section b – abstracts

1.  general (including land use)


The African Trypanotolerant Livestock Network coordinates extensive collaboration between ILCA, ILRAD, national and regional centres in several sub-Saharan African countries, and institutions elsewhere. Research has been carried out on the epidemiology of trypanosome resistance to trypanocidal drugs and on factors affecting estimates of tsetse challenge and trypanosomiasis risk and susceptibility to trypanosomiasis in N'Dama cattle and sheep. The effects of trypanosomiasis on animal health and performance, and criteria of trypanotolerance and their link with performance have also been investigated. Special studies have been made of the effect of trypanosomiasis on the resumption of post-partum ovarian function in East African Zebu cattle, and of the differential susceptibility to trypanosomiasis of Orma and improved Kenya Boran cattle. The genetics of trypanotolerance have been studied in N'Dama and Zebu cattle and Djallonke sheep and a practical genetic improvement programme has been developed for N'Dama cattle. Other studies include the socio-economic evaluation and environmental impact assessment of alternative trypanosomiasis control measures, including opportunities for local participation in tsetse control. This report provides an overview of the work carried out in 1993 and a list of publications is appended.


Case studies, mainly in Zimbabwe but also in Zambia, investigated economic aspects of controlling savanna species of the tsetse fly, which is the vector of bovine trypanosomiasis in southern Africa. Costs for the four major techniques for tsetse control, each of which has been used on a large scale in the recent past, were analysed on a comparative basis. The costs of using odour-baited insecticide-treated targets compared well with traditional ground spraying using DDT, which is increasingly disfavoured on environmental
grounds. The cheapest method of tsetse control is to treat cattle with appropriate insecticides. There are many situations where this is not feasible, for lack of cattle, but the approach is generally very promising and needs urgent technical development. Although aerial spraying is likely to be the preferred method for tsetse control in some specific situations, it is the most expensive of the four techniques which were evaluated. A case study showed that the policy of the Government of Zimbabwe was justified in relying upon tsetse control rather than the use of trypanocides. However, the comparative advantage is variable according to specific circumstances. A methodology for cost comparison has been developed and demonstrated, based upon simple economic models usable by planners without formal economics training. The second area of investigation concerned the alleged inappropriateness of tsetse control in the Zambezi Valley. A multidisciplinary case study sought and examined evidence of environmental degradation associated with sustained smallholder mixed farming in areas cleared of tsetse. A rapid appraisal methodology was developed for the study, which led to the conclusion that, in the area of the case study, it is inappropriate to argue against tsetse control on the grounds that the ecology of the area is inherently unsuited to agriculture. However, evidence is presented to argue that land use issues must be addressed in close coordination with tsetse control programmes, in order to promote sustainable land use. There is a key role for the economics profession in assisting to ensure that coordination is effective and appropriate.


Tsetse and trypanosomiasis control is now considered to be technically feasible following the introduction of relatively simple and environmentally acceptable attractant techniques for vector control. The collection and analysis of data, the significance of tsetse to area development, the influence of tsetse control on resource utilisation, and technical issues such as programme coordination, sustainability of
control and training are considered. It is stressed that trypanosomiasis control is a single element within the overall objective of sustainable agricultural production: expertise should be exploited at multidisciplinary level and a comprehensive database should be established. The role of expanding human populations in fragmenting tsetse infestations must be taken into account when planning control interventions. It is recommended that livestock owners should be made aware of the availability of modern vector control techniques and governments should be made aware of the problems associated with chemotherapy. FAO should assume global responsibility for the overall coordination of control programmes, with the creation of specialist working groups to update progress. Viable, cost-effective, socially acceptable and sustainable control systems must be developed, with long-term environmental monitoring.


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Cost-benefit analyses were carried out and projected for a 10 year period using a herd model. In Ethiopia and Kenya, trypanosusceptible East African Zebu are produced using trypanocidal drugs but profitability is not sustainable due to high risks of drug resistance. At Ghibe in Ethiopia, vector control was considered to be more profitable than drug use. Traditional use of trypanotolerant cattle was studied at Keneba and Gunjur in The Gambia and Boundiali in Côte d'Ivoire, where socio-economic considerations were found to be important constraints on profitability. Imported trypanotolerant cattle were studied in Togo and Zaire: profits were much higher in Zaire due to differences in the métayage (lease) system, local production alternatives and labour availability. Control methods were divided into those requiring heavy initial capital investment (aerial and ground spraying, SIT, importation of trypanotolerant livestock) and those with recurrent expenditure (traps and screens, deltamethrin treatment of cattle, drugs and locally available trypanotolerant stock), which are less risky.
and more flexible. Because of trypanosome resistance, drugs should be used more for strategic purposes and in integrated control. Trypanotolerant cattle are suited to situations with low to medium trypanosomiasis prevalence but their introduction may not be economical. Tsetse control is appropriate in situations with higher disease risk but requires long-term commitment; traps and screens are considered to be the most profitable method.


