losses caused by the ticks and tick-borne diseases.

The review team was concerned at the use of Toxaphene in the study at Lolgorien. ICIPE should take a lead and abstain from using pesticides that are either environmentally damaging or hazardous to human health.

HOST RESISTANCE/GENETICS

Studies on various aspects of host resistance of traditional cattle were reported from Rusinga Island and Lolgorien in the Transmara, and of improved Boran cattle from Mutara ranch in northern Kenya. Observational data from other parts of Africa have demonstrated the high level of adaptability of zebu cattle to tick infestation. However, none of the studies have involved the Boran breed.

Experimental measurements of tick survival on cattle on Rusinga Island covered various aspects of the tick-host relationship. They were aimed firstly at finding a suitable index with which to rank cattle for resistance to ticks. The complex index with 13 variables was simplified to the use of only adults of Rhipicephalus appendiculatus and nymphs and larvae of Amblyomma variegatum. Further simplification, perhaps excluding non-'standard sized' females and males of R. appendiculatus and larvae of A. variegatum is desirable for later use in field application.

The use of artificial infestations to quantify the survival rates of ticks on high and low resistance animals and on Friesian cattle showed an innovative ability under difficult circumstances and provided valuable information for use in modelling.

There is evidence from other countries in Africa that ticks may undergo selection for different diurnal rhythms of detachment from their hosts, as a result of the practice of confining cattle in 'bomas' overnight. Data from Rusinga indicated that the majority of ticks detached in the afternoon, whereas other data have

shown a maximum of 10% of the ticks detached at that time. These observations may have considerable practical significance where cattle management practices are amenable to small changes. The review team believes that this aspect of the work should be pursued further.

Attempts to compare the numbers of ticks picked up by resistant zebu or susceptible, tick-naive Friesian cattle were inconclusive. It is recommended that cognisance be taken of published work that shows that cattle learn to avoid ticks on pasture. In addition, greater numbers of tick-naive animals are needed to demonstrate differences with statistical significance.

The Rusinga observations on the tick-host relationship are exceptional for their scope and detail in dealing with traditional cattle. They have provided valuable insights into this important relationship.

The investigation into the ability of improved Boran cattle to control tick infestations at Intona is important and has been referred to in relation to the impact of ticks of the productivity of such animals. The results showed that the levels of resistance expressed by such animals were insufficient to protect them from debilitating infestations. Animals that had not acquired their resistance were even more vulnerable. It is vital that the experiment be repeated in the future, with intensive measurement of all ecological factors that might affect the results.

At Mutara ranch, young improved Boran bulls were selected for tick resistance, following commendable attempts to devise methods of visual assessment of tick infestation levels. The levels of tick infestation on the bulls, which were repeatedly dipped at 4 week intervals, was surprisingly high. Boophilus decoloratus was the most common species in the virtual absence of R. appendiculatus and A. variegatum from large areas of the ranch. B. decoloratus very rarely reaches infestations levels exceeding 10 per beast on traditional zebu cattle. Thus the infestations exceeding 30 per beast in the semi-arid environment at Mutara are surprising and warrant detailed study of the resistance levels of the Boran animals, interactions between tick species and the management of the herd.

For experimental selection of high levels of tick resistance in cattle, maximum selection rates may be achieved by using the largest engorged females collected from resistant host individuals.

The intradermal skin test works well for identifying tick-exposed cattle, but whether the technique can be modified to serve as an indicator of genetic resistance is questionable. Some research into this question is warranted.

Discriminant analysis of susceptible versus resistant hosts offers interesting and potentially valuable possibilities, but it can be dangerous when used on small or inappropriate data sets, or when biologists do not work closely with statisticians. The review team believes this approach should be encouraged provided the above concerns are addressed and the needs of the end users for a simple measure are taken into account.

SOCIO-ECONOMICS

The review team commends ICIPE for adding socio-economic studies to their Livestock Tick Program. The overall approach is appropriate to program goals and the procedures employed are very thorough and well designed. Progress to date has been excellent and has contributed substantially to prospects for improving tick control in many African countries.

It is important that the socio-economic study be allowed to continue to completion on Rusinga Island. Results should be published in a peer reviewed journal in addition to being used to direct future research planning.

The review team recommends incorporating socio-economics into studies of a totally pastoral system (such as the Maasai) and another mixed farming system elsewhere. Without repeating the Rusinga Island study in other locations and settings it is impossible to generalize the results.

