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Some Aspects of Cattle Raising under Prophylactic Treatment against Trypanosomiasis on the Mkwaja Ranch, Tanzania

J. FORD
Hope Department of Entomology, University Museum, Oxford, and

E. BLASER
Mkwaja Ranch, Amboni Estates, P.O. Box 117, Tanga, Tanzania

Chemoprophylaxis against bovine trypanosomiasis has been in widespread use in tropical Africa for about 15 years and large quantities of drugs are dispensed every year. Few attempts, however, have been made to assess the results of intensive treatments in large populations of cattle. The stock population of Mkwaja Ranch has been the object of detailed record keeping since 1959. This paper does not attempt an analysis of these records, but draws attention to their existence. It also points to ecological lessons, not necessarily connected with trypanosomiasis, which might emerge from a full study of these data[1].

History of Mkwaja Ranch

The ranch, of some 120,000 acres, lies about 60 miles south of Tanga. Its eastern border runs north to south some 5 to 2 miles from the sea shore. The Msangazi River drains the northern half and the Mligaji River forms the southern boundary of the ranch. The western boundary follows the line of the Dar-es-Salaam to Korogwe railway.

Amboni Estates Limited acquired the Mkwaja Ranch in 1953 and, in the next year, began to stock it with female cattle bought in Ugogo and Mbulu, i.e., with East African zebus. Boran bulls were purchased in Kenya. No fresh bulls have been obtained since 1958 but artificial insemination has been used to introduce new Boran blood and, also, Charolais. In October 1970 the ranch was carrying 12,300 head of cattle.

The sandy, often shallow, soils of the ranch overlie coral rag. Rainfall (13 year mean) is 1,100 mm per annum. The vegetation (coastal

[1] We wish to thank Professor R. Geigy and Mr. C. E. Ammann for encouraging us to prepare this paper and for facilitating Mr. Ford's visit to Mkwaja.

forest-savanna mosaic) varies from open grassland to dense, high, thicket, with large areas of wooded grassland carrying a vigorous growth of doum palm (*Hyphaene* sp.) and/or a gall acacia (*Acacia zanzibarica* [S. Moore] Taub.). The wild fauna includes elephants and hippopotamus. Warthogs are abundant and, during August and September 1970, seven lions carried off 90 head of cattle. The ranch is infested with *Glossina pallidipes* Aust., *G. brevipalpis* Newst. and *G. austeni* Newst. The flora and fauna are thus typical of much of the East African coast.

Two factors influenced the decision to establish Mkwaja Ranch. The first was the need to use some of the profits accruing as a result of the very high price of sisal in the early fifties. (This price, of £240 per ton, contrasted with that fixed at the outbreak of war in September 1939, at £19. 10s. c.i.f. London.)[2] The second was the production of the drug Antrycide (quinapyramine *B. vet. C.*), which promised to enable cattle to be kept in tsetse-infested bush without previous entomological control. The primary intention of the ranch was to provide meat for the 3,000 or so employees of the Amboni Estates.

In 1954, five years after the appearance of Antrycide, current thinking on prophylaxis postulated that it should enable profit from cattle sales to accrue from the outset and that these profits could, in part, be used to offset the cost of eliminating *Glossina* (and, hence, trypanosomiasis) when convenient. There should be no need to embark on heavy expenditure for tsetse control before development could begin. To ensure that the programme looked forward to the eventual disappearance of the flies, the Tanganyika Territory Government imposed, as a condition for the lease of the land, an obligation to undertake a certain amount of bush clearing.

Studies on the use of organic insecticides, especially DDT, for tsetse control had begun in 1946. It seems that the original plan must have envisaged the obligatory clearing as a means of isolating the ranch from the surrounding bush. When this was achieved a variety of tsetse control techniques, including insecticide spraying, could be used to remove *Glossina*. The ranch is very roughly rectangular in shape and is divided into northern and southern halves, each of rather under 100 square miles. A barrier clearing of 1,000 yards width was made along the eastern, northern and western boundaries of the northern half and, for a short distance, along its southern side. The anti-tsetse work was supervised, for some years, by a field worker of long practical experience. Much of the programme was carried out, but without