Kilonzo: Rodent Research Project, Sokoine University of Agriculture, P.O. Box 3110, Morogoro, Tanzania. The epidemiology and control strategies of African trypanosomiasis and other zoonotic diseases in Tanzania have been described. Initial outbreaks of trypanosomiasis in Tanzania were caused by Trypanosoma brucei gambiense which originated from West Africa and reached Tanzania via Zaire around 1902. T. b. rhodesiense, which is currently responsible for human trypanosomiasis in Tanzania, was introduced from Mozambique around 1910 and quickly spread to many parts of the country. The disease is currently prevalent in the western, northern and north-western parts, the southern highlands and southern regions. Over 6000 cases have been reported since 1979. Control strategies against sleeping sickness in Tanzania include chemical control of vectors, treatment of patients with trypanocides and avoidance of human-tsetse contact.


Groenoord 66, 2401 AG Alphen a/d Rijn, Netherlands. Management procedures adopted by Fulani herders in northern Nigeria to protect their cattle from disease are briefly described. Trypanosomiasis is associated with tsetse fly bites and common control measures include the application of home-made fly repellents, lighting fires to drive off insects and avoiding fly-infested grazing areas and shade trees. Annual migration routes are carefully chosen to avoid tsetse-infested areas. In the rainy season the cattle are brought to the Fulani’s ancestral homeland in the Sudan zone, where tsetse only occur among riverine
vegetation. With the advent of the dry season the cattle are moved southwards through the savanna tsetse belt, where possible following disease-free tracks scouted in advance, to the subhumid Guinea zone. Some exposure to tsetse is unavoidable, but the Fulani allow their animals to spend only a very short time at watering places with bush or forest vegetation.


KETRI, P.O. Box 382, Kikuyu, Kenya; ibid.; ibid.; ibid.; National Veterinary Research Centre, KARI, Kabete, Kenya.

Trypanosomiasis forms a major constraint to livestock development in the rangelands of Kenya, causing production losses and restricting the introduction of more productive but susceptible stock into certain areas. The most economically important species are tsetse-transmitted *Trypanosoma vivax, T. congolense* and *T. brucei* in cattle and *T. simiae* in pigs, and mechanically-transmitted *T. evansi* in camels. The tsetse belt is more or less clearly defined and includes western districts (South Nyanza, Kisumu, Siaya, Busia and Bungoma) and the coastal region. Control measures include chemotherapy, with the extensive use of homidium compounds as prophylactic drugs; vector control, with increasing use of insecticide-impregnated or odour-baited traps and targets; and the use of trypanotolerant livestock, including the Orma Boran. The introduction of trypanoresistant genes into trypanosusceptible but highly productive Friesian cattle is a goal for the future. Integrated control is seen as the most cost-effective approach.

2. tsetse biology
(a) REARING OF TSETSE FLIES


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Prince Léopold, Nationalestraat 155, B-2000 Antwerpen 1, Belgium.

Three species of tsetse flies, *Glossina morsitans morsitans*, *G. palpalis palpalis* and *G. p. gambiensis*, representing altogether seven lines, are maintained as breeding colonies in Antwerp, Belgium, at the Prince Leopold Institute of Tropical Medicine. The history and pedigree of these lines are detailed. Insectary conditions and procedures used for keeping these *Glossina* spp. in Antwerp are described in detail. This information should be useful in comparing results obtained with other lines of these species, which may differ genetically or due to the conditions in other laboratories.

(b) TAXONOMY, ANATOMY, PHYSIOLOGY, BIOCHEMISTRY

[See also 17: nos. 8487, 8493.]


USDA, ARS, Medical and Veterinary Entomology Research Laboratory, P.O. Box 14565, Gainesville, FL 32604, USA; ibid.; USDA, ARS, Biosciences Research Laboratory, Fargo, ND, USA.

Gas liquid chromatography (GC) was used to analyse the cuticular alkanes of 26 species and subspecies of tsetse flies. Unique interspecific and intraspecific (males v. females) chromatographic patterns were observed. Solvent extraction of dried museum specimens and fresh specimens were equally successful and left specimens undamaged. GC peaks were used as characters with one of five character states per peak, to show phenetic relationships among species by sex using a UPGMA algorithm, using 23 peaks for males and 40 peaks for females. Comparisons among species of the *morsitans* group often agreed with recognised *morsitans* group classification using morphological techniques, with *G. austeni* being somewhat aberrant. *G. tachinoides* was less closely related to others in the *palpalis* group than previously described using morphology. Eleven members of the rarely studied *fusca* group were also classified by this methodology.

Gooding: Department of Entomology, University of Alberta, Edmonton, Alberta T6G 2E3, Canada.

