International Centre of Insect Physiology and Ecology

(ICIPE)

Adaptive Research to Assess the Sustainability of the ICIPE NGU Trap for Community-based Management of Tsetse and Trypanosomiasis in Lambwe Valley, Kenya

FINAL TECHNICAL REPORT

9th September, 1996

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LIST OF ABBREVIATIONS:

ADP	- Animal Draught Power
BS	- Baseline Studies
CFG	- Catalytic Farmers' Group
CMTTT	- Community-Managed Tsetse Trapping Technology
FEW	- Frontline Extension Workers
	- Farmer-to-Farmer Extension
ICIPE	- International Centre of Insect Physiology and Ecology
IFAD	- International Fund of Agricultural Development
	- International Livestock Research Institute
	- ICIPE Researchers
MPFS	- Mbita Point Field Station
	- National Programme Officer
NRES	- National Research and Extension Systems
	- Natural Resources Institute
O&M	- Organisation and Management
	- Ruma National Park
	- Tsetse Trapping Technology
	World Resources Institute

PROJECT TITLE: **Adaptive Research to Assess the Sustainability of the ICIPE NGU Trap for Community-based Management of Tsetse and Trypanosomiasis in Lambwe Valley, Kenya**

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1.0 EXECUTIVE SUMMARY

This section of the report synthesizes the information presented on four major substantive aspects of the project; namely background, project purpose, research activities and outputs and, their contribution.

1.1 Background

The developers of the ICIPE NGU trap described it as low-cost, highly efficient and suitable for community management (Brightwell *et. al.*, 1987). Following this, it was subjected to further evaluation in Lambwe Valley, Western Kenya, in 1988. Within 8 months, apparent fly density was reduced from 200 flies/trap/day to below 1 fly/trap/day. Noting these results, the community began to press for a control scheme. They even organised meetings and raised funds. However, their request caught ICIPE unprepared. Only the reduction of tsetse and disease had been assessed. The impact on livestock productivity and the environment, its cost and benefits, and the process of community adoption had not been studied. ICIPE used this opportunity to develop a community-based project, April 1992 - March 1996, funded by the Natural Resources Institute (NRI), London, to investigate all these aspects.

1.2 Project Purpose

The most important objective was to demonstrate that the community can, on its own, finance and manage tsetse and trypanosomiasis, using the NGU trap. Other objectives were to: prepare a monitoring plan; assess the impact on tsetse population, trypanosomiasis, cattle productivity, and the environment; train extension workers and develop extension tools and, develop a framework for the widespread adoption of community-managed tsetse trapping technology (CMTTT).

1.3 Research Components, Activities and Outputs

RESEARCH ACTIVITIES

1.3.1 Studies of adoption of CMTTT
1.3.2 Assessment of the impact of CMTTT on

1.3.2.1 Tsetse population
1.3.2.2 Trypanosomiasis
1.3.2.3 Animal productivity and human welfare
1.3.2.4 Land-use and cropping systems
1.3.2.5 Farmers' participation in impact assessment

Monitoring and evaluation of overall project results

RESEARCH OUTPUTS

Studies of the adoption of tsetse trapping

Development of adoption model. A model describing the relationships among strategies, methodology, implementation plan and outputs was developed. Four major strategies are outlined here. First, the community is wholly responsible for financing and managing CMTTT. Second, adoption is science-based, i.e. farmers gain a sound understanding of tsetse, trypanosomiasis, trapping and, organisation and management. Third, researchers train a small catalytic farmers' group (CFG) who, in turn, train and mobilise their community (farmer-to-farmer extension). Fourth, collaboration is built. Regarding implementation, a seven-step plan is followed: baseline studies, community mobilisation, formation of organisation, resource moblisation, trap deployment and impact assessment. Monitoring and evaluation go on continuously. The execution of this plan sets in motion predictable outcomes: reduced tsetse population and trypanosomiasis, increased livestock productivity and human welfare (Ssennyonga *et. al.,* 1996).

Implementation

Community mobilisation. At the completion of seven baseline studies, researchers trained a CFG (42 individuals) in the biology and ecology of tsetse, trypanosomiasis, trapping, principles of organisation and management (November 1992 - April 1993). The CFG in turn convened 35 mobilisation meetings and trained the community, covering the topics listed above. The community accepted the responsibility for financing and managing CMTTT. (Ssennyonga *et. al.,* 1992).

Formation of organisation. The CFG organized 35 more meetings in which several options were considered after which a decentralised organisation was set up as follows. The 44 villages were grouped into 15 blocks, new organizational units. A new unit, KISABE, an acronym from Kibwer and Samba, lowest administrative units, was created. The block is headed by a committee made up of chairman/vice chairman, secretary/vice secretary, treasurer and 7 - 9 trap managers. Blocks were to manage traps in their areas. KISABE, managed by a committee made up of chairman/vice chairman, coordinator, secretary/vice secretary, treasurer, 8 trap managers, 3 co-opted members and an auditor, coordinates the activities of blocks and liaises with other agencies. Women make up 30% of leaders.

Mobilization and management of resources. Money, materials and labour have been mobilized and managed on a continuous basis. Two methods of fund raising have worked: (i) a homestead capitation of K.Shs. 150.00 and, (ii) a membership registration fee of K.Shs. 20.00. US$ 1825 have been raised so far. Four problems have been encountered: (i) lack of training in financial mobilisation and management; (ii) crop failure in 1993 and 1994; (iii) the dependency syndrome, e.g. some members have argued for finding a donor to finance CMTTT; (iv) free-riders who have not participated but have benefited. But, self-reliance has prevailed.

Trap deployment. Community trap managers selected trap sites in January 1994, drew up a three-phase trap deployment plan, and made the first batch of traps in March-June, 1994. In May, 56 volunteers cut 16 transects in Nyaboro thicket at the end of which trap managers placed 64 traps between July and December 1994. In 1995, 20 traps were placed along Ruma National Park (RNP). In addition, 35 traps were deployed as replacements for worn out (22) or vandalised (13) traps. Each block is expected to recruit 4 persons on each Wednesday and Saturday to service traps, but this arrangement is not strictly implemented. Trap deployment is far more labour intensive than was believed. Thus, 1428 persondays have been expended on making (2.1%), placing (14.4%) and servicing (83.5%) traps, women contributing 40 per cent of the labour. Trap deployment will therefore take longer to complete than planned.

Management of the organisation. To achieve these results, a relatively high degree of management efficiency was achieved mainly through 273 management meetings in which activities were planned, coordinated and controlled through participatory decision making.

Training extension staff and development of training modules. A veterinarian and two animal health assistants seconded to the project were trained in all aspects of CMTTT. Training materials were also distributed.

1.3.2 Impact Assessment

1.3.2.1 Impact on tsetse population

Reduction of G. pallidipes population. To monitor tsetse reduction by removal trapping, male and female data were combined and monthly post-control trap catches expressed as percentages of the average pre-control catch. The results showed that 95-99.9% tsetse suppression was achieved.

1.3.2.2 Impact on Trypanosomiasis

Trypanosome infection rate of G. pallidipes. A total of 6907 and 449 tsetse flies were examined microscopically for trypanosome infections before and after control, respectively Overall, there was a significant (40.7%) reduction in the mean tsetse infection rate following suppression trapping. A decline of 91.0% in the trypanosomiasis challenge was also brought about by the reduction in the vectorial capacity of *G. pallidipes.*

Trypanosome infection rate in cattle. Changes in disease prevalence mimicked those in tsetse density. In the high challenge areas, there were significant ($P < 0.05$) 84.0% and 77.4% reductions in the mean disease prevalence in the farmers' and the sentinel herds, respectively. Most importantly, results from monthly records of infected sentinel animals suggest that no serious trypanosome drug-resistance exists.

Trypanosomiasis has been reduced to levels at which it can be managed under normal veterinary services.

1.3.2.3 Impact on animal productivity and human welfare

Studies were undertaken to determine the impact on three indicators of human welfare, namely incomes, cattle productivity and the use of animal draught power (ADP)

Study of herd structure. Data were collected from 546 head of cattle, on the breed, sex, age, age at first calving and total number of calves ever born to female cows. Results were used to purchase a sentinel herd of 60 head of cattle (Ngugi, A.N. and Ssennyonga, J.W. 1993).

Study of crop and livestock production, incomes, consumption and marketing prior to trap deployment. This study shows that the willingness to invest in tsetse control is likely to be high even though disposable incomes are low (Lako, G.T. and Ngugi, A.N. 1993). The same set of data have been collected since the commencement of trap deployment. But, as part of a centre-wide restructuring in 1994, the position of economist was frozen; as a result, the data for this and the following two studies have not been analysed but arrangements are being made to get the work done.

Study of cattle productivity. Data on milk off-take, weight gain, calving, cost of treating nagana and, mortality were collected from a sentinel herd of 60 head of cattle for one year prior to trap deployment and thereafter up to now.

Study of the cost of tsetse trapping. All costs related to trapping activities have been recorded regularly.

1.3.2.4 Impact on land-use and cropping systems

Methodology.

Methods developed and used to monitor changes include: the identification and determination of the significance of indicator-parameters of the relationships between land use and tsetse control. Indicators classified as significant are migration, overstocking, use of draught power, and reduced pasture. Those designated most significant include settlement, tsetse infested area, increased cropped area, overgrazing etc.

Monitoring activities

Classification of Communities. Communities were classified by residential altitude and land use categories (Tables 4a & b)

Community-drawn maps. Using available implements such as stones, farmers drew maps on the ground showing key resources and later walked with researchers along transects selected by themselves. They recorded and gave explanations for observed changes in soil, water resources, vegetation cover and biodiversity which researchers drew onto a map. (See Omolo *et. al.*, 1995).

Cartographic maps. Three cartographic maps of topography based on farmers' recall of changes were produced.

GIS land use map. Based on land use and vegetation data interpreted from air photographs of the study area and field surveys, an ARCINFO GIS of 1:25,000 was developed.

Baseline ecological study of Lambwe Valley. This study, carried out in March-April 1995, documented vegetation clearance, soil degradation and functional regulation of ecological processes due to increased vegetation clearance, hill slope farming and reduction in habitat sizes.

Longer term environmental assessment. This activity will continue under the collaborative project between ICIPE, the International Livestock Research Institute and IFAD.

1.3.2.5 Farmers' participation in impact assessment. Farmers assessed four kinds of impacts. First, 78 farmers participated in the scientific monitoring of tsetse population, trypanosome infection rates of tsetse and cattle. Second, a sentinel herd of 60 head of cattle was divided among 15 farmers who keep records of daily milk off-take, calving and deaths. Third, as reported above, farmers took part in assessing environmental changes. Fourth, in a workshop funded by the World Resources Institute (WRI), farmers evaluated the contribution of collaboration and user participation to project results. (Ssennyonga, 1995).

1.3.3 Monitoring and Evaluation of Overall Project Results

Quarterly (16), annual (4) and mid-term reports were submitted to the NRI. Apropos of this, three NRI staff made six visits to ICIPE and the project site.

1.4 Contribution of Project Outputs

Viability of the model. The model implemented in Lambwe Valley is under validation in a semi-nomadic Maasai pastoralist community in S.W. Kenya.

Strategies. Community acceptance of the responsibility was not an irrevocable commitment, but a continuous process of negotiations spanning the entire life of the project. Given the dependency syndrome embedded in the relationships between North and South, it is extremely difficult to convince communities that it is in their best interest to finance and manage tsetse or other development enterprises on their own. Success was due to the fact that the community recognised: (i) tsetse as a big problem and also took the initiative to mobilise resources for a control programme and, (ii) the NGU trap as an efficient and manageable technology and, (iii) through health education and other forms of capacity building and empowerment, appreciated the advantages of self-reliance. These conditions are therefore essential for the success of a community-managed control scheme.

Collaboration. In the context of National Research and Extension Systems (NRES), collaboration is bound to be thwarted by lack of: (i) positions for social scientists in agencies implementing tsetse control schemes and, (ii) institutional mechanisms for collaboration among government ministries/agencies. At the community level, free-riders and the legacy of disincentives for participation in tsetse control also erode collaboration. The community's handling of these problems through education and persuasion is commendable.

Farmer-to-farmer Extension (FFE). The CFGs have shown an amazing capacity for grasping so quickly and passing on to members of their communities scientific information and technical skills. By contrast, frontline extension workers in Kenya are trained to control tsetse themselves but not to impart any knowledge or skills to farmers, a situation which is not unique to Kenya. Under these conditions, FFE is bound to be the most cost-effective strategy.