[2] There is a useful brief history of the Tanzanian sisal industry in HILL & MOFFETT (1955) from which one learns that the Amboni Estates began their development with the importation of 1,000 bulbils of *Agave sisalana* from Mexico in 1906.

the anticipated good results. This is not to say that the ranch has failed, for cattle are being reared successfully and show considerable improvement on the parent stocks from which they are derived. But tsetse are still present, perhaps in greater numbers than at the beginning. The problem of trypanosomiasis remains unsolved. Why? Management of the ranch has been of a high standard since its foundation and from its very comprehensive records some of the real problems of stock raising in the East African coastal bush are beginning to emerge.

The Present Situation

From April 1969 to March 1970 the average stock population of the ranch was 13,070 head. The sales take-off for the year was 14.93 per cent and calf production 22 per cent. Average weight of Gogo cattle bought in 1954 was 220 kg. Present mean female weight is 285 kg. Steers, sold at 4 years, weigh 340 to 350 kg. In 1964/5 the average weight of 4-year-old steers was 380 kg. This peak weight was achieved during the phase of build-up of the ranch herd. In 1966 the peak population of 14,700 head was reached: but by this time weights were falling off and productivity was declining. The ranch had become 'overstocked'. The meaning of this over-worked word is far from clear.

Well before 1966 it had become obvious that regeneration on the clearings was presenting a problem more formidable than had been the original felling of the bush. Furthermore, certain areas which had been open grassland in 1954 were becoming invaded by doum palms and *Acacia zanzibarica,* which were also regenerating very thickly in the clearings. The only way to finance the additional commitments for bush control was to produce bigger profits and these, in turn, could only come from a larger breeding herd. But already by 1964 loss of productivity had begun to overtake population growth (see Figure 1, B and C). Evidently the original postulate that control of trypanosomiasis by prophylaxis would enable sufficient profit to be made to finance tsetse elimination and, more important, to maintain pasture, was wrong.

Much progress has been made in devising different bush control techniques suited to the various vegetation communities on the ranch. Both mechanical and manual methods for felling and uprooting woody vegetation are in use, combined with the application of arboricides appropriate to the species involved. What is not possible, of course, is the use of fire on a large scale. In any case the coast climate is not one where fire alone could be used to extend grassland at the expense of bush. Nevertheless, the consumption of grass by cattle instead of by fire must be a principal factor encouraging tree and shrub growth.