Two large colonies, originating from allopatric populations of *G. pallidipes* in the Shimba Hills and Nguruman, Kenya, which differ biologically and with respect to vectorial competence, were compared at 14 enzyme loci using polyacrylamide gel electrophoresis. The colonies had similar levels of genetic diversity with approximately half of the loci being polymorphic, an average of 1.6-1.7 alleles per locus, and a mean heterozygosity per locus of approximately 18.4%.

However, the colonies differed significantly in allele frequencies at the loci for phosphoglucomutase, glucose-6-phosphate dehydrogenase, xanthine oxidase, octanol dehydrogenase and phosphoglucose isomerase. The results were compared with earlier studies on this species and no evidence was found for selection of specific alleles during establishment or maintenance of colonies of *G. pallidipes*, nor were specific chromosomes, or marker genes, associated with the biological differences between the two colonies.


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Electrophysiological techniques have been applied to tsetse fly Malpighian tubules for the first time. In either Cl or SO₄²⁻ Ringer, both non-perfused and perfused tubules displayed transtubular potentials (*V*) at or close to 0 mV. Exposure to cyclic AMP elicited a marked secretory response and, in SO₄²⁻ Ringer, a sharp (lumen-positive) increase in *V*. In Cl Ringer, despite more than double the secretory response, there was little or no change in *V*. Replacing Cl with SO₄²⁻ Ringer, in the presence of cyclic AMP, promptly increased *V*. In perfused tubules, this occurred irrespective of the Cl or SO₄²⁻ composition of the perfusate. In Cl Ringer, the transepithelial resistance (*R*ₜₐₜ) was less than half that previously reported in Malpighian tubules of other species. Cyclic AMP reduced *R*ₜₐₜ still further, whether tubules were bathed in Cl or SO₄²⁻ Ringer. Current-voltage (*I/V*) plots often displayed current rectification, both before and more frequently after exposure to cyclic AMP.
AMP, thus permitting estimation of both the electromotive force of the Na\(^+\) transport mechanism \(E_{\text{Na}}\) and of the shunt resistance \(R_{\text{shunt}}\). Both \(E_{\text{Na}}\) and \(R_{\text{shunt}}\) were markedly lower in tubules bathed in Cl\(^-\) than in SO\(_4^{2-}\) Ringer. Cyclic AMP was without effect on \(E_{\text{Na}}\) and \(R_{\text{shunt}}\), in either Cl\(^-\) or SO\(_4^{2-}\) Ringer. In terms of the equivalent electrical circuit, the secretory response to cyclic AMP was due solely to a fall in resistance of the active transport pathway \(R_{\text{series}}\). The absence of an appreciable \(V_t\), in Cl\(^-\) Ringer, is consistent with an apical Cl\(^-\) shunt.


Jura, Otieno: ICIPE, P.O. Box 30772, Nairobi, Kenya; Zdarek: Institute of Organic Chemistry and Biochemistry, Czech Academy of Sciences, Prague, Czech Republic.

Newly deposited G. m. morsitans larvae were chilled over ice and inoculated with 1 µl of either virus suspension derived from G. pallidipes salivary gland homogenate or sterile tsetse physiological saline. They were allowed to pupariate and then maintained at 25°C and 70% r.h. until soon after emergence when their salivary glands were examined for enlargement and presence of virus particles. Teneral G. m. morsitans which received the virus inoculum \(n = 135\) as larvae all became infected as revealed by gross hypertrophy of their salivary glands and ultrastructural manifestation of virus particles within the glandular epithelial cells and lumina. In the control group, which received the tsetse physiological saline \(n = 91\), only 1.1% of the flies showed the salivary gland enlargement, a level equivalent to the prevalence of virus infection normally detectable in the G. m. morsitans colony. This technique opens the way for testing the biocontrol potential of this virus. The DNA virus from G. pallidipes is clearly infective to G. m. morsitans, suggesting that the hypertrophied, chalky-white salivary glands, reported in various Glossina spp., are a manifestation of infection by one and the same virus.


Department of Biochemistry and Applied Molecular Biology, UMIST, P.O. Box 88, Manchester M60 1QD, UK.
The thoracic eclosion muscles of flies die by cytotoxic attack under neural control. We have investigated the innervation, ultrastructure and immunohisto-chemistry of the ventral eclosion muscle of *Glossina morsitans*. Two neurons located in the thoracic ganglion innervate this muscle. One of these is immuno-reactive for serotonin and does not provide motor innervation. It appears to terminate near the attachment of an immunocyte involved in the dismantling of the muscle. The neuromuscular junction has features that distinguish it from any other chemical junction. A narrow, 3 nm gap separates pre- and post-synaptic membranes and this apparently acts to limit diffusion into and out of the junction. The immunocyte may use neuromuscular innervation as a path-finder to all muscle fibres and may even receive direct input from this source. Neuromuscular transmission is probably chemical as decreasing temperature results in decreasing amplitude of the (graded) muscle potential.