Forming the Organisation. This is the single most critical task and entails deciding whether to: (i) work with existing organisations or form a new one; (ii) pursue tsetse control as a single goal or combine it with other projects; (iii) allow individually-managed traps as well; and (iv) operate through centralised or decentralised management. Among these options, decentralisation is the most crucial because it places the burden of tsetse control on small local groups and preempts the need to create a bureaucracy which, in order to service traps in the entire control zone, would require transport and pay. But, if it is found inefficient, the entire control scheme is put in jeopardy. Further strengthening the capacity for managing the organisation is essential.

Resource Mobilisation. The first task is to put in place an effective mechanism for continuous resource mobilisation to finance a public good. Three major challenges, namely, (i) an undeveloped capacity for fund raising, (ii) the dependency syndrome and, (iii) low disposable cash income, are likely to retard fund raising in most countries affected by tsetse. Strengthening the capacity for financial mobilisation and management is therefore necessary.

Trap deployment in areas with low tsetse population density. The community strategy to deploy suppression traps starting with Nyaboro thicket and only later along the boundary with Ruma National Park (RNP), the major reservoirs of tsetse, seems to have been a reasonable decision because, following suppression of flies in Nyaboro area, there was a significant reduction in trypanosomiasis in both the trap-treated and untreated areas. This will enable the community to assess the necessity of deploying additional traps in light of results achieved so far.

Trypanosome drug resistance. No clear evidence of trypanosome drug-resistance was observed. The fact that there were no trypanosome infections over several months after control suggests no drug-resistant trypanosomes were being circulated by the few tsetse remaining in the area. This is a rare situation in tsetse infested areas in Africa where usually trypanocide resistance frustrates effort to integrate chemotherapeutic intervention with tsetse control (Mihok *et al.*, 1992).

A promising new alternative. Tsetse control by targets in RNP (Opiyo *et al.*, 1990), in operation since 1988, has of late suffered from lack of funds. In this context, community control of *G. pallidipes* has ushered in a promising alternative approach to the management of tsetse.

Impact on Environment. Pioneering work was done on the development of a methodology for assessing the impact of tsetse control on land-use and cropping systems. The new ICIPE/ILRI/IFAD project will integrate environmental management into tsetse control.

Farmer participation in impact assessment. Three issues have to be resolved, namely, the activities, kind and intensity of participation. The importance of tsetse, relative to other problems facing the community and, what the community is willing to do, should be the yard-stick. The goal is to build community capacity for integrating environmental management into tsetse control.

Dissemination of results. The quarterly and annual reporting system has created a valuable data base. However, its intensity has retarded the synthesizing and publication of research findings compiled in 17 research papes. This is therefore the immediate task of project researchers. It should also be noted that the project has already featured in one film and two video documentaries. Dissemination of results through the vision media will be explored further.

1.5 New Research Issues

Applicability of the model to other socioeconomic settings. The model has been implemented by an agricultural community in a relatively small area. Would it be successfully applied in large and/or sparsely populated areas? It is currently in the initial stage of implementation in a semi-nomadic pastoralist Maasai community. Further research is therefore needed to throw light on this issue.

Collaboration between communities and other stakeholders. Some of the wildlife conservation agencies believe that tsetse flies are the custodians of wildlife and other natural resources in Africa. Now that the NGU trap can be used to manage tsetse without harming wildlife, it is feasible for communities to collaborate with these agencies on projects combining wildlife conservation with tsetse control. Further research is needed to address this issue.

Time frame. A four-year cycle has proved inadequate for a CMTTT. If the community is solely responsible for financing and managing TTT and, if impact assessment is also an objective, then the life span can be estimated as follows: planning, recruitment and purchase of equipment, 8 months; baseline studies, 12 months; training and community mobilisation, 8 months; formation of O&M, 6 months, resource mobilisation, trap deployment and impact assessment, 36 months; assessment of sustainability and publication of results, 14 months; a total of 7 years.

Terminal Trap Density. Currently, traps are placed at intervals of 200 metres in Nyaboro thicket, and 50 metres along RNP. Can this density be reduced without adversely affecting the trypanosomiasis situation? If so, to what density?

Terminal Tsetse Density. Should tsetse density be reduced to even lower levels? If so, to which level and at what marginal net gain?

Acceptable level of trypanosomiasis. Should trypanosomiasis be reduced even lower? If so, to what level and at what marginal net gain?

Answers to some of these questions would greatly improve the efficiency and validity of the model of CMTTT. Hopefully, the on-going ICIPE/ILRI/IFAD project will enable the community to experiment and provide answers to some of these questions. Finally, it is believed that, with minor modification, the model can guide the dissemination and adoption of other technologies.

MAIN REPORT

2.0 BACKGROUND

In the 1960s, animal trypanosomiasis and a virulent form of sleeping sickness transmitted by *G. pallidipes* appeared in the Lambwe Valley and have since persisted up to the present. The number of reported cases of sleeping sickness has been oscillating between peaks and troughs. Livestock trypanosomiasis has also been oscillating; for example, during the epidemic of 1980, overall mortality for cattle was 40%, reaching 60% in some locations. Higher mortality rates were recorded for small stock. The situation was aggravated by the extension of tsetse in farther suitable habitats and encroachment of settlements and livestock to the park (Turner, 1981). There is also evidence that trypanosomiasis may escape the Lambwe area to affect the livelihood of lakeshore communities through the agency of *G. fuscipes fuscipes* (Turner, 1986; Wellde *et al.*, 1989). Trypanosomiasis is therefore a big problem in the Lambwe Valley and adjoining locations with an estimated human population of 51,300 and 101,700 head of cattle in an area of 450 km^2. Human population in the study zone of 100 km^2 is 12,000, rearing 22,600 head of cattle.

Although the Lambwe fly belt is small and isolated, and thus ideal for control, to date, tsetse has survived all control attempts including intensive insecticide applications (Turner and Golder, 1986). This is due to the fact that the methods used suffer from a combination of four major constraints: they are costly; many of them, such a aerial and ground spraying, pollute and/or destroy the environment; they have largely been managed by outside agencies rather than the target users making them unsustainable; and drug resistance, principally by trypanosomes and, to some extent by tsetse, is a growing problem. A propos of this, there is concern about the current control by odour-baited targets in RNP which started in August 1988 (Opiyo *et al.*, 1990) and still continues: the exposure of tsetse to low doses of deltamethrin on targets over approximately eight years may result in the development of insecticide resistance. Turner and Golder (1986) had already reported evidence of tolerance to endosulfan of *G. pallidipes* in the Lambwe Valley. ICIPE researchers tried a different approach and developed a low-cost, highly efficient, odour-baited tsetse trap designed for community management in 1987, at Nguruman, South Western Kenya. The deployment of NGU traps resulted in a 90-99% reduction in the *Glossina pallidipes* and a virtual elimination of nagana in a control zone of 100 km^2 at Nguruman. (Dransfield *et. al.*, 1990).

Following this success, the NGU trap was validated in Nyaboro thicket, Southern Lambwe Valley starting in 1988. Within 8 months, apparent fly density was reduced from 200 flies/trap/day to below 1 fly/trap/day. Noting these results, the community began to press for a control scheme. They even organised meetings and raised funds for this purpose. However, their request for a control scheme caught ICIPE unprepared. Only the reduction of tsetse and disease had been assessed. The impact on livestock productivity and the environment, its cost and benefits, and extension requirements had not been assessed. Above all, although the Maasai reportedly participated in trap deployment, the process of community adoption had not been studied. ICIPE used this opportunity to develop a community-based project which was implemented during April 1992 - March 1996 with funding from the Overseas Development Administration through Natural Resources Institute (NRI), London.

3.0 PROJECT PURPOSE

The most important objective was to demonstrate that the community can, relying on its own resources, manage tsetse and trypanosomiasis, using the NGU trap. Other objectives were to: provide a framework for the widespread dissemination of tsetse trapping technology; prepare a monitoring plan; assess the impact of Tsetse Trapping Technology (TTT) on tsetse population, trypanosomiasis, cattle productivity, and the environment; train extension workers and develop extension tools; and develop a framework for the widespread adoption of community-managed trapping technology.

4.0 RESEARCH COMPONENTS, ACTIVITIES AND OUTPUTS

Research activities have been carried out under four major components as follows:

4.1 Adoption of tsetse trapping
4.2 Assessment of the impact of tsetse trapping technology on:

4.2.1 Tsetse population
4.2.2 Trypanosomiasis
4.2.3 Cattle productivity
4.2.4 Human welfare
4.2.5 Land-use and cropping systems
4.2.6 Farmers' participation in impact assessment

4.3 Monitoring and evaluation of overall project results

Detailed descriptions of the research activities under each of these components follow.

4.1 Studies of the adoption of tsetse trapping

A. Research Activities

As indicated above, the major objective of the project was to demonstrate that, relying on its own human and financial resources, the community can manage tsetse and trypanosomiasis using the NGU trap. It was therefore necessary to carry out two kinds of studies, namely baseline investigations to assess key community capabilities and socio-economic features (1-3) and actual adoption of tsetse trapping (4-10) below.

1. Study of the community's awareness of tsetse problems and willingness to solve them;
2. Study of community's capacity for organisation and management;
3. Study of socio-economic stratification of the community.
4. Development of adoption model
5. Study of community mobilisation
6. Study of the formation of organisation and management
7. Study of the mobilisation of resources for TTT
8. Study of the deployment of traps by the community
9. Study of farmers' participation in the assessment of the effects of tsetse control
10. Training extension personnel and development of extension training modules.

B. Outputs

1. **Community awareness of tsetse problems and willingness to participate in tsetse control.** Studies of community knowledge, traditional tsetse control practices, and

willingness to participate in tsetse trapping were conducted (prior to this project) at the time of the 1989 technical evaluation of NGU trap. Results showed that all interviewed farmers regarded tsetse and trypanosomiasis especially for people, as major problems and 83% expressed their willingness to take active part in any control activities initiated by ICIPE (Oendo, *et al* 1989).

2. **Study of local organisations.** This study was designed to gather information that would facilitate (a) the selection of farmers for training courses; (b) the determination of local capacity for organisation and management; and (c) tailoring the training to fill up the gaps. Results show that: (a) the study area had 46 organisations dominated by women in demographic and leadership terms, and (b) although leaders have several skills, hardly any have been trained in organisation and management. The study also enabled researchers to test farmers' hypothesis that combining several organisation goals brings about greater numerical enrollment to the organisation. Results disproved the hypothesis (Table 1 and, Ssennyonga and Were 1995).

3. **Study of socioeconomic stratification of the community in the tsetse control zone.** Data were collected from a sample of 311 homesteads in the control zone on: (a) gender and residential status of homestead head; (b) employment and salary; (c) livestock species and number owned, and monetary value; and (d) number, type and monetary value of houses. Results from the study show: (i) the community has adequate resources to finance tsetse trapping technology (TTT); and (ii) economic stratification is skewed. Also, based on the study results, a reliable sampling frame for selecting homesteads to participate in project activities was developed (Ssennyonga and Mungai, 1992).

4. **Development of adoption model.** The model developed describes the relationships among four sets of variables, namely strategies, methodology, implementation plan and outputs. (Fig. 1). Only a few aspects of the model are briefly described here. The community is the key player wholly responsible for financing and managing TTT. Adoption is science-based, i.e. farmers gain a sound understanding of tsetse biology, trypanosomiasis, trapping and basic principles of organisation and management. Farmer-to-farmer extension strategy would be applied where initially researchers train a small catalytic farmers' group (CFG) who train, mobilise their community and disseminate the technology. The implementation plan has a built-in logical sequence which, if implemented, in a collaborative framework (Fig. 2), sets in motion a causally-linked set of outcomes. (Ssennyonga *et. al.*, 1996).

5. **Community mobilisation.** Researchers and resource persons from some of the collaborating institutions (Fig. 2) trained a CFG of 42 individuals in the biology and ecology of tsetse, trypanosomiasis, trapping, principles of organisation and management (November 1992 - April 1993). The CFG in turn convened 35 community mobilisation meetings and, using training materials prepared during their course, and translated into the local Luo language, trained members of their community along the lines described above. The community accepted the responsibility for financing and managing TTT. (Ssennyonga *et. al.*, 1992).

6. **The formation of organisation and management (O&M).** The CFG organized a new series of 35 meetings to form the O&M framework. A five-tier decentralised organizational structure was set up as follows. The bottom tier consists of the 1800 homesteads, the second tier is made up of the 44 villages, the third tier comprises 15 blocks made up of 2-5 villages depending on their spatial and geographical size.

Blocks are new organizational units. The fourth tier consists of the two sub-locations, Kibwer and Samba. The fifth, a new unit, KISABE, an acronym from Kibwer and Samba was created to bring together the two sub-locations, the lowest formal administrative units of the Kenya Government. (Fig. 3).