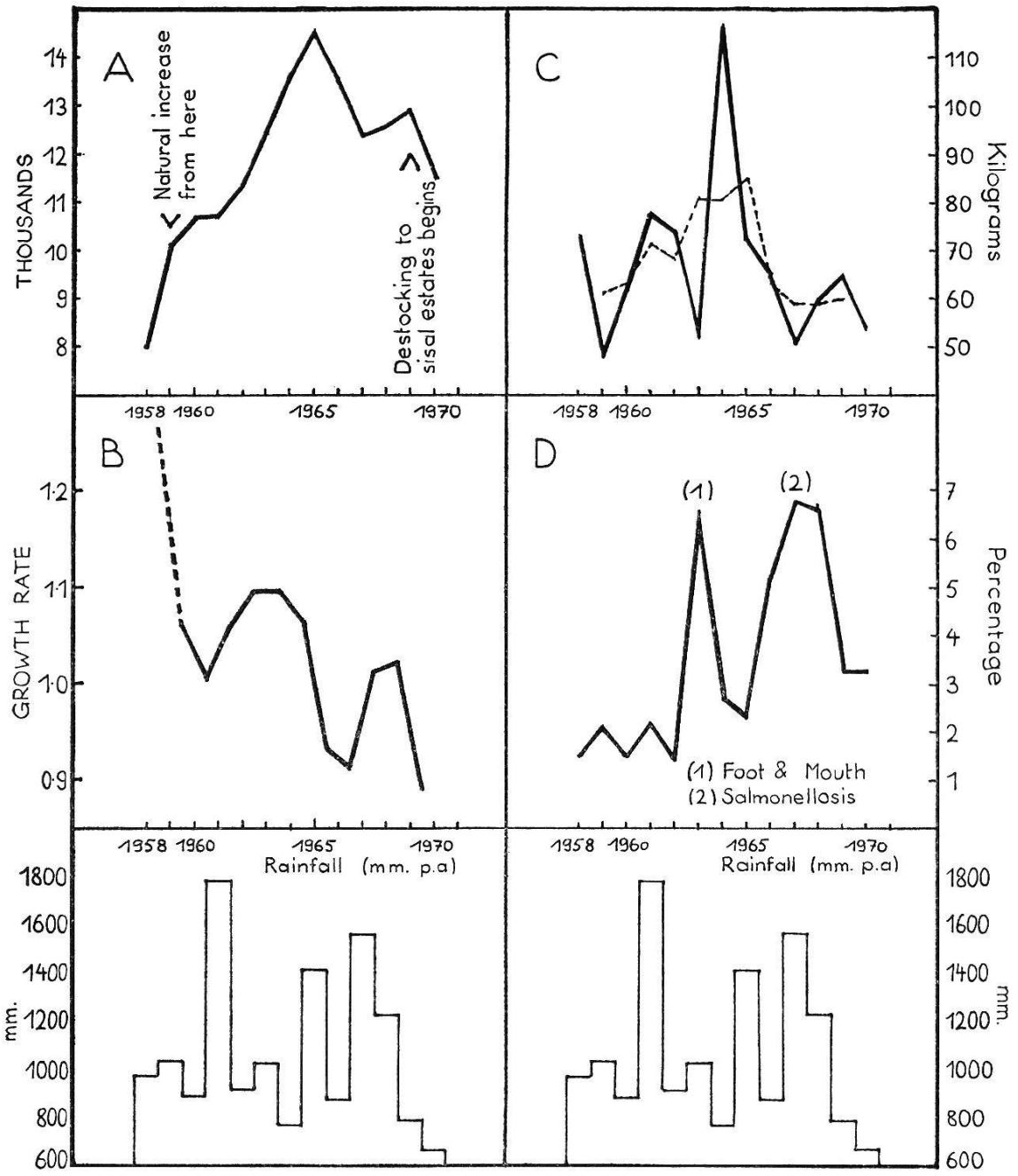

Fig. 1. Mkwaja Ranch Statistics. A. Cattle populations at the end of each April/March financial year. B. Cattle population increase rates =

$$\frac{\text{Population of year X}}{\text{Population of year X} - 1}$$

C. Mean annual weight increase of steers (kilograms per animal per year). D. Disease incidence per cent. With annual rainfall for comparison.

Ranch Procedures

All animals are numbered, tagged and weighed at birth. They are weaned at about eight months and again weighed. Before weaning calves are de-wormed and given an injection of Samorin (Isometamidium chloride) to relieve them temporarily of the trypanosome burden during this period of stress. All males, save those chosen for breeding, are castrated, fattened for three years and then sold. Females are classified as heifers until the first servicing. (At one time they were called heifers until the first calf was born.) Finally they become breeding cows.

Up to 1965 all females that did not conceive after service were culled, fattened and sold. At about that time, that is at about the time of maximum mean weight and just preceding the population maximum (Figure 1, A and C) failure of conception became more and more frequent. Since that time, therefore, cows have been culled after two service failures.

The herds number 200 to 300 each. Each herd is identified by name and entry of herd names on the record cards allows the whereabouts of any animal to be traced throughout its life. Every herd has its own night paddock so that there can be no mixing. The cattle are watered at noon at dams, of which there are 20 functional (out of 65 constructed). Dam building and maintenance in the sandy soil is not an easy task. Each herd contains 10 tests oxen which are weighed every month. This gives an adequate measure of mean weight change for the herd as a whole.

Diseases other than Trypanosomiasis

East Coast Fever (theileriosis) and anaplasmosis are enzootic and cattle are dipped and hand-dressed every week. Tick-borne disease is thus kept well under control. The last case of E.C.F. among animals reared on the ranch occurred in May 1959. Epizootics of salmonellosis have created difficult problems and were associated with frequent abortions. Aborting cows are at once culled and slaughtered. There is no evident correlation between abortion or conception failure and trypanosomiasis. There was an epizootic of foot and mouth disease in 1963 (Figure 1 D).