Cooperation and communication between the social science and biological science components of the Livestock Tick Program are outstanding. The establishment and maintenance of confidence between cooperating farmers and research personnel is essential to acquiring accurate data. The ICIPE staff have been very successful in establishing such a relationship.

COLLABORATION

The review team was impressed by the large network of collaborating agencies and individuals listed below. It was noted that collaboration has been productive and should be continued or expanded as appropriate.

The team recommends future collaboration be made in the areas of testing for cross protection of tick vaccines, genetics of host resistance, and host-finding behaviour of the tick in relation to climate and host stimuli.

INSTITUTIONS COLLABORATING WITH LTRP

INSTITUTION	AREA OF COLLABORATION
ICIPE	
- Chemistry & Biochemistry	Vaccine(antigen isolation)
- Sensory Physiology	Vaccine (membrane feeding)
- Biomathematics Research Unit	Ecology (data analysis; modelling)
- ARPPIS	Vaccine; Ecology (Ph.D. training)
KARI/Kenya Veterinary Dept.	Ecology (Rusinga; Transmara; Mariakani; Muguga/Kabete) Genetics of Host Resistance (Mutara ranch)
ILRAD	Vaccine (Immunochemistry) Ecology (Modelling)
Nairobi Cluster	Ecology (Tick survival)
ADC	Genetics of Host Resistance (Mutara)
GTZ	Ecology (Transmara)
University of Neuchatel	Vaccine (Antigen isolation) Ecology (Amblyomma variegatum)
Hebrew University	Vaccine (Antigen isolation)
Small cattle owners	Rusinga Island and Lolgorien (Production Systems)

STAFFING

The review team is impressed with the quality of ICIPE's professional staff. This was evident by the progress being made towards achieving the specified goals, the quality of the presentations and the publication record.

In immunochemistry the level of staffing is barely adequate to achieve the stated objectives in the projected time frame (e.g. having a vaccine ready for production in 6-8 years).

The review team noted the recent high rate of loss of professional staff, which if allowed to continue will affect the orderly progress toward goals. The rate of turnover is related to management policies and significantly impacts on the continuity of scientific research being conducted. The review team recommends that efforts be made to improve communication between staff and management regarding issues affecting the professionals such as salaries, freedom to set goals, and logistical support.

TRAINING

The Tick Program's participation in ARPPIS is contributing greatly to improving the scientific expertise of Africa. ICIPE also benefits from the intellectual stimulation and from the students' contributions to its programs.

The Livestock Tick Program cannot currently predict the type and number of graduate students that will be available to it the following year. The students when available may not be suited to the program's main thrust. The review team therefore, recommends that the Tick and other Programs develop a list of potential research areas consistent with the program's goals for students who might be interested in studying at ICIPE. This list should be publicized widely and the student intake be related to the goals of the programs.

MANAGEMENT

The Program Leader has succeeded in identifying program goals, building a positive team attitude and becoming involved with individual scientists at an appropriate level. The review team encourages the continued building of this teamwork particularly for ICIPE's continued growth into a competitive International Centre.

The review team would prefer that the mission (primary goal) of the Livestock Tick Program as stated in the Strategic Plan for 1987-89 be rewritten to communicate more forcefully that ICIPE wants to discover techniques and develop implementable outreach programs to suppress tick population levels.

The review team commends the program leader for the direction of the Livestock Tick Research Program. This could be further improved if goals were made more explicit by using project management tools such as Gannt charts, critical path analyses, flow charts, etc. Especially important is to state goals (not activities) with target dates for achieving each.

Communication among scientists has been hindered by inadequate facilities and perhaps management decisions. The review team recognizes that moving to Duduville will provide significant opportunities to improve communication and recommends that efforts be made to do so. It is suggested that more responsibility be delegated to the senior scientist in each research area to develop individual scientific inputs. The review team especially encourages regular sharing of research plans, experimental design and preliminary results. Modelers and statisticians should be involved in all such discussions.

SUMMARY OF REVIEW TEAM RECOMMENDATIONS

Vaccine

1. The effort to produce a cattle tick vaccine should be continued.

2. The vaccine chemistry and especially the immunochemistry effort needs to become more focused.

3. The cattle tick vaccine experiments should be conducted in cattle.

4. Better adjuvants for the potential tick vaccines should be acquired.

5. The characterization of the tick SMP as a vaccine should be pursued vigorously in terms of optimal dose and delivery systems (adjuvant) and cross-protection to other tick genera.