There are no management roles for homesteads and villages. The block is headed by a committee made up of chairman/vice chairman, secretary/vice secretary, treasurer and 7 - 9 trap managers. Each block elected one delegate from among these leaders to represent it at the KISABE level. Blocks were given the responsibility to manage traps in their areas. KISABE is managed by an 18 - member committee made up of chairman/vice chairman, coordinator, secretary/vice secretary, treasurer, 8 trap managers, 3 co-opted members and an auditor. KISABE plays two major roles; it coordinates the activities of blocks and liaises between the community and external agencies. Elected leaders (30% women) took over from the CFG the responsibility for managing the organisation, mobilising resources and trap deployment. (Ssennyonga, 1994)

7. **Mobilization and management of resources**. Data have been collected on four different kinds of resources: money, materials, labour, and premises, which have been mobilized and managed on a continuous basis. Results show that two methods of fund raising have been applied: (i) a homestead capitation of K.Shs. 150.00, payable in cash or in kind; and (ii) a membership registration fee of K.Shs. 20.00. Altogether, K.Shs. 88, 641 (US $ 1825) have been raised so far (Fig. 4). Four problems have been encountered. First, there is a lack of training in financial mobilisation and management. Second, in 1993, Lambwe Valley experienced a severe crop failure. The following year, army worms invaded and destroyed the crops. Third, the dependency syndrome is hard to erode. Members who did not attend either the training courses or community mobilisation meetings, argued for finding a donor to finance TTT. But the spirit of self reliance has prevailed. Fourth, there are free-riders who have not participated but have benefited. The community has opted to educate these members rather than use coercion.

8. **Trap deployment.** First, trap managers selected 493 trap sites in January 1994 following which a three-phase trap deployment plan was drawn up: 64 traps in Nyaboro thicket (phase 1), 120 barriers traps along RNP (phase 2) and 309 traps at the foothills (phase 3). But it was later agreed that the number for phase 3 would be determined after evaluating the impact of traps in the first two phases. Trap managers made the first batch of traps in March-June, 1994. In May, 16 crisscrossing transects were cut in Nyaboro thicket at the end of which 64 traps were placed between July and December 1994. In 1995, 20 traps were placed along RNP. In addition, 35 traps were deployed as replacements for worn out (22) or vandalised (13) traps. In principle, each block recruits 4 persons on each Wednesday and Saturday to place and/or service traps, but there is flexibility in implementation. Data collected so far reveal that trap deployment is far more labour intensive than is commonly believed. Thus, it took 952 mandays to cut the 16 transects in Nyaboro thicket. In addition, 1428 persondays have been expended on making (2.1%), placing (14.4%) and servicing (83.5%) traps, women contributing 40 per cent of the labour. (Fig. 5). Labour budgets are big mainly because Nyaboro thicket is covered for most part by thorny shrubs and becomes waterlogged in wet months. Trap deployment will therefore take longer to complete than planned.

9. **Management of the organisation.** To achieve these results, a relatively high degree of management efficiency was required. This was achieved mainly through meetings in which financial, trapping and other activities were planned, coordinated and controlled through participatory decision making. Altogether, 273 management meetings have been held, 62% and 38% at block and Kisabe levels respectively (Fig. 6).

10. **Training extension staff and development of training modules.** Two groups of extension staff have been trained. First, a veterinarian and two animal health assistants seconded to the project on a part time basis were trained in all aspects of community-managed tsetse trapping. For example, together with ICIPE research staff, they spent eleven days each month monitoring tsetse, trypanosomiasis, cattle productivity and community adoption of the technology.

    Second, an IFAD-funded project on the dissemination of TTT was implemented by ICIPE and Ministry of Agriculture, Livestock Development and Marketing (MALDM) in November 1993-January 1994. ICIPE researchers (IRs) trained 7. Kenya National Programme Officers (NPOs), who, under IR's supervision, trained 10 frontline extension workers (FEWs). FEWs, under the supervision of NPOs and IRs, trained three CFG (total of 15 persons) who in turn trained and mobilised their communities. Training materials were produced and distributed to NPOs, FEWs and CFG. One of these communities went on to implement a community-managed tsetse control project. Some of the trained CFG were subsequently deployed as trainers in other parts of Western Kenya (Ssennyonga, J.W. and Oloo, F., 1994).

4.2 Impact Assessment

4.2.1 Impact on tsetse population

To illustrate the impact of community trapping on *G. pallidipes* population, trypanosome prevalence in tsetse and cattle and the health of cattle, the following monthly research activities were undertaken over 16 months before and 18 months after control using standard monitoring techniques (Leak *et al.* 1995).

A. Research Activities

1 Monitor changes in the apparent density (mean catch/ trap/day) of *G. pallidipes* for four days each month using twenty baited biconical traps.

2. Ageing of male and female *G. pallidipes* (Jackson, 1946; Challier, 1965).

B. Outputs

1. Reduction of G. pallidipes population

Changes in the apparent densities of male and female *G. pallidipes* showed similar trends before and after control (Fig. 7). Following the placement of suppression traps in July-December 1994, tsetse declined steadily with records of zero catches of males and females in March and September 1995, respectively. To monitor the progress in tsetse reduction by community removal trapping, male and female data were combined and monthly post-control trap catches expressed as percentages of the average pre-control catch. The results showed that up to 99.9% tsetse suppression was achieved.

2. **Age of** G. Pallidipes

All age classes were represented in the samples of males and females taken before the placement of traps in July 1994. By October 1994, no male of wing fray category 6 and female older than ovarian group 5+ were present. Between October 1994 and March 1995 only five (7.4%) of all 68 females caught were older than ovarian age class 3 (4+ and above), whereas the latter classes comprised 30 (30.9%) of 97 females in July, a week before trap deployment (Chi^2 = 11.9, DF = 1, $P < 0.0006$). A similar trend was also observed in males: males of wing fray category 4-6 comprised 27.1% of 59 in the July sample, but only 12.0% in 108 males caught between October 1994 and March 1995 (Chi^2 = 5.0, DF = 1, $P < 0.03$). Ageing of tsetse was discontinued after March 1995, because of the low catch sizes (< 10 flies/80-trap-days each month).

4.2.2 Impact on Trypanosomiasis

A. Research Activities

1 Trypanosome infection rate of *G. pallidipes*

2. Trypanosome infection rate in the farmers' cattle and a sentinel herd of 60 head of cattle bought by the project.

3. The percentage of packed red blood cell volume (%PCV) of both groups of cattle as an indicator of their health (Murray *et al.* 1977).

B. Outputs

1. Trypanosome infection rate of G. pallidipes.

A total of 6907 and 449 tsetse flies were examined microscopically for trypanosome infections before and after control, respectively. Out of the total 976 infections detected, *Trypanosoma vivax* (proboscis only) comprised 90.6%, *T. congolense* (gut and proboscis), 9.3% and *T. brucei* (proboscis + gut + salivary gland), 0.1%. Infection with the *vivax* parasites (Fig. 8) was high (up to 30%) during the pre-control period; it declined simultaneously with tsetse suppression and disappeared completely from October 1995 onwards. In contrast, there were no clear changes in the level of *congolense* infections before or after control until September 1995 after which they disappeared together with *the vivax* infections. Overall, there was a significant (40.7%) reduction in the mean tsetse infection rate following suppression trapping (Table 2). The post-control infection rates shown are misleading because very few flies were available for dissection after suppression. To appreciate the impact of control on the trypanosome prevalence in tsetse, the trypanosomiasis challenge was calculated (= apparent tsetse density (males + females) X trypanosome infection rate). The results (Fig. 9) showed that there was a steady decline in the challenge with the advance of tsetse control. The challenge dropped from a peak of 200 in January 1993 to zero after September 1995. Comparison of the means before (73.4 ±14.6) and after control (6.6 ± 3.5) indicated over 91.0% reduction ($P < 0.0004$) in the trypanosomiasis challenge in the area. **This reduction in trypanosomiasis challenge has been brought about by (i) the decline in the vectorial capacity of** Glossina pallidipes **through the suppression of tsetse population by traps; (ii) lowering of its mean age and, (iii)**

by the monthly Berenil treatment of cattle from which tsetse could no longer acquire new infections.

2. **Trypanosome infection rate in cattle.**

The trypanosomes diagnosed in the farmers' and tagged sentinel cattle included all three groups of pathogenic salivary in both the low and high challenge areas (Figs. 10 and 11), but the *brucei* group did not feature in any location after August 1994. Low challenge areas are those villages whose cattle usually graze far from Nyaboro and Ruma National Park: (Nyamadede, Pundo, Magunga, Nyasoti, Oma, Sangla, Lwala) as opposed to the cattle in high challenge areas straddling Nyaboro and Ruma National Park: Nyaboro, Sanjweru, Olando, Ugoro, Wiga, Kigoto, Gendo, Seka (Fig. 12). In both kinds of locations the temporal changes in disease prevalence mimicked changes in the tsetse density until August 1995 (Fig. 7), with the mean prevalence in high challenge areas 2-4 times greater than in low challenge areas. In the high challenge areas, there were significant ($P < 0.05$) 84.0% and 77.4% reductions in the mean disease prevalence in the farmers' and the sentinel herds, respectively. The corresponding figures for low challenge areas were 60.6% (significant) and 71% (ns). Most important was that monthly records of infected sentinel animals during the pre-control showed only two individuals out of 55 with repeated *T. vivax* infections for three consecutive months. However, both afflicted animals were eventually cured after the last Berenil treatment and no more repeat infections were detected after the start of control. This result suggests that currently no serious trypanosome drug-resistance exists in the Lambwe Valley area.

3. **Percentage packed cell volume (PCV%) of cattle.**

Data on the PCV% of cattle are presented in Figs. 13 - 14. In both areas and for both groups of cattle there was a clear decline in animals with PCV% at or below 24% following tsetse suppression. There were, significant reductions in the mean proportions of low-PCV animals of the sentinel and farmers' herds in high challenge areas although nor similarly so for the sentinels in low challenge areas. There were also direct associations between the monthly trypanosomiasis challenge in the high challenge areas and corresponding proportions of cattle with low PCV% (farmers' cattle r = 0.35, df = 32, $P < 0.0002$; sentinel cattle r = 0.17, df = 26, $P < 0.05$). No similar correlations could be obtained for cattle exposed to low tsetse challenge at the 5% probability level.

4.2.3 Impact on human welfare

A. Research Activities

The objective was to determine the impact on three aspects of human welfare, namely incomes, dairy products and the availability and use of animal draught power (ADP). The achievement of other social objectives such as having animals for paying bridewealth, slaughter at funerals, and social security would also be demonstrated, albeit indirectly. To achieve these objectives, economic analysis would be carried out to determine:

Costs of and incomes from livestock production prior to and after tsetse control;

Affordability of tsetse trapping by the community;

Cost/benefits before and after tsetse control

4.2.4 Studies of impact on land-use and cropping systems

Almost in all cases, tsetse control frees land previously inaccessible for agricultural production, thereby facilitating changes in land use, ecological structure and function. Environmentalists rightly fear that, if not properly managed, changes in land use may precipitate environmental degradation and loss of wild life. Environmental impact assessment is therefore an important aspect of tsetse control, which, nevertheless, has not been addressed in conventional tsetse control schemes. As a result, much of what is reported below is an effort to develop methodological approaches and apply these to monitor changes.

A. Research Activities

1. Development of methodology
2. Actual monitoring of land use changes

B. Outputs

1.0 Methods developed

1.1 Identification and determination were made of the significance of indicator-parameters of the relationships between land use and tsetse control. Indicators were classified into significant and most significant. Among the significant indicators are: migration, overstocking, use of draught power and reduced pasture. Among those designated most significant are: settlement, tsetse infested area, increased cropped area, overgrazing etc. (Table 3).

1.2 Simple and sensitive techniques for impact monitoring were developed. These include the use of participatory research, rural rapid appraisal techniques, etc..

1.2.1 Actual monitoring of impact

1.2.2 Classification of communities in terms of land use (Table 4)

1.2.3 Community-drawn map. Using available implements such as stones, farmers drew maps on the ground showing key resources and later walked with researchers along transects selected by themselves. They observed and recorded changes in soil, water resources, vegetation cover and biodiversity. They discussed with researchers their explanations for the observed changes. Later, researchers copied the farmers' own map onto paper and asked them to comment on and/or add to the maps. Both farmers and researchers agreed that the exercise had provided valuable lessons (See Omolo *et. al.*, 1995).