Trypanosomiasis

In each area of the ranch several herds, watering at the same dam, are grouped under one headman. Cattle are counted by the herdsmen

on entering and leaving their paddocks. Any beast seen to be out of condition is reported to the headman, who takes a blood slide. This is sent to the ranch headquarters where it is examined by the veterinarian, who prescribes appropriate treatment, which is usually administered the same evening. Positive diagnoses are entered on the animals' record cards. About 1 per cent of infections appear as *Trypanosoma brucei,* 5 per cent as *T. vivax* and the remainder as *T. congolense.*

Treatment regimes have changed during the lifetime of the ranch. From 1954 to May 1961 prophylactic injections of Antrycide Pro-salt were administered to all animals at two-monthly intervals. Because of fears of drug-fastness this treatment was replaced by monthly administration of Berenil (Diminazene aceturate *B. vet. C.*) until October 1964. Prophylaxis was then resumed, using three-monthly injections of Samorin, until April 1967. There was then another reversion to Berenil lasting until June 1968, when three-monthly Samorin was once again administered.

The sliding of apparently sick animals by the headmen has been mentioned. In addition, in each week of the third month of every prophylactic period, some 40-odd slides are taken from each herd, i.e., a 10 to 15 per cent sample. They are probably not taken at random because the herdsmen would tend to select the poorer looking animals. Records of these examinations are available for each herd over several years. For example, in April 1960 there were 171 *T. congolense* and 19 *T. vivax* positives out of 1256 slides examined. Ten years later, in August 1970, 670 slides yielded 173 *T. congolense,* 5 *T. vivax* and 5 *T. brucei* infections. The first result was obtained at the end of the initial period of Antrycide Pro-salt treatment. The second, recorded after a period of 3-monthly administration of Samorin, since June 1968, suggests roughly a doubling of the incidence of patent infection over the 8-year interval. These break-through infections at the end of a prophylactic period are always immediately treated with Berenil. Their significance, either as indicating an increased potential for morbidity or of a developing drug-fastness, is not clear. There has never been any notable mortality from trypanosomiasis and, although the animals when inspected on the occasion of the original drafting of this paper in September 1970 were not at their best, they were in far better condition than the average Tanzanian cattle at the end of the dry season.

The clinical manifestations of trypanosomiasis in the individual beast vary with its nutrition state. This was emphasized by HORNBY (1952) in his descriptions of *T. congolense* infections in oxen kept on different food rations. Similarly the problem of the persistence of enzootic trypanosomiasis under drug prophylaxis is inseparable from the problem of pasture maintenance.

The Pasture Problem

The Mkwaja area, when acquired by Amboni Estates, had existed as more or less untouched bush for many years previously. One supposes that its flora and fauna were in a state of unstable equilibrium in which fires played a part. The flora may be thought of as composed of trees and shrubs on the one hand and of grasses and herbs on the other. The fauna may be thought of as grazers, browsers (though some animals are both), seed and fruit eaters, predators and scavengers. These range from elephants to termites, from lions to bee-eaters, from warthogs to beetles. Into this ecosystem were introduced by purchase and natural increase, over a dozen years, a cattle population which, at its peak, reached 14,700 head. Including stock of all ages we may guess an average weight of 500 lbs. The live weight of cattle on the ranch, at the peak date, therefore reached about 7.5 million pounds or, approximately, a biomass of 40,000 lbs per square mile. PETRIDES & SWANK (1966) calculated that the Queen Elizabeth National Park in Uganda carried 5.379 elephants weighing 27,116 lbs per square mile. The biomass (living weight per unit area) of cattle on Mkwaja ranch was thus about 1.5 times greater than that of elephants in the National Park. Cattle eat grass and so prevent grass fires; elephants eat and destroy trees and so encourage grass growth and fires. The Murchison Park, also in Uganda, with an elephant population of similar density to that in the Queen Elizabeth Park, has been converted, in little over a quarter of a century, from woodland to treeless grassland (BUECHNER, BUSS, LONGHURST & BROOKS, 1963; FORD, 1966). Cattle, even under the difficult conditions of the tsetse-infested East African coast, are probably much better converters of vegetable matter into meat than are elephants (GOLLEY & BUECHNER, 1968) and, therefore, are likely, weight for weight, to have a less disruptive effect on the ecosystem. Nevertheless, it is evident that their introduction must have had a massive impact upon the Mkwaja vegetation, principally by preventing grass fires, the main agent in the control of woody plants.