Ecology

1. The precise questions to be answered and the ultimate use of the models should be defined in detail first.

2. Develop, initially, a simple life-cycle model

3. Develop a deterministic simulation model based on population dynamics.

4. Acquire and dissect appropriate existing models - especially the T3Host model from Australia.

5. Begin descriptive phase of the ecological programme in other major habitats at Mariakani and Mutara ranches and complete ecological descriptions at Muguga, Ukunda, and the Transmara.

6. The data from Rusinga Island should not be used both to build and to validate the same model.

7. There is a need to collect further data on survival and particularly on behaviour of the important tick species in relation to climate and range of vegetation type at each location.

8. Also use truly natural populations in collecting data about population dynamics.

9. Continue seeking better ways to quantify mortality rates.

10. Convene a monthly meeting of modellers and ecologists to define goals and review progress.

11. Ecological studies should be performed on ticks no more than one generation removed from the field whenever possible.

Productivity

1. Involve the socio-economist in a totally pastoral system (Maasai).

2. Careful planning should be used in large-scaled field experiments to ensure that every possible piece of information will be gathered.

3. It is vital to define experimentally the effects of tick-borne diseases on the subsequent productivity of surviving animals. Factors which should be included in this study are nutrition and vaccination against East Coast fever.

Host Resistance/Genetics

1. Pursue the different diurnal rhythms of detachment from their hosts observed on Rusinga Island.

2. Use greater numbers of tick-naive animals for study of numbers of ticks picked up by their hosts.

3. Repeat the experiments at Intona with Borans. The study should additionally include Maasai cattle and intensive measurement of all ecological factors that might affect the results.

4. Study in detail the resistance levels of the Boran cattle.

5. Use the largest engorged females collected from resistant host cattle for tick challenge experiments.

6. Further study the intradermal skin test for identifying tick-exposed or resistant cattle.

7. Be cautious in applying discriminant analysis to susceptible versus resistant hosts.

Socio-Economics

1. Complete socio-economic study of Rusinga.

2. Perform socio-economic study in a totally pastoral setting and a mixed farming system elsewhere in Kenya.

Staffing

1. Efforts should be made to improve communication between scientists and between staff and management in areas of salaries, freedom to set goals, and logistical support.

Training

1. Develop a list of potential research areas consistant with the programme's goals to be publicized for recruitment of graduate students.

Management

1. Goals of the LTRP should be made more clear by using project management tools such as Gannt charts.

2. Delegate more responsibility to the senior scientists in each area to develop individual scientific inputs.

3. Encourage regular sharing of research plans, experimental design and preliminary results.

Appendix A.

THE INTERNATIONAL CENTRE OF
INSECT PHYSIOLOGY AND ECOLOGY
PO BOX 30772, NAIROBI, KENYA

DRAFT

USAID/ICIPE REVIEW OF LIVESTOCK TICK PROGRAMME

Scope of Work

The Livestock Tick Research Programme (LTRP) is researching methods of tick control that are an improvement on the current 'saturation' use of acaricides.

There are three main areas of work:

(i) Inducement of immunity in the host by vaccination with tick antigens.

(ii) The use of much reduced or zero dipping regimens to control ticks.

(iii) The selection of cattle with inherited tick resistance characteristics.

The review team should:

(a) Receive formal presentations from the Programme Leader and all graduate staff descibing the current state of work and the progress since the last review (1985).

(b) Have discussions with individual scientists and examine their data and conclusions.

(c) Visit all field sites of the programme: Mbita Point (Rusinga Island), Lolgorien (Trans Mara), Muguga (KARI), Mutara Ranch. Have discussions with the relevant scientists on the ground.

(d) Visit all collaborating institutions for discussions with management.

(e) Peach conclusions as to the relevance of the work being performed, the quality of the experimental design, and the significance of the results obtained to date.

(f) Make recommendations on the continuance or cessation of any part of the current programme of work and any necessary additions.

(g) Comment on the level and quality of staffing, the management, and the budgetary provisions of the programme. Detail any changes seen to be necessary to achieve the programme objectives

(h) Produce a written report for submission to USAID and ICIPE..

PBC
USAID4:DOC
21.Oct.87.