1.2.4 Cartographic map. Three cartographic maps of topography were based on farmers' recall of changes between 1972 and 1992. Changes that had taken place included area under cultivation, crops grown, area under tree and vegetation cover, pasture availability and soil fertility.

1.2.5 GIS generated land use map of 1993. Based on land use and vegetation data interpreted from air photographs of the tsetse control zone and field surveys validation, an ARCINFO GIS of 1:25,000 was developed at the Natural Resources Institute.

1.2.6 **Baseline ecological study (BES).** The BES of Lambwe Valley was carried out in March-April 1995 by a consultant supported from a special grant by NRI. The study examined impacts on land use changes in relation to: (i) biodiversity, (ii) soil fertility, and (iii) water resources. Some of the major impacts identified include: vegetation clearance, soil degradation and functional regulation of ecological processes (e.g. reduced primary productivity) due to increased vegetation clearance, hill slope farming and reduction in habitat sizes (ecological fragmentation). A full report was submitted to NRI in June 1995.

1.2.7 **Longer term assessment of impacts on the environment.** A collaborative project between ICIPE, the International Livestock Research Institute (ILRI) and International Fund of Agricultural Development (IFAD) is continuing the assessment of the impact of tsetse control on the environment in Lambwe Valley. This project utilises the BES and other information such as land use maps generated under the ICIPE/NRI project to assess changes in ecological processes due to tsetse control.

4.2.5 Impact on Social Institutions.

KISABE is increasingly recognised as a viable channel for disseminating new technologies. Two examples may be cited. First, a private company is using KISABE as a catalyst to promote sunflower production to provide vegetable oil. Second, the Sisal Board of Kenya have given exotic cattle to six KISABE farmers in a bold move to promote the production of sisal. (Sisal waste is cattle feed).

4.2.6 Farmers' participation in impact assessment.

The fact that farmers are wholly responsible for financing and managing tsetse and trypanosomiasis entitles them to assess the results from their effort. To this end, arrangements were made to enable them assess six different kinds of impacts. First, a total of 78 farmers were trained and participated in the scientific monitoring of tsetse population, trypanosome infection rates of tsetse and cattle. Second, as stated earlier, a sentinel herd of 60 head of cattle was divided among 15 farmers who keep records of daily milk off-take, calving and deaths. Third, farmers took part in assessing environmental changes. Some of their observations of the changes that had taken place between 1972 and 1992 were drawn on cartographic maps. Fourth, as reported above, farmers drew a map showing major resources and discussed factors causing changes. Fifth, in a participatory workshop funded by the World Resources Institute (WRI), 36 farmers evaluated the contribution of collaboration and user participation to project results. (Ssennyonga, 1995). Sixth, farmers have participated in several external (e.g. mid-term review) and internal reviews of the project.

4.3 Monitoring and evaluation of overall project results

A. Research Activities

1. Monthly meetings of project researchers

2. Periodic project management meetings at the ICIPE

3. Quarterly and annual reports
4. Mid-term review
5. Periodic visits by NRI staff.
6. Final technical report

B. Outputs

1. **Monthly meetings of project researchers**

ICIPE project researchers have held monthly meetings at Mbita Point Field Station (MPFS) to review progress and coordinate their activities.

2. **ICIPE project management meetings.**

Project management meetings have been held as need arises.

3. **Quarterly and annual reports**

16 quarterly reports have been prepared and presented to the NRI.

Four annual reports have been submitted to NRI.

4. **Mid-term Report**

A mid-term report was submitted in February 1994 and was used as the basis for the mid-term review, February-March 1994. A mid-term review report was produced by NRI.

5. **Periodic Visits by NRI staff.**

Six visits have been made to ICIPE and the MPFS project site by three NRI staff.

6. **Final Technical Report**

ICIPE has submitted this final technical report in August 1996.

5.0 CONTRIBUTION OF PROJECT OUTPUTS

5.1 Technology Adoption

Viability of the model. The validation process described in this paper clearly shows that the model is both manageable and effective. This view is supported by the achievements on each of the components of the model as shown below.

Strategies. The first strategy is to give the community the role of key player responsible for managing traps using own resources. Evidence from this study shows that the community accepted the responsibility. But this was not a one-time irrevocable commitment; it was the result of a series of negotiations which went on throughout the entire life span of the project. Given the dependency syndrome embedded in the relationships between aid donor and recipient , it is extremely difficult to convince communities that it is in their best interest to finance and manage tsetse or other development enterprises on their own.

During the WRI sponsored workshop, farmers also observed that in the past there were negative incentives for non-participation in tsetse control. For instance, not only did the Government try to control tsetse on its own, it paid individuals to cut the vegetation. There were also a few members of the community who expected to be paid money for participation but on realising that this was not going to be the case, they became disinterested in the project. These issues had to be addressed by trained farmers and later, by block and KISABE leaders. It is therefore no mean measure of success that the Lambwe Valley community accepted and implemented Community-Managed Tsetse Trapping Technology (CMTTT) with good results. Success was partly due to the fact that, the community not only recognised tsetse as a big problem but also took the initiative to mobilise resources for a control programme. They also recognized the NGU trap as an efficient and readily manageable technology. Under these conditions, giving centre stage to the community was a logical response to its initiatives. These conditions are therefore essential for a community-managed control scheme.

Collaboration. The model postulates that collaboration is essential at three levels: disciplines, agency institutions and the community. Case study material has shown that interdisciplinary collaboration played a vital role. Biologists, social scientists, extension workers and farmers learned a great deal from each other. However, in the context of NRES, collaboration is bound to be thwarted by three major constraints. First, tsetse control is, in most countries, managed by the MALDM which does not have positions for social scientists to address economic and O&M issues. Second, collaboration with other ministries which have social scientists is very difficult unless this is built into an agency-funded project. This raises doubts on sustainability.

At the community level, collaboration has been, and still is, intensive. But, as discussed above, three constraints have been addressed, namely the issue of free-riders and the legacy of disincentives for self-help. The community's handling of these problems through education and persuasion is commendable. Indeed it is the good performance of the community that has attracted more collaborators.

A third constraint was highlighted during the WRI workshop. Farmers pointed out that their efforts had saved considerable sums of money. The collaborating ministries should have ploughed some of the savings in better medical and veterinary services. Apropos of this, it was realised that three other ministries should have been involved formally in the collaboration. These are: Ministry of Culture and Social Services which has the capacity for taking over the role of ICIPE social scientists, the Ministry of Natural Resources and Environment which has the capacity for assisting the community to manage the environment sustainably and the Ministry of Tourism and Wildlife which has a stake in the conservation of RNP. The challenge is to work out a collaborative framework that will enable these ministries work together in assisting the community. In this regard, the contributions of recent partners namely WRI, ILRI and IFAD have generated a new synergy in the collaboration.

Community mobilisation. As described above, the strategy was to train a CFG who in turn mobilised their community. Adoption was deliberately designed as science-based to enable the farmers maintain traps even if traps caught few or no tsetse flies. This strategy had both advantages and challenges. One of the biggest hurdles is the fact that many of the key scientific concepts such as vector, trypanosomes etc. are not found in the languages spoken in the community.

Farmer-to-farmer Extension. The CFGs have shown an amazing capacity for grasping so quickly and passing on to members of their communities a large body of scientific information and technical skills. Reliance on FFE was made even more justified by a discomforting finding that there are no frontline extension workers in Kenya. FEWs are trained to carry out the control themselves but not to impart any knowledge or skills to farmers. What is more, most of them have never been trained in tsetse biology, ecology or trypanosomiasis. This situation is not unique to Kenya. Kisabe leaders are in fact better trained to impart skills to others than FEWs. Under these conditions, the strategy of FFE has proved to be the most cost-effective and time saving strategy. It has also contributed to the development of a scientific culture in Lambwe Valley.

The project has also trained several categories of Kenyan Officers. The three officers attached to the project have, together with ICIPE researchers, monitored every aspect of the project and are therefore in a position to train other officers. In addition, Kenya Government NPOs and FEWs were given courses and training materials on the dissemination of TTT. Some of these officers are implementing CMTTT projects.

Large time budgets. Attendance of meetings involves long walks of up to 8 km one way waiting up to 3 hours for meetings to start which may also last up to 2 hours longer than was planned. These time budgets, are costly for members of the community, extension workers and the agency staff monitoring the adoption process and should be taken into account when designing CMTTT.

Forming the Organisation and Management. This is the single most critical task and entails making several decisions: whether (i) to work with existing organisations or form a new one; (ii) to pursue tsetse control as a single goal or combine it with other projects; (iii) to allow individually-managed traps; (iv) to operate through centralised or decentralised management. In the event, a new O&M was formed, TTT was pursued as a single goal, but three farmers maintain individually managed traps. Decentralisation was adopted because it places the burden of tsetse control on small local groups and preempts the need to create a bureaucracy which, in order to service traps in the entire control zone, would require transport and pay. Furthermore, if the bureaucracy is inefficient, the entire control scheme is put in jeopardy. Finally, the O&M created by the community raises interesting theoretical issues. Ssennyonga and Were, (1995) discuss the relevance of the O&M to Ruttan and Hayami's (1985) theory of technology-induced institutional innovation. Kisabe and the block are institutional innovations in response to technological demand in a situation of resource scarcity.

Management. The model puts a premium on management precisely because every activity must be planned, coordinated and controlled for quality; information must be passed on both from below and above, and members have to be motivated. The degree of efficiency in performing these tasks effectively determines the level of overall success. Unfortunately, O&M performance of these tasks is generally regarded as a matter of common sense. For example, during training, farmers are more interested in acquiring the "scientific" skills which, ironically, are easier to acquire than the O&M capacity.

Resource Mobilisation. The first task is to put in place an effective mechanism for continuous resource mobilisation to finance a public good. Three major challenges had to be met, namely, (i) an undeveloped capacity for fund raising, (ii) the dependency syndrome and (iii) adverse weather conditions in 1993 and 1994. All these constraints are likely to retard fund raising in most countries affected by tsetse. Training to strengthen the capacity for financial management is therefore necessary.

5.2 Impact Assessment

The model postulates that CMTTT will bring about favourable impacts on tsetse population, trypanosomiasis, livestock productivity, human welfare, and the environment Results and their relevance to other contexts are summarised below.

Validation. The present study evaluated the impact of community suppression trapping on the population of *G. pallidipes* and subsequent epidemiological implications. Tsetse was suppressed by 95-99.9% with significant reductions in trypanosome prevalence in both flies and cattle. These results demonstrated and confirmed earlier findings obtained under scientists' management at Nguruman, Kenya (Dransfield *et al.*, 1990) but contrast with the inconclusive results obtained in a trial in which the community participated in the deployment monitoring and maintenance of targets in Western Zambia (Dietvorst, 1994; Muneku F. M, 1994).

Trap deployment in areas with low tsetse population density. Suppression traps were deployed only in Nyaboro thicket (phase 1) and along the boundary with RNP (phase 2), reservoirs of *G. pallidipes*. Thickets with sparse infestation (0.006 flies trap/day catch) have not been treated. It now looks likely that control of the low density populations would needlessly strain the available resources with little guarantee of catching all the odd flies present. This assessment is based on the fact that following suppression of flies in Nyaboro area, there was simultaneous significant reduction in the incidence of cattle trypanosomiasis in both the trap-treated and untreated areas. Furthermore, Turner & Brightwell (1986) believed that flies found in isolated thickets outside Ruma National Park are "immigrants" and would probably be unable to maintain themselves provided there is effective control of tsetse in the main thicket habitat in the valley floor.

Trypanosome drug resistance. In the present study, no clear evidence of trypanosome drug-resistance indicated by repeat infections was observed following Berenil treatment. The fact that no trypanosome infections over several months after control were observed, suggests no drug-resistant trypanosome were circulating by the few tsetse remaining in the area. This is a rare situation in tsetse infested areas in Africa where usually trypanocide resistance frustrates effort to integrate chemotherapeutic intervention with tsetse control.

PCV% as indicator of a successful tsetse control. The PCV% of cattle is often used to gauge the improvement in cattle health after tsetse control, but it is not yet a proven reliable indicator of success or failure of the campaign. This is because anaemia in animals has various likely causes including inadequate husbandry, poor nutrition, infections with gastrointestinal parasites and haemoparasitic infections including anaplasmosis, babesiosis and trypanosomiasis. Nevertheless, significant direct correlations were obtained between the trypanosomiasis challenge and the proportions of low PCV% cattle exposed to high tsetse challenge though not with those in low challenge areas. This suggests that trypanosomiasis was not the major cause of anaemia in the latter locations.