Other changes may also be important. Small vertebrates and insects living upon seeds and tree and shrub seedlings may, perhaps, have been reduced in number, while the consumption by the cattle of the greater part of the vegetative and fruiting portions of grass plants must have reduced the power of the latter to compete with woody plants. The proliferation of trees and shrubs which would be consequent upon these changes would, in turn, favour the multiplication of thicket-loving animals such as bushpig and bushbuck and, hence, of the tsetse-flies that feed upon them. All three species of *Glossina* at Mkwaja are, essentially, thicket or forest flies.

These effects are reflected in the cattle situation in two ways; avail-

able pasture is reduced and the parasite burden is increased. Reduction of pasture leads to weight loss and population decline. The increase in parasites leads to increased drug costs, though this may be offset by the build-up of immunities and the gradual adjustment of the cattle to chronic infection. However, these latter benefits may be achieved at the expense of productivity and growth.

It is usual to sum-up such effects as due to 'over-stocking'. This is a meaningless over-simplification. In 1965/66 with a population of 14,700 head it seemed that Mkwaja was 'over-stocked'. But, at the outset in 1954, some areas were already naturally covered with dense thicket, preventing their profitable use and acting as foci of infection. If the means could be found to prevent the proliferation of woody plants and, ultimately, to remove all except those required for shade, timber, windbreaks, etc., then the ranch could almost certainly support 18,000 to 20,000 head of cattle. If it is now over-stocked, it is over-stocked with trees, shrubs and wildlife and not with cattle.

Discussion

The successes of Mkwaja so far have been due to good management which has enabled one problem after another to be dealt with, usually with good results, on a purely empirical basis. Its difficulties have arisen from the incorrect suppositions of successive generations of applied scientists of one kind and another that the problem of disease can be treated in isolation from the ecological situation as a whole.

For the first ten years of the ranch's development it must have seemed that all was going well. The stock population was growing, tick-borne infections were under control, mean weight was going up and trypanosomiasis was not hindering progress. Too often, in tsetse and trypanosomiasis control work, success has been too quickly proclaimed. The falling-off of the population increase rate and of steer growth rate (Figure 1 B and C) in the middle sixties showed that the profits of disease control were accruing too slowly to enable the adverse effects of bush encroachment on pasture to be overcome. It is still not possible to say whether management will succeed in controlling vegetation and disease at the same time or whether, in the end, these obstacles to cattle raising will prove too expensive for the ranch to continue.

One may think of the ranch as capable of receiving and converting to living matter a certain quantity of solar energy. The problem then appears as one of directing this flow of energy away from trees, shrubs and wild animals and into grass, cattle and, ultimately, the slaughter-house. In the exploitation for stock-raising of the African savanna, whether or not it is tsetse-infested, capitalisation (apart from the cost of

land and stock purchase, water, roads, fences, buildings, etc.) should be directed principally towards pasture maintenance and improvement. The costs of disease control will then form only a small portion of total expenditure and should continue to decrease. It is clear at Mkwaja, as elsewhere, that even had there been no tsetses on the estate at the beginning, the introduction of cattle, without sufficient compensating effort to maintain and extend the grass crop, would have led, ultimately, to the disappearance of all pasture and its replacement by thickets.

Enterprises like Mkwaja may also be thought of as large-scale field experiments. They may not always yield the sort of results expected by their promotors, but provided adequate records are kept it should be possible to interpret what has happened. At Mkwaja the records are probably unique in East Africa. An elaborate card indexing system was inaugurated in May 1959 and there now exist individual histories of some 31,500 animals born on the ranch since that date. The value of these records in planning the future of the ranch should not be overlooked.