THE INTERNATIONAL CENTRE OF
INSECT PHYSIOLOGY AND ECOLOGY
P O BOX 30772, NAIROBI, KENYA

DRAFT

USAID/ICIPE REVIEW OF LIVESTOCK TICK PROGRAMME

Scope of Work

The Livestock Tick Research Programme (LTRP) is researching methods of tick control that are an improvement on the current 'saturation' use of acaricides.

There are three main areas of work:

(i) Inducement of immunity in the host by vaccination with tick antigens.

Questions of interest here are:-

(a) What animal species have been vaccinated?
(b) What antigens and adjuvant systems were used?
(c) What was the state of purification of the antigens and what methods were used to purify?
(d) How was the biological response to vaccination assessed?
(e) Has any estimate of effect on tick pasture populations been made?
(f) What are the time scales to: Field trial of a purified antigen: Large scale production of the selected purified antigen: General availability of a vaccine?

(ii) The use of much reduced or zero dipping regimens to control ticks.

Questions of interest here are:-

(a) What type of model will be used to predict the effects of altered dipping regimens- determinative or stochastic?
(b) From what range of climatic biotypes is data being gathered?
(c) What equipment is being used to collect and analyse climatic and tick population data?
(d) Have existing models been examined, why is a new model necessary?
(e) What data is being collected and for how long?
(f) Where will field trials of new regimens be carried out?
(g) Will the model and the regimens have any value outside of Kenya?
(h) What are the external factors influencing the success of reduced dipping regimens?

(iii) The selection of cattle with inherited tick resistance characteristics.

Questions of interest here are:-

(a) Where is this work being carried out and what data is being collected?
(b) What are the significant results to date?
(c) Have any heritable tick resistance factors been demonstrated?
(d) How will this work relate to the other areas of activity within the programme?
(e) How will this work benefit the national productivity?
(f) What is the projected use of the breeding herd now being established?
(g) How can this breeding process be speeded up?
(h) What are the time scales of this work?

The review team should:

(a) Receive formal presentations from the Programme Leader and all graduate staff descibing the current state of work and the progress since the last review (1985).

(b) Have discussions with individual scientists and examine their data and conclusions.

(c) Visit all field sites of the programme: Mbita Point (Rusinga Island), Lolgorien (Trans Mara), Muguga (KARI), Mutara Ranch. Have discussions with the relevant scientists on the ground.

(d) Visit all collaborating institutions for discussions with management.

(e) Reach conclusions as to the relevance of the work being performed, the quality of the experimental design, and the significance of the results obtained to date.

(f) Make recommendations on the continuance or cessation of any part of the current programme of work, and any necessary additions.

(g) Comment on the level and quality of staffing, the management, and the budgetary provisions of the programme. Detail any changes seen to be necessary to achieve the programme objectives

(h) Produce a written report for submission to USAID and ICIPE..

PROJECT DESIGN SUMMARY

LOGICAL FRAME WORK

LIFE OF PROJECT: FROM FY 1988 FOR THREE YEARS
TOTAL US FUNDING: _____
DATE PROPOSAL: _____

HOST RESISTANCE INTEGRATED TICK CONTROL DAN 4083-6-55-3063-00

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
PROGRAME GOAL			
To contribute to increased food production in East Africa by raising the level of animal health and productivity of cattle, sheep, and goats	Annual Report of ICIPE Published papers in refereed journals	On site review by USAID appointed review team	
PROJECT PURPOSE	**EOPS**		
To improve methods of tick control to a level whereby the present high level of acaricide use is brought to zero, or significantly reduced	Objectives		Objectives
Objectives	1. Experimental vaccine positive tick control of one species of tick and the immunising protein(s) ready for large scale prodution and large scale field trials.	i) USAID Team review with presentation of data by scientists	1. It proves scientifically possible to define and purify these proteins
1. Develop antitick vaccine for cattle sheep and goats.	2. Data for a predictive model will have been produced and the model verified by field trial in one site.	ii) Peer review of published results	2. That a farm can be identified with adequate tick-borne disease control
2. Develop reduced or zero acaricide use regimens.	3. Resistance assessement criteria will be available for National Programmes to commence to implement culling.		3. Facilities of Muturu are made available by MOC
3. Develop methods of assessing tick resistance that can be used by National Programmes for culling tick susceptible cattle by 1991.	4. Degree of tick control and increased productivity on 10 resource poor farms.		
4. Define data base and control tick population on Rusinga Island and increase productivity.			
OUTPUTS			
Objectives	Objectives		
1. See Para 1.1-1.5 appendix 1	1. Three proteins tested as vaccines in two species of animal. OVI Examination of laboratory results	i) USAID Team review with presentation of data by scientists	
2. See Para 2.1-2.5 appendix 1	2. An achievable % reduction in acaricide use will have been demonstrated. OVI Examination of experimental data. Field inspections.	ii) Peer review of published papers	
3. See Para 3.1-3.4 appendix 1	3. One or more methods of assessing immunity have been developed and shown to be valuable in the field. OVI Examination of herd breeding records.	iii) Field inspections	
4. See Para 4.1-4.5 appendix 1	4. Two breeds of cattle assessed for tick control and productivity increases. OVI. Records and field inspection.		
INPUTS			
USAID Inputs			
1. Technical assistance Para 1.1 app. 2 2. Commodities Para 2.1-2.3 app. 2 3 Local currency support Para 3.1 app. 2 4. Host Country Inputs Para 4.1 app. 2 5. Other Donor Inputs Para 5.1 app. 2	ICIPE'S Annual Externally Audited Accounts	ICIPE External Auditor's Report USAID review of Audited accounts	