A promising new alternative. Despite the suitability of the Lambwe fly belt for conventional control, all past control attempts, insecticidal or otherwise, have failed to eliminate tsetse from the area (Turner and Golder, 1986). The current tsetse control by targets (Opiyo *et al.*, 1990) has dragged along for several years. Of late the latter campaign has suffered from lack of funds and further operations are now doubtful. In this context, the present limited trial of community control of *G. pallidipes* has ushered in a promising alternative approach for the trypanosomiases management in the area.

Impact on Environment. Four different kinds of maps each portraying a different perspective, have been produced. Pioneering work was done on the identification and measurement of indicators of the impact of tsetse control on land-use and cropping systems.

The baseline environmental study provided valuable information on basic environmental processes such as biodiversity, ecological structure and soil fertility. The new ICIPE/ILRI/IFAD project will facilitate longer term environmental assessment.

Farmer Participation in Impact Assessment. The community has participated intensively in the scientific monitoring of the various impact parameters. The aim was to build a capacity for assessing and evaluating the various changes associated with tsetse control. The long term effectiveness of the training in impact assessment will also be monitored under the new project. Three issues have to be resolved, namely, the activities, level, and the intensity of participation. The objective is to achieve optimal involvement. The importance of tsetse relative to other problems facing the community as well as what the community is willing to do should be the yardstick.

New Research Issues

Apart from throwing light on issues investigated, research should also raise or lead to new research issues. So it is in this case. Seven specific research issues raised by this study are briefly outlined below.

Applicability of the CMTTT Model to Large Control Areas. The model has been implemented by an agricultural community in a relatively small area. Would the model be successfully applied in conditions of large and/or sparsely populated areas colonised by tsetse? It is currently in the initial stage of implementation in a semi-nomadic pastoralist Maasai community practising transhumance. Further research is therefore needed to throw light on this issue.

Alternative community strategy. Can different organisational and management systems be applied reflecting the circumstances and needs of particular communities? Can the level of input (labour and money) be reduced?

Collaboration between Communities and other Stakeholders. Many tsetse infested areas are often designated as game parks and/or tourist resorts. Some of the agencies supporting wildlife conservation seem to believe that tsetse flies are the custodians of wildlife and other natural resources in Africa and do not look forward to the day Africa will be rid of tsetse. Now that the NGU trap can be used to manage tsetse flies without harming wildlife or the environment, it is feasible for communities to collaborate with these agencies on projects combining wildlife conservation and tourism development with tsetse and trypanosomiasis control. Further research is needed to address this issue.

Time Frame for CMTTT. It can be concluded from the present project that a four-year cycle is inadequate for a CMTTT. What would the optimal life span be? To answer this question one should bear in mind the objectives of the project. If the community is solely responsible for financing and managing TTT and if assessment of the impact on livestock productivity is also an objective, then the life span can be estimated as follows: planning, recruitment and purchase of equipment, 8 months; baseline studies, 12 months; training and community mobilisation, 8 months; formation of O&M, 6 months, resource mobilisation, trap deployment and impact assessment, 36 months; assessment of sustainability and publication of results, 14 months; a total of 84 months or 7 years.

Terminal Trap Density. Currently, traps are placed at intervals of 200 metres in Nyaboro thicket, and 50 metres along RNP. Can this density be reduced without adversely affecting the trypanosomiasis situation? If so, to what density? Reduction in trap density would, no doubt lower the cost of CMTTT.

Terminal Tsetse Density. A reduction of 95-99 per cent has been achieved. Should tsetse density be reduced to even lower levels? If so, to which level and at what marginal net gain?

Acceptable level of trypanosomiasis. Should trypanosomiasis be reduced even lower? If so, to what level and at what marginal net gain?

Answers to some of these questions would greatly improve the efficiency and overall viability of the model of CMTTT. The on-going ICIPE/ILRI/IFAD project may provide answers to a few of these research questions. Finally, it is believed that, with minor modifications, the model can guide the dissemination and adoption of other technologies.

Scientific Papers

The reporting system comprising of quarterly and annual reports to NRI and various other reports to ICIPE has, no doubt, facilitated the development of a valuable data base on all aspects of research. However, the same system has retarded the synthesising of research findings for publication in international journals. This is therefore the immediate task of project researchers. Fortunately, several papers are currently under peer review in readiness for submission for publication. It should also be noted that the project has already featured in one film, two video documentaries and two reviews in publications. Apropos of this, a recent external reviewer of social science research at ICIPE has recommended that a video documentary of the project should be produced for a wider clientele. This recommendation is being considered.

APPENDIX 1

TABLES

Table 1. Pearson correlation between organisation goals enrollment and roles

Variable	Total number of members	Total number of roles	Total number of goals
Total number of goals	-0.40952	0.15904	1.00000
Total number of roles	-0.26063	1.00000	0.15904
Total number of members	-1.00000	-0.26063	-0.40952

Table 2 Detransformed mean trypanosome infection rates (+/- SE) of *G. pallidipes* before and after control by odour-baited traps in the Lambwe Valley

		% infection rate*		
Control status	*N*	*T. vivax*	*T. congolense*	Total
Before	16	18.1 + 2.4	6.1 + 1.7	19.9 + 2.8
After	18	10.4[a] + 2.4	4.1 + 0.8	11.8[b] + 2.1
% reduction	-	42.5	32.7	40.7

N = number of sampling months, each sample consisted of 8-450 flies;

* only one T. brucei infection was encountered; means followed by letters are significantly different from those in the same column at $P < 0.05$.

Table 3 Indicators according to the intensity of their impact

Human population

* Migration
** Settlement
* Farming

Tsetse

** Bush tsetse clearance
** Tsetse infested areas
** Fallow lands

Animal husbandry

* Overstocking
** Time when animals are brought back to the homestead
* Improved animal health and survival
* Use of draught power
* Use of other animals for ploughing
* Age at which animals start ploughing

Crop production

** Increased cropping land
* Cropping system
* Use of ox-plough
* Reduced yield per unit area

Vegetation cover

* Reduced woody perennials and trees
* Reduced pasture
** Overgrazing

Soil degradation

** Soil erosion
* Low soil fertility

Key to indicator categorisation:

* Significant ** Most significant

Table 4a Classification of communities in terms of land types and use

RESIDENTIAL ELEVATION	SETTLEMENT	FARMING SYSTEMS	VEGETATION	SOILS	LIVESTOCK
Top of hills (1800m above sea level)	Low-level settlement	Mixed farming	Forest-exotic and indigenous trees and grasses	Clay soils coloured brown and somehow reddish	Cattle Sheep Goats Donkeys
Slopes of the hills (1350m-1800m above sea level)	High-level settlement	Mixed farming	Bushes, grasses and weeds. The vegetation is moderately cleared and grazed	Gravel; stony clay soils and isolated sandy clay soils	Cattle Sheep Goats Donkeys
Bottom of the valley (1110m-1350m above sea level)	Medium-level settlement	Mixed farming	Thickets, bushes weeds and grasses Most vegetation has been cleared and overgrazed		Cattle Sheep Goats Donkeys

RESIDENTIAL ELEVATION	CROPS	GRAZING	FORESTRY	WATER RESOURCES	TSETSE CHALLENGE
Top of hills (1800m above sea level)	Vegetables -cabbages -tomatoes -carrots -kale -maize Sorghum and Irish potato-es	Fairly balanc-ed grazing. There is a balance betwe-en the number of animals and vegetation as well as water resources.	No Agro-forestry Trees are planted alone, both exotic and indigenous	Springs	Rare challenge
Slopes of the hills (1350m-1800m above sea level)	Cassava, sweet potato-es, groundnu-ts, finger millet and simsim	Moderately grazed	Some limited amount of trees planted on their own or with crops	Streams	Medium challenge
Bottom of the valley (1110m-1350m above sea level)	Sunflower, cotton, sorg-hum, beans, bananas and sugarcanes	Overgrazed Most vegetati-on is cleared, limited water-ing points and higher number of animals	There is a project of Agro-forestry in lowlands where crops are planted with fruits, trees and other multi-purpose trees (DANIDA)	Boreholes Dams Shallow wells and Floods	High challenge

FIGURES

Fig 1 MODEL OF COMMUN TY-MANAGED TSETSE AND TRYPANOSOMIASIS

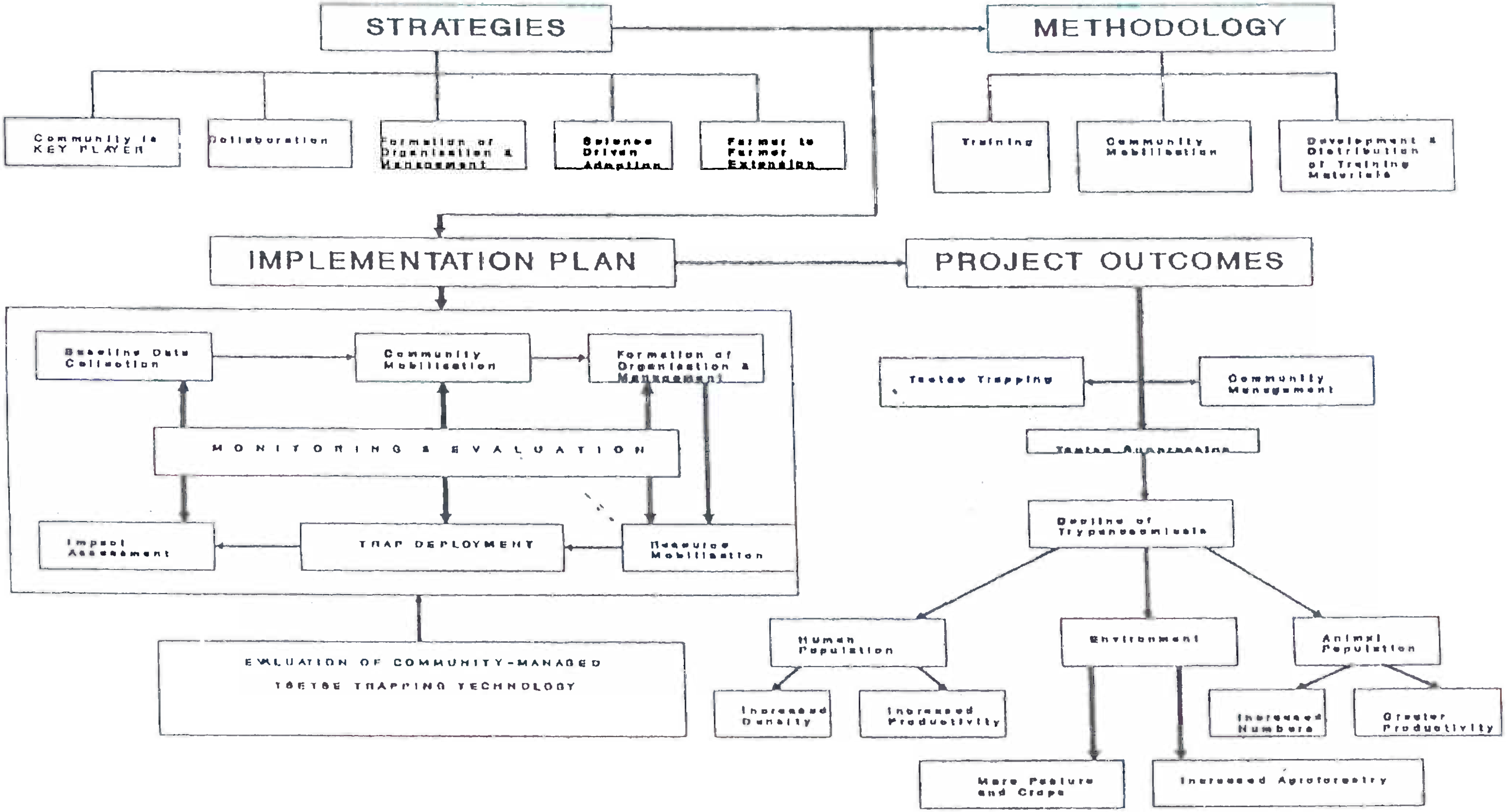
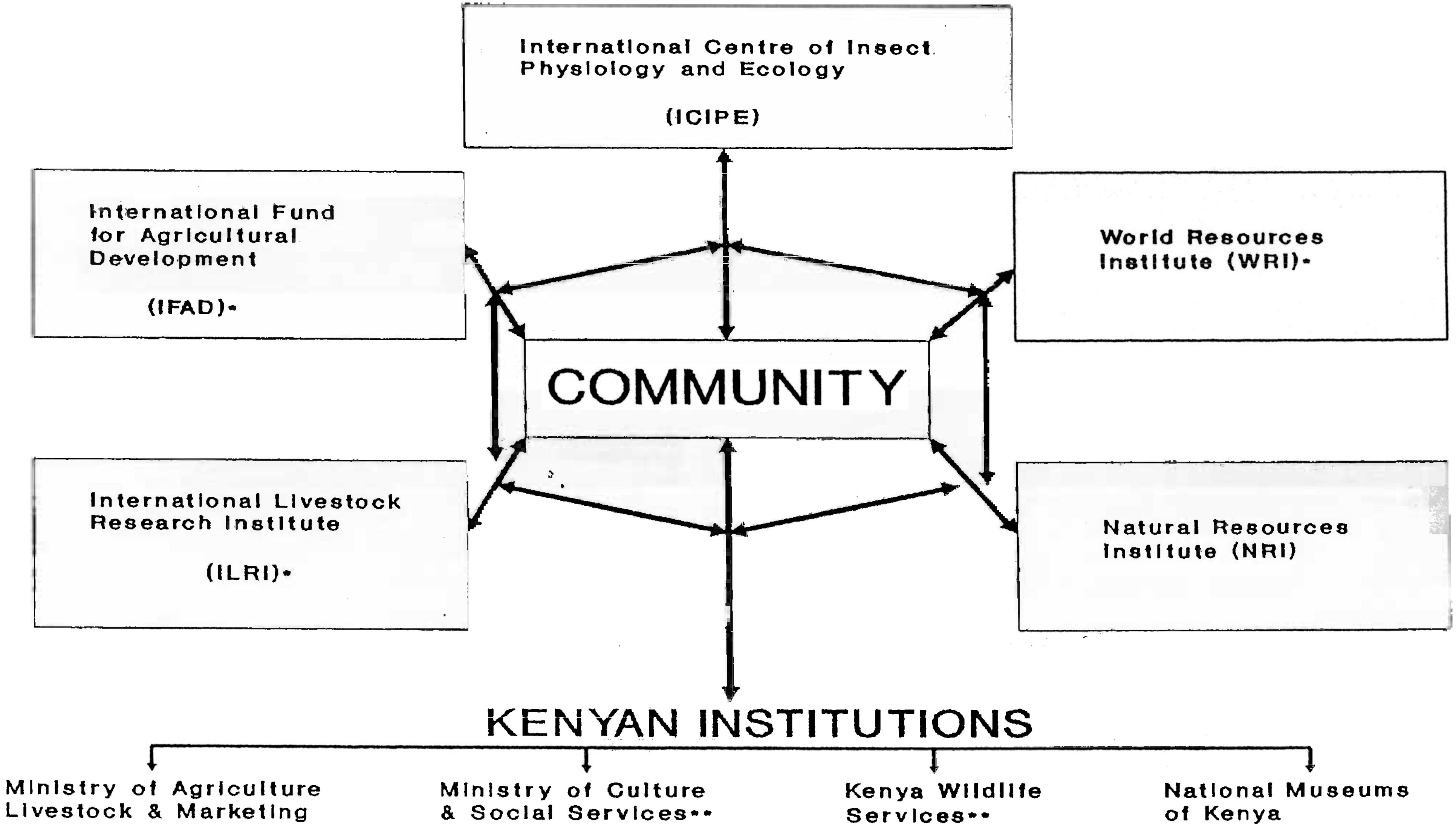