About 6 years ago Imperial Chemical Industries considered making a computer analysis of the Mkwaja records with the object of finding out whether, under the drug regime then in use, cattle had built up immunities and transmitted them to their offspring. They decided against the project on the grounds that the prophylactic properties of the drugs would mask any such trends. This decision, we think, involved assumptions about the action of the drugs and also about the nature of immunisation against trypanosomiasis which cannot be fully sustained. In any case, under natural conditions, the survival of cattle in tsetse-infested bush is not necessarily solely a matter of antibody formation and transmission.

The object of computer analysis, in the first place, should be to sort out and measure the parameters relevant to an enquiry about what has happened on the ranch. It might well include a study of the incidence of parasitaemias in relation to genealogy through the dams. (It would not be possible for the male lines.) Changes in proportion of *congolense, vivax* and *brucei* patencies might well be related to mean host age, to herd and pasture area, as well as to events in ranch history such as bush clearing, change in drug regime, use of insecticide and incidence of other infections. The requirements of programming should be determined by a veterinary parasitologist working together with the ranch manager.

Parallel to this study there should be an ecological survey of the vegetation and wildlife of the ranch. Much might be learned by study of aerial photographs. It would be of value to assess the rates of change of area occupied by different plant communities and hence of changes in pasture availability and of tsetse habitat. On this side of the survey a

tsetse biologist should work together with an agronomist and a wildlife ecologist. Ecological assessment should be undertaken in terms of production ecology or energetics. Its first and chief aim would be to estimate (a) the weight of grass crop needed to support the stock population necessary to meet the needs of the Amboni economy and (b) to recommend a development programme to achieve this target. Out of these broader studies others, more specialised, might be developed with advantage. The third and final study would relate the ecological assessments to commercial history and to possible futures for the ranch.

A solution to the problems of Mkwaja may lie in the present low price of sisal and in the policy of the Tanzanian Government of taking back from foreign companies land not in immediate productive use. When acreage under sisal is reduced the land thus freed must be put to other uses or be lost. The Amboni sisal plantations lie on soils which are more productive than are those of Mkwaja and prolonged cultivation has much reduced the rate of bush regeneration. When unwanted sisal plants are removed they are replaced by a very rich growth of grass. Freshly weaned animals from Mkwaja, transferred to these lands, have shown remarkable rates of growth. This may be one beneficial change in practice. It suggests another on the ranch itself. The principal tsetse habitats and infection foci are, undoubtedly, the areas of extensive continuous thicket, such as is seen along parts of the Msangazi valley. It is likely that these are relatively fertile areas. Their felling, followed by cultivation, probably with fodder crops, would have the double advantage of eliminating the habitat of the principal hosts of *Glossina* and of providing a food reserve for cattle in the lean seasons of the year. One need not necessarily think of the elimination of all wildlife, but any large mammals retained should be managed as part of the ranch production and looked upon as a potentially valuable supplement to the cattle crop.

It would be of the greatest interest to select a herd of about 100 animals, perhaps basing choice upon analysis of ranch records, and let them and their offspring continue without further drug protection. That such an experiment would be fraught with risk is certain and stringent precautions would have to be taken; but there is at least the possibility that mortality and morbidity would be far less than one might anticipate. The closest parallels with Mkwaja are found in Rhodesia. There, in part of the Sabi River valley, a cattle population under continuous risk of infection grew, under cover of a varying prophylactic regime, from some 10,000 to 20,000 head in about 10 years. At that point refusal of owners to allow further treatment was followed, not by a heavy mortality as predicted by the government veterinarians, but by continued increase and the appearance of self-curing infections both of *T. congolense* and *T. vivax*. On the other hand, in another area, Inyanga

North, involving comparable numbers of cattle, cessation of treatment after only 4 years was followed by very many deaths (FORD, 1971). The present scientific assessment of such situations is highly equivocal (see, for example, the chapters by WILLIAMSON, J. & MACLENNAN, K. J. R. in Mulligan, 1970). This is partly because of the difficulties inherent in field experimentation. At Mkwaja there are, perhaps, in addition, to the research possibilities outlined above, valuable opportunities for immunological, pharmacological and pathological investigations which might lead to a considerable break-through in the problem of how to apply control techniques to cattle trypanosomiasis under natural conditions.

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