Appendix B.

DOCUMENTS CITED

AID Handbook 3, Project Assistance, Chapter 12 (Supplement), "AID Program Design and Evaluation Methodology Report No. 7"

ICIPE Strategic Plan for 1987-1989

Second Triennial Review Report, October 1986

Approved Detailed Budget for the Financial Year: 1988

FAO Volume 34, 1980.

INDIVIDUALS AND AGENCIES CONTACTED

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-- Mr. Robert McColaugh, Agriculture Development Officer

The Present Status of Livestock Tick Research Programme

Introduction

The three main scientific areas of study have been: Laboratory antigen studies designed to lead to a "tick vaccine"; Studies on the ecology of Rhipicephalus spp. and Amblyomma spp. including survival and development at different biotypes leading to population modelling for decreased use of insecticides; Investigations into acquired and inherited resistance to ticks.

These studies have taken place in Nairobi, Rusinga Island, Intona and Mutara Ranches and at Muguga and in collaboration with Kenya Agricultural Research Institute, University of Neuchatel, International Laboratory for Research in Animal Diseases, Veterinary Laboratories - Kabete and the Agricultural Development Corporation..

Achievements

i) Antigen studies

Antigens from the whole tick, salivary gland, tick midgut and reproductive organs have been investigated for their antitick activity when used as mixtures formulated into vaccines and injected into rabbits, sheep, goats and cattle. Significant protective effects have been demonstrated in rabbits, sheep and goats and it is clear that the concept of an antitick vaccine is viable. Specific proteins or subunits with molecular weights ranging from 25 KD, 48-80 KD, 140 KD, 232 KD and upto 390 KD have been demonstrated as well as two carboxylproteinases from midgut. Enriched fractions of these proteins are being prepared for assessment of signficant biological activity by vaccination studies.

ii) Ecological Modelling studies

Preliminary tick development survival and host population data for R. appendiculatus has been obtained for Rusinga Island, Nairobi and

Intona Ranch and this is being combined with climate data to produce a mathematical model of the tick ecology in these biotypes. Further studies using A. variegatum and R. appendiculatus with electronic data loggers have commenced in these three biotypes. The model will be used in tick control studies at Rusinga. Studies of a different biotype at Mutara Ranch have commenced to enable strategic dipping to be evaluated in that environment.

iii. Resistant Studies

It has been established that the strains of cattle at the Boran National Stud have a high degree of natural resistance to ticks. These observations are repeatable and resistance ranking of bulls is feasible. This observation provides a basis for proceeding to selective breeding and eventually studies on genetic typing at a cellular level.

Naturally acquired resistance failed to have a significant effect on productivity over a wide range of tick numbers. A threshold effect was observed at approx. 400 ticks per animal. Above this level animals with naturally acquired resistance performed poorly compared with dipped controls.

An intradermal test using R. appendiculatus tissue culture cell material has been developed to screen animals for tick exposure when required for immunity studies.

Considerable progress has been made in developing an in vitro feeding test to distinguish immune and non immune cattle without resorting to direct tick challenge.