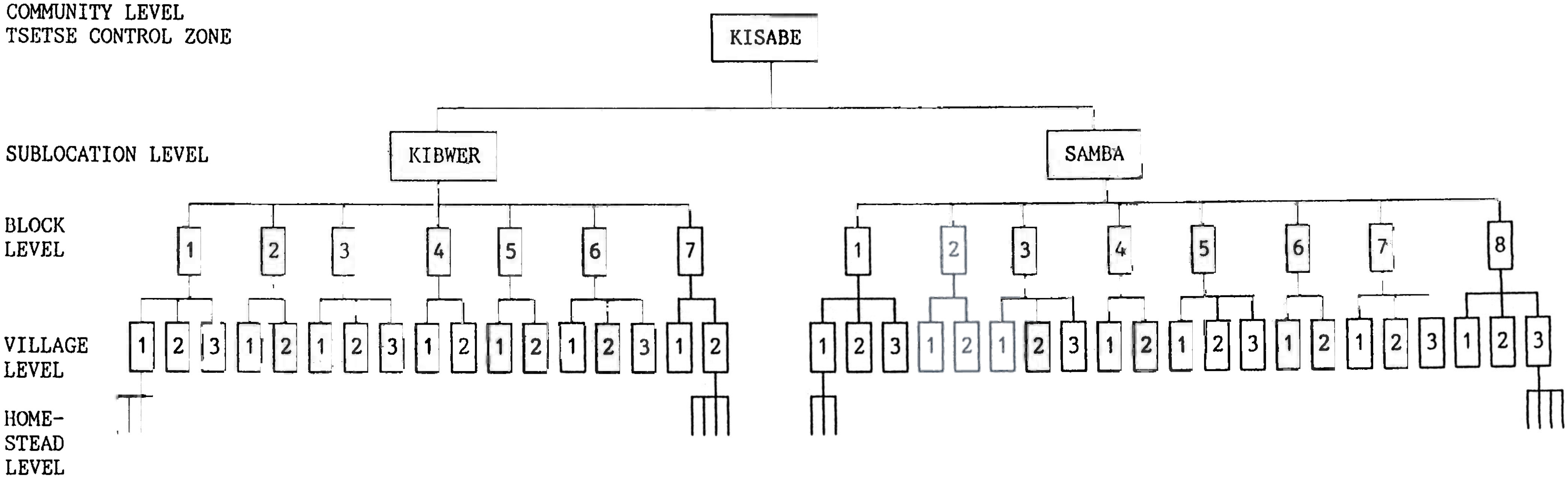
Fig. 2 CURRENTLY



Collaboration started in 1995

** Collaboration is on an informal basis

Fig 3 ORGANISATION STRUCTURE FOR CMTTT, LAMBWE VALLEY



BLOCKS IN KIBWER

1 SEKA
2 GENDO
3 UGORO
4 KIGOTO
5 NYAMADEDE
6 OLANDO
7 WIGA

BLOCKS IN SAMBA

1. NYABORO
2. SAJWERU
3. PUNDO
4. NYASOTI
5. SANGLA
6. OMA
7. MAGUNGA
8. LWALA

F g 4 MOBILISA ION AND MANAG M NT OF R SOURC S

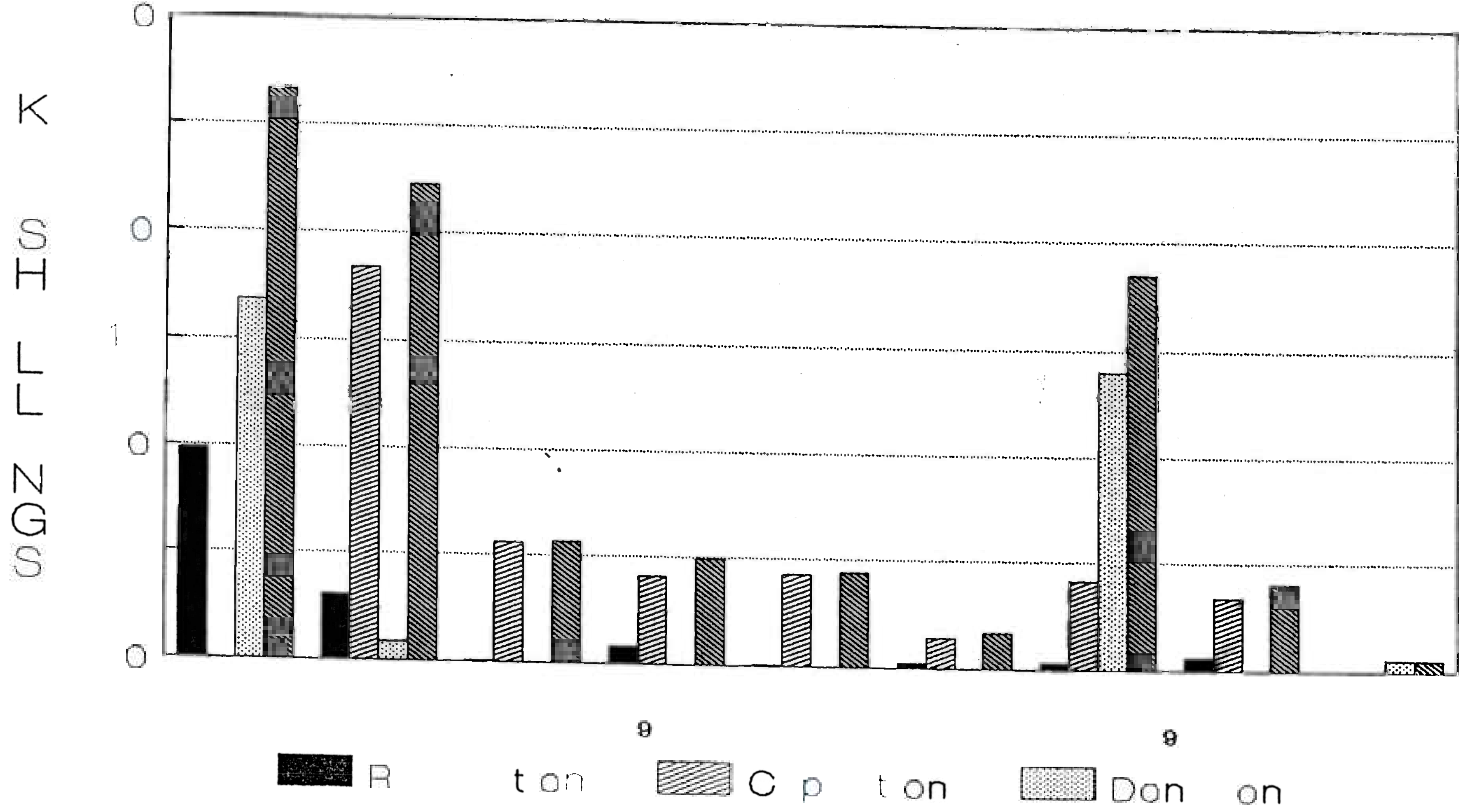


Fig. 5 PERSONDAYS SPENT ON TRAP DEPLOYMENT

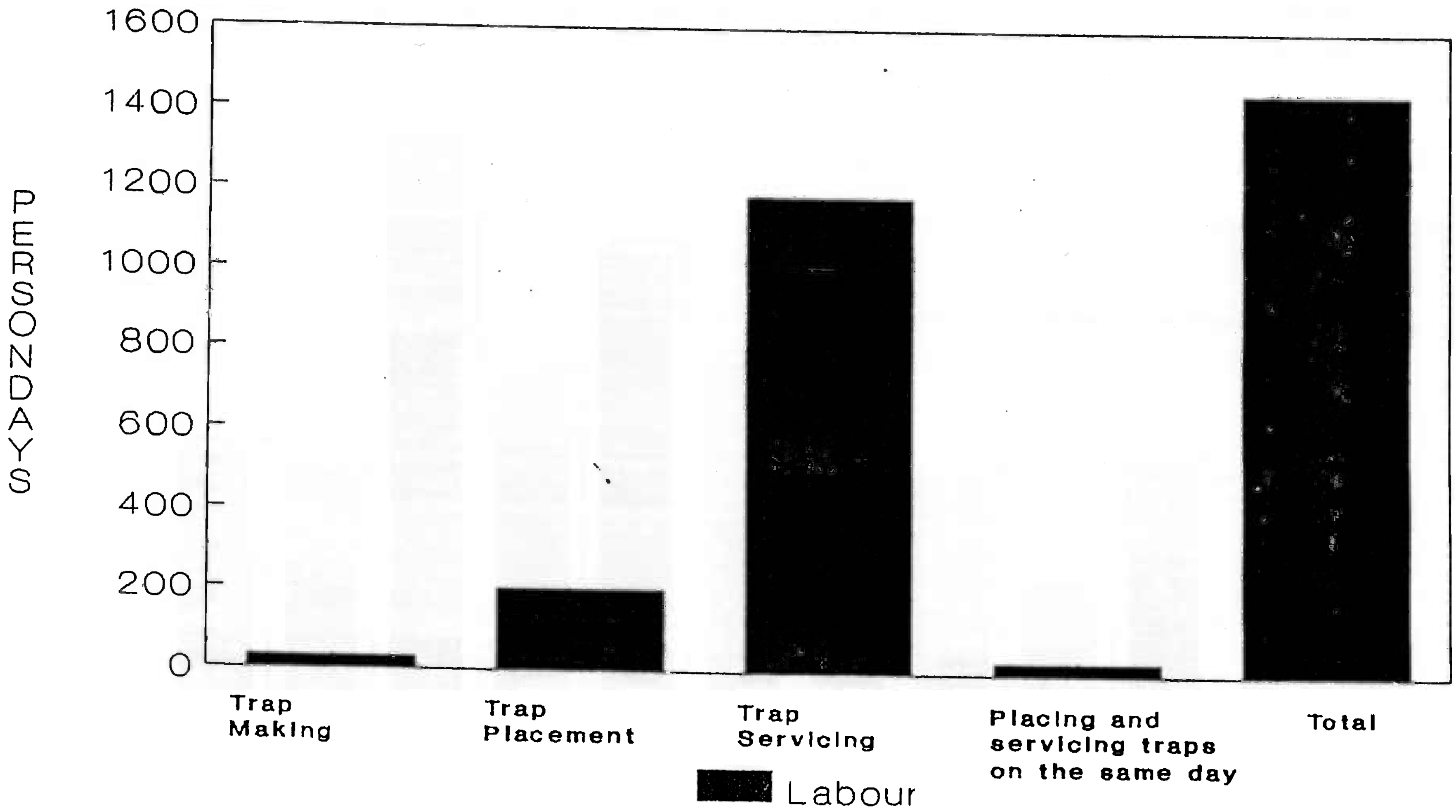
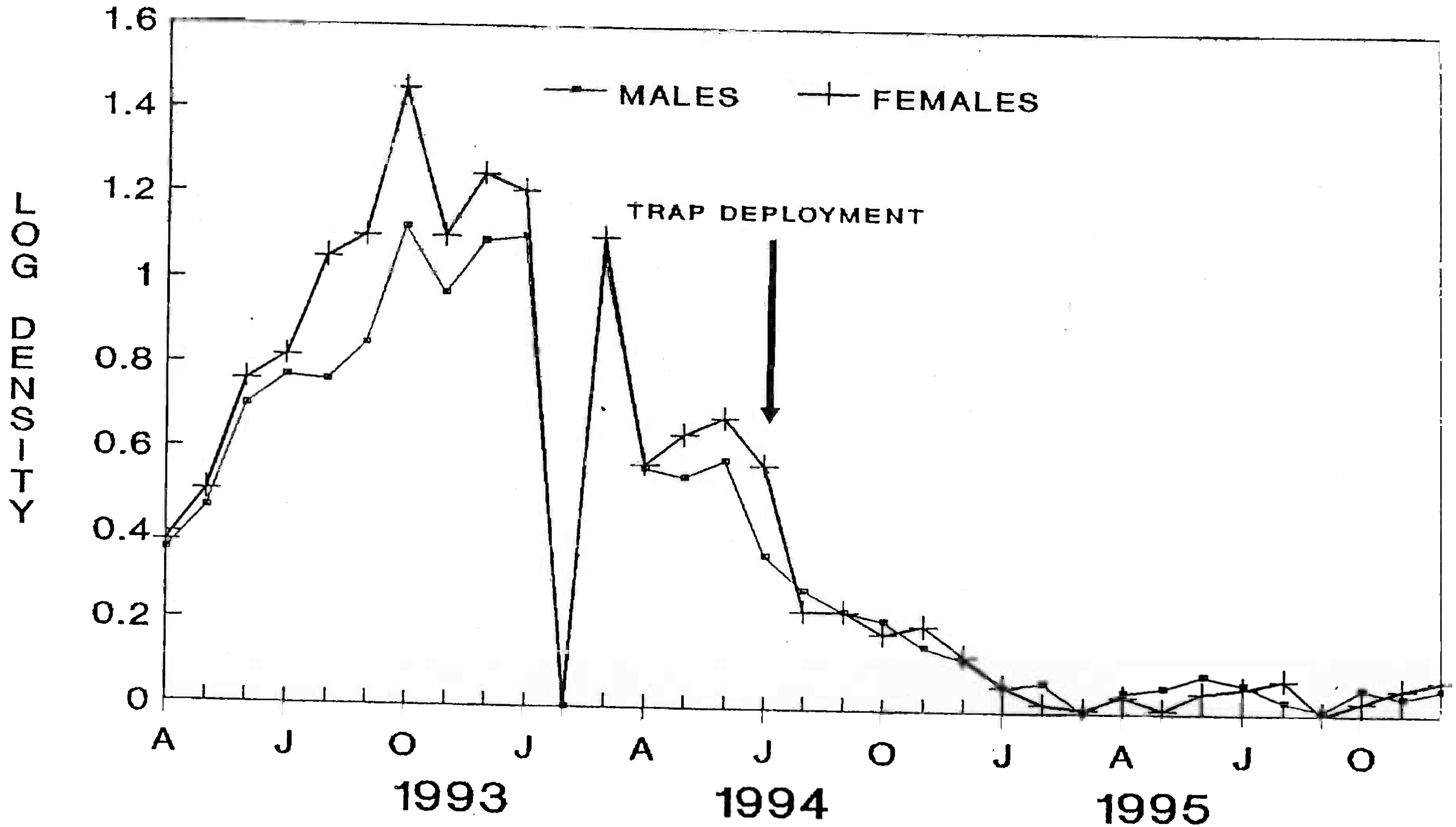
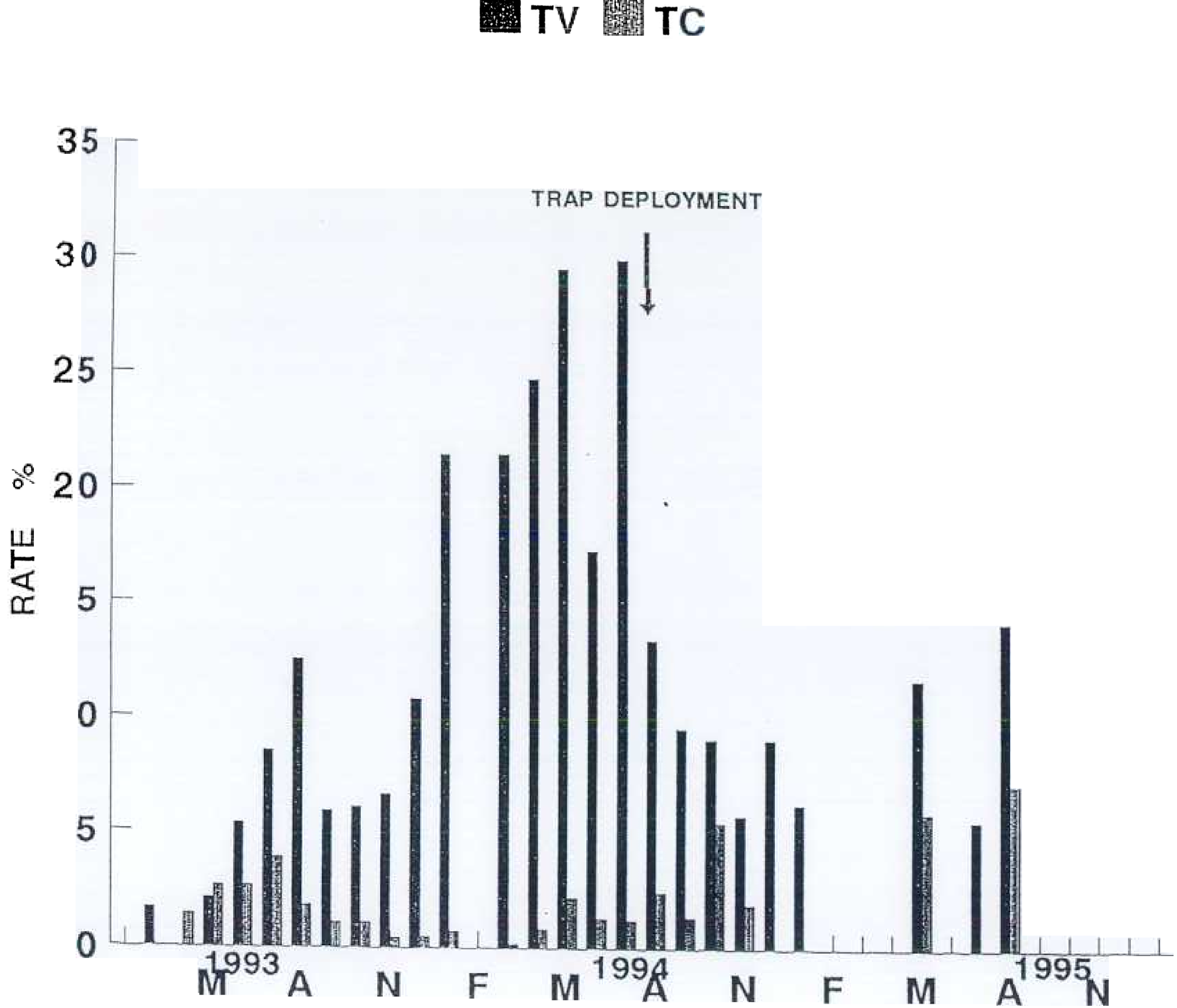


Fig. 7 DENSITY (CATCH/TRAP/DAY) OF G. PALLIDIPES BEFORE AND AFTER CONTROL TRAPS, LAMBWE VALLEY



g 8 TRYPANOSOM NFECT ON RATES % O *G. PALLIDIPES* BEFORE AND AFTER CONTROL LAMBWE VALLEY



F g TRYPANOSOM ASIS CHALL NG A D X INF CT ON RAT
FOR AND AFTER CONTROL OF G PALLIDIPES LAM W VALL Y

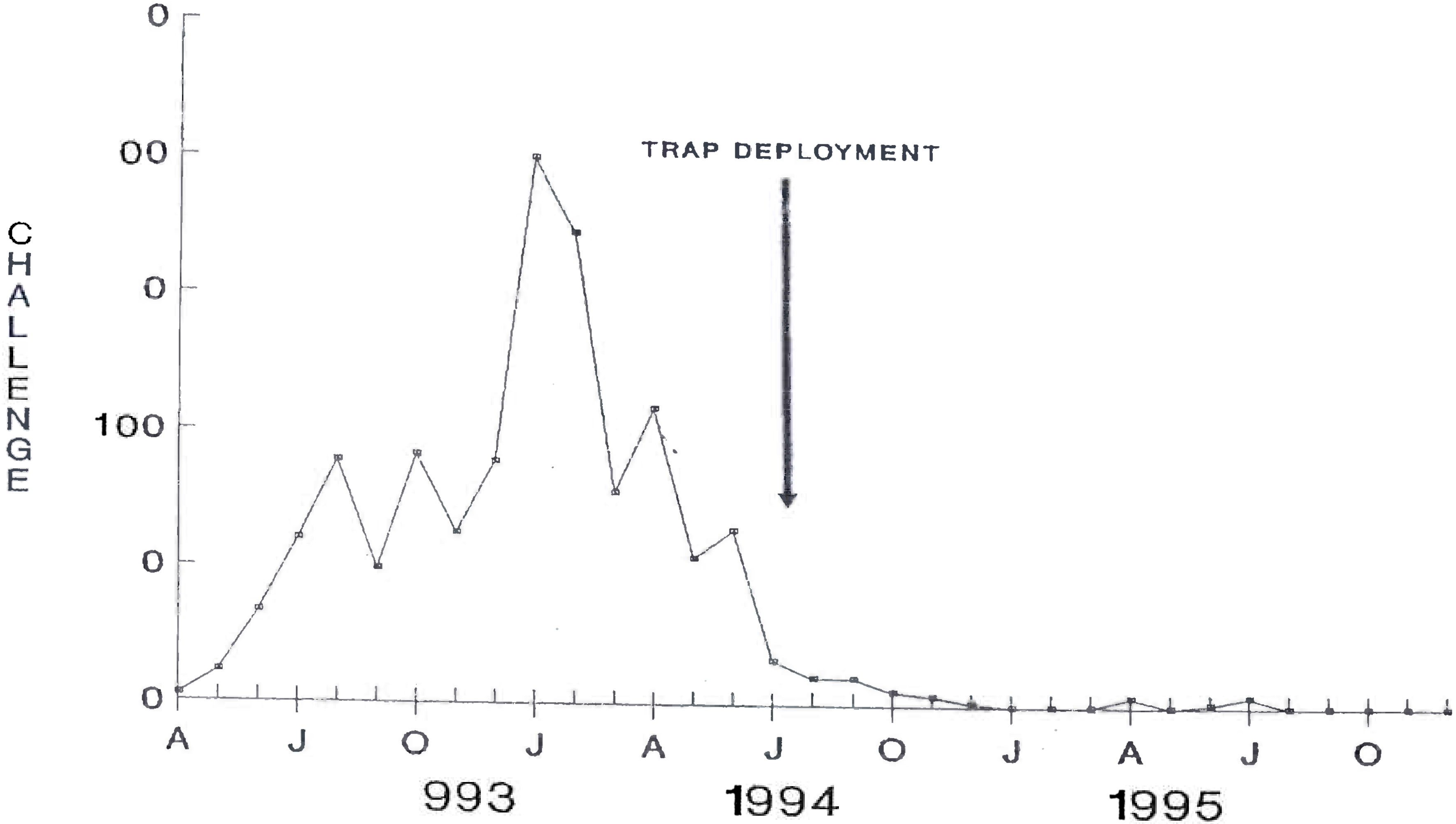


Fig. 10 TRYPANOSOME INFECTION RATES OF CATTLE BEFORE AND AFTER CONTROL (H. CHALL.)