On Rusinga Island the definition of a productivity data base, which includes tick borne disease losses, is well established. Weight gains, milk yield, births, deaths, cull losses and disease incidence are being recorded on 10 farms prior to interventions aimed at controlling tick populations while improving productivity. This site will be an excellent base for testing a tick vaccine in a resource poor farmer context.

STATUS OF INITIAL OUTPUTS

(a) To survey the ticks and tick transmitted diseases affecting the indigenous Zebu cattle maintained on communal pastures according to indigenous cattle management practises and then implement and evaluate tick and disease control procedures to protect cattle.

In general this objective has been pursued and is still being worked on, particularly on Rusinga Island. There, tick-borne disease (t.b.d.) has been recorded for the last year (In connection with productivity data collection) and a specific project in conjunction with ILRAD on ECF epidemiology is in the late stages of completion. Specific tick borne disease control measures have not been evaluated following the general agreement of ICIPE with the Gov't and ILRAD that the Institute would not work on Tick borne disease. We have however, proposed a joint programme with ILRAD that we should produce a joint mathematicasl model of the tick and tickborne disease pcsition on the Island, with ICIPE producing the tick data and ILRAD the t.b.d. data

As detailed in the programme of work and the reports the tick population data objective has been pursued for two years and will finish soon. This will be the basis of the tick part of the model, which will guide the design of the next phase which is the evaluation of rational tick control procedures.

(b) To determine if tick resistant Boran steerss vaccinated against ECF will cause a decline in the tick population and subsequently maintain it at a low level in a pasture containing no other tick hosts and if the weight gains of these animals will ne comparable to Boran Steers dipped weekly in acaricides to effect tick control.

This objective has been pursued vigorously at Intona Ranch and has been completed and reported on. In brief, tick resistant Boran steers do not cause a decline in the pasture tick population, but this increases at a rate similar to that of pasture which is maintaining susceptible cattle .

The weight gains of susceptible, resistant and dipped cattle have been determined and it is clear that dipped cattle have a superior weight gain to the other treatment groups.

(c) To establish a breeding herd on improved Boran cattle in an ECF enzootic area, to control ticks by using acquired tick resistance and strategic acaricide applications, to control ECF by vaccination and the use of curative drugs, and to compare the productivity and levels of tick infestation on the Boran cattle with animals in a Maasai herd of indigenous Zebu cattle maintained in a communal grazing are adjacent to the experimental pasture.

Some of the objectives of this output have been or are in the process of being acheived. A breeding herd is in the process of being established in Mutara Ranch, ticks are being controlled in the herd by reduced dipping regimens, and other alternative methods of acaricide application have been investigated (Ear tags etc). ECF in this herd and in the other animals on the farm has been controlled by allowing natural infection to take place and then treating with curative drugs (A type of controlled "Field" vaccination).

Tick pick-up and tick burdens (essential ingredients for determining productivity) and disease losses of several breeds of cattle as well as Boran and Maasai have been determined under identical tick challenge. It is clear that Maasai and then Boran have positive advantages in these respects over *Bos taurus* breeds. However these experiments were terminated due to the appearance of a highly fatal strain of Heartwater that made further experiments impossible. The original intent of the work cannot be fully achieved until adequate vaccines against Heartwater, Anaplasmosis and Babesiosis are available.

(d) To conduct laboratory experiments to obtain additional information on the ability of ticks to stimulate acquired resistance in cattle and to determine the affects on ticks of feeding on resistant cattle.

These objectives are still being pursued, and a large body of data has been accumulated. We now know that it is impossible to stimulate a resistance in cattle using natural infestations that will give adequate tick control in the absence of acaricides. Artificial stimulation using irradiated ticks and then natural infestations gave no better results.

The use of natural infestations has thus been dropped and superceded by studies to isolate "concealed" tick antigens that would produce a more positive effect. This work has been fully reported and several purified antigens are under study. We have however, shown that it is possible to cotrol tick infestations (using these concealed antigens as mixtures) in rabbits, sheep and goats much more positively than with natural infestations. These investigations are proceeding with considerable input of resources.

(e) To extend preliminary research on the transmission of Theileria parva to and from tick resistant cattle.

This objective has not been pursued following the agreement with ILRAD and the Kenya Govt that ICIPE would not work on tick-borne diseases. The resources now un-utilised have beeen reallocated to the study of inherited resistance characteristics at the national Boran stud at Mutara. When suitable methods for inducing immunity to ticks are available this phenomenon will become important to define and will be studied in conjunction with KARI and ILRAD.

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