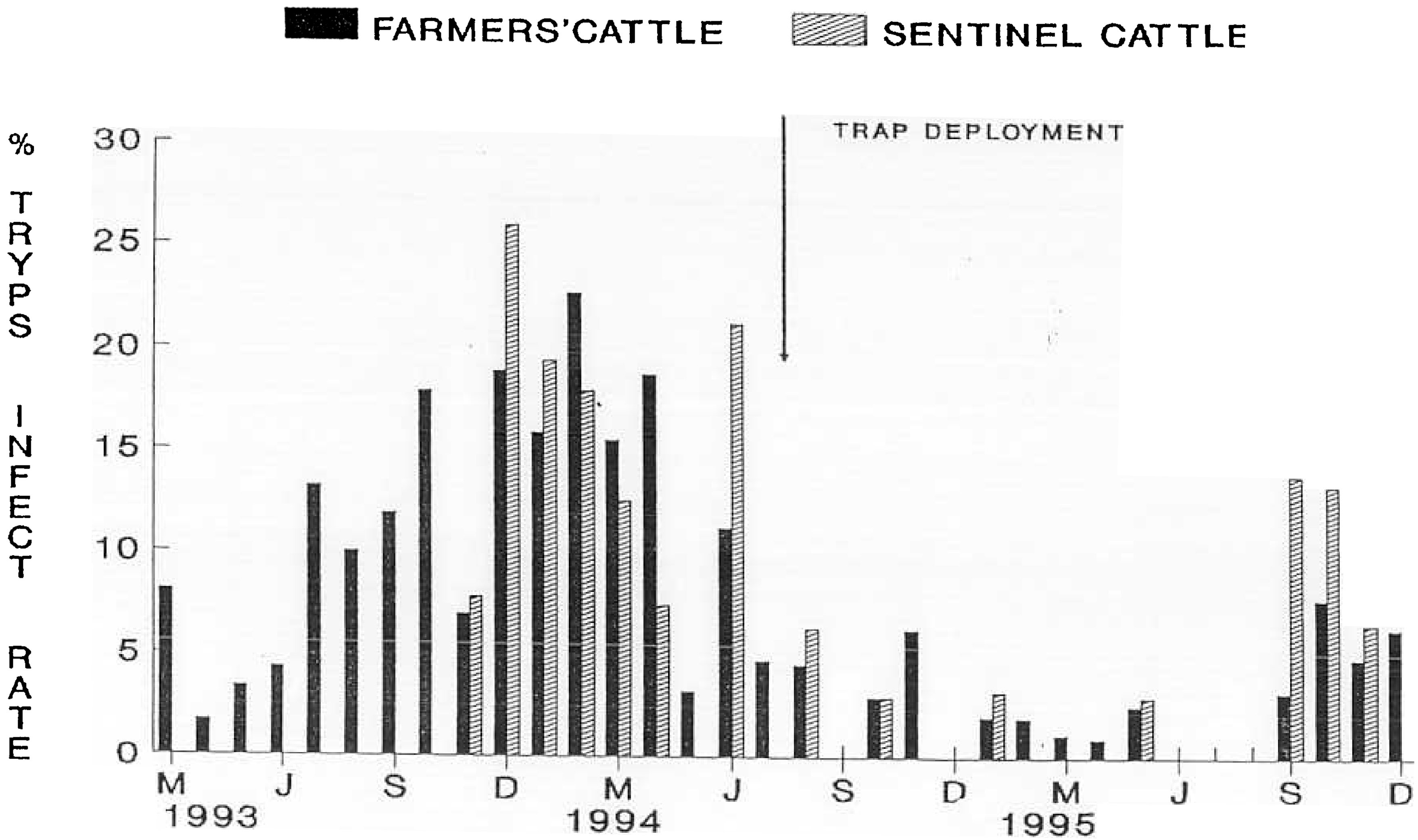


Fig. 11 TRYPANOSOME INFECTION RATES OF CATTLE BEFORE AND AFTER CONTROL (L. CHALL.)

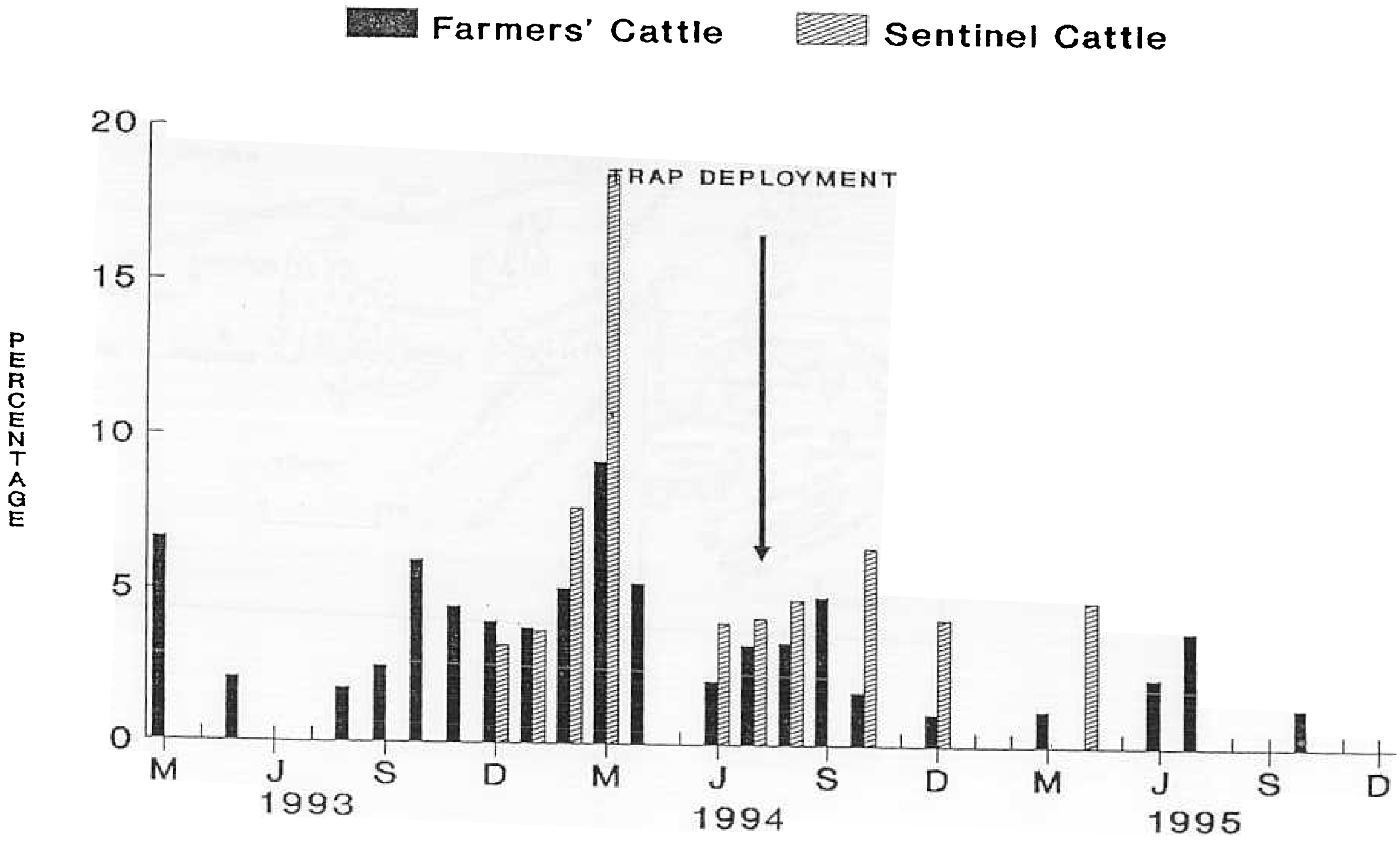
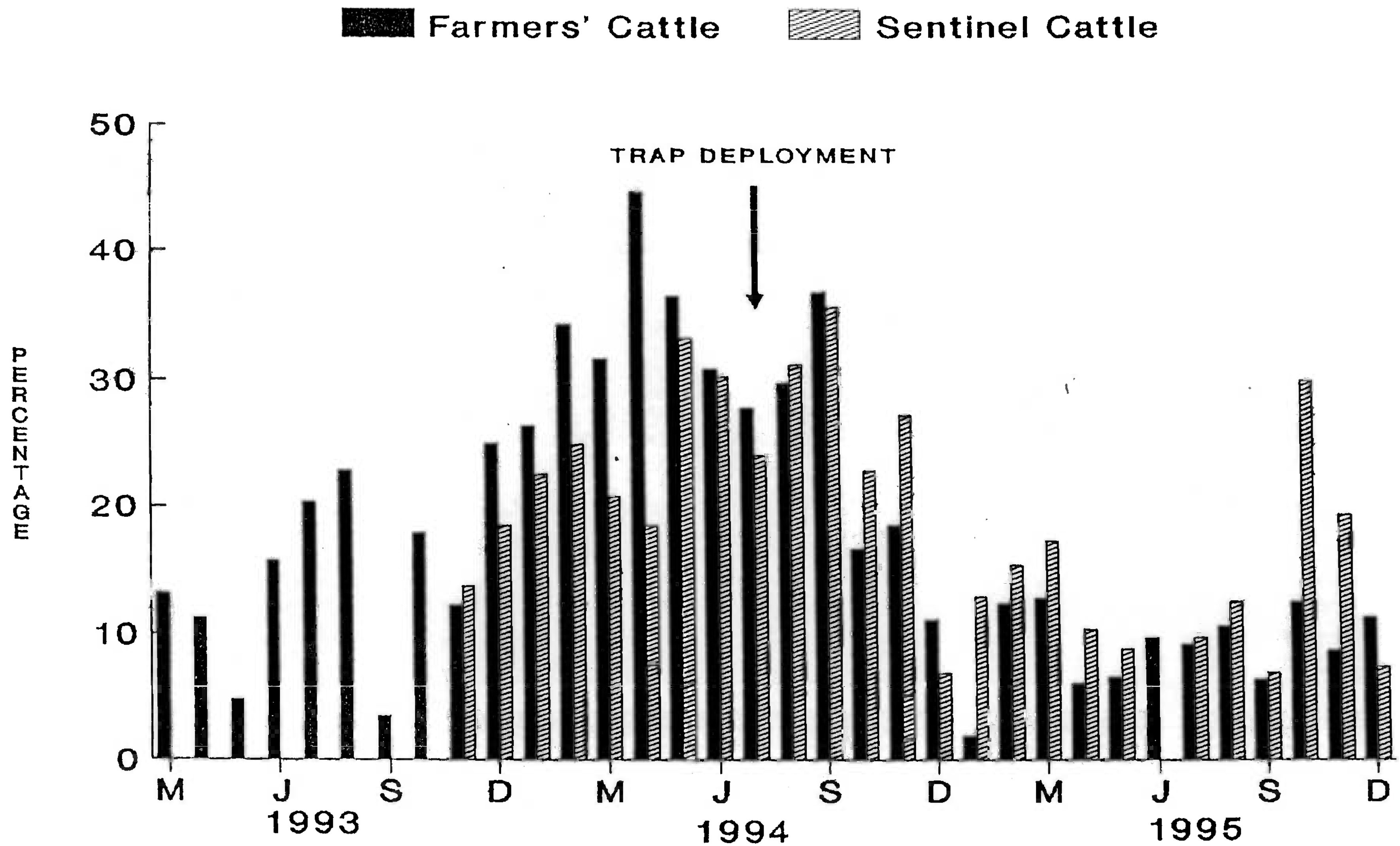


Fig. 13 PRE & POSt- CONTROL PROPORTIONS OF CATTLE WITH PCV BELOW 24%, LAMBWE VALLEY (H. CHALL.)



F 14 PROPORTIONS % OF CATTL W TH PCV B LOW 4% B FOR AND AFT R CONTROL L CHALL