(c) DISTRIBUTION, ECOLOGY, BEHAVIOUR, POPULATION STUDIES


Tsetse Research Group, Department of Veterinary Medicine, Bristol University, Langford, Bristol BS18 7DU, UK.

A laboratory bioassay was developed to allow blind testing of panels of odours for their effect on target-orientated behaviour of tsetse (*Glossina* spp.) in the laboratory. Landing responses of *G. m. morsitans* on black and blue targets were increased up to four-fold in the presence of carbon dioxide but no significant effect of any other odours could be demonstrated. 2-Methoxyphenol gave an apparent increase in landing behaviour in the laboratory but this substance diminished rather than increased landing of *G. pallidipes* and *G. m. morsitans* on targets in the field, as well as repelling tsetse from the target vicinity. Black, blue and red targets elicited strong landing behaviour in male *G. m. morsitans* in the laboratory and white and yellow targets elicited little or none, whether carbon dioxide was present or not. In the field, high ultraviolet reflectivity increased landing behaviour of *G. pallidipes* but only when there was a proportion of transmitted light through the target. Ultraviolet reflectivity always reduced
overall attraction of tsetse to a single-coloured target. Two-coloured targets incorporating ultraviolet-reflecting white cloth obtained strong landing on the white panels but caught fewer flies overall than all-black or blue-and-black targets.


Groenendijk, Dekker, Takken: Department of Entomology, Agricultural University, P.O. Box 8031, 6700 EH Wageningen, Netherlands; Otieno: Tsetse Programme, ICIPE, P.O. Box 30772, Nairobi, Kenya. (Correspondence to Otieno.)

Populations of G. pallidipes have recently been found in neighbouring areas and the Lambwe Valley population can no longer be regarded as isolated. Odour-baited biconical traps were used in an area extending from Kavirondo Gulf in the north to the Nyandhiwa road in the south, and from Lake Victoria in the west to the Kodera Forest in the east, to determine the presence of tsetse; trapped flies were dissected to assess trypanosome infection and ovarian age. The results indicate that G. pallidipes is breeding in areas to the east and north-east of Lambwe Valley, especially in the Ruri Hills, the coniferous plantation on the Kanyamwa escarpment and the Kanyabala Forest. These populations probably feed on domestic livestock and were infected with Trypanosoma vivax, T. congolense and T. brucei. G. fuscipes was also trapped in areas to the west and north-east of Lambwe Valley and is a potential vector. The incidence of animal and human trypanosomiasis is rising and the situation resembles that before the 1966 epidemic. Fly density should be reduced using baited targets or Nguruman traps.


Onderstepoort Veterinary Institute, Pretoria, South Africa.

Trypanosomiasis carried by Glossina brevipalpis and G. austeni killed about 10,000 cattle in Zululand in 1990 and research into trapping these vectors has been carried out. The synthetic ox odour combination developed in Zimbabwe for attracting G. morsitans and G. pallidipes was
found to be very effective in attracting *G. brevipalpis* to black cloth targets. Attraction increased with target size, 1.5 × 1 m being optimal. Phthalogen blue targets were significantly more attractive than black targets but, as in Zimbabwe, few flies alighted on them. Individual odour components showed some attraction for *G. brevipalpis* but were not as attractive as the four-component Zimbabwe combination. Phthalogen blue was the most attractive colour to *G. austeni*, followed by white, baby-blue and black. There was no significant difference between the attractiveness of individual odours and the Zimbabwe combination, and the synthetic odour did not appear to increase the number of *G. austeni* attracted to targets or traps.


Institute for Animal Health, Pirbright Laboratory, Ash Road, Pirbright, Woking GU24 0NF, UK; ITC, P.M.B. 14, Banjul, Gambia; ibid.; ibid. A country-wide survey of the distribution of *G. m. submorsitans* and *G. p. gambiensis* was carried out in The Gambia during 1989-90 using box traps at 1654 sites over an area of 10,000 km². The general distribution of tsetse had changed little during the last 45 years. *G. m. submorsitans* was present in dry, canopied woodland throughout most of the country, but was absent from an area south of the River Gambia stretching from the coast to some 100 km inland. *G. p. gambiensis* occurred in evergreen forest and woodland near the coast, and in riparian habitats along the length of the River Gambia and its major tributaries. Nowhere in the country was more than 20 km from tsetse-infested areas. Five major foci of *G. m. submorsitans* infestation were identified. Demographic, climatic and environmental factors affect tsetse populations in The Gambia, but it is expected that these foci of infestation will persist for at least the next 5-10 years. The numbers of tsetse trapped, expressed as relative densities, were used to assess the extent and severity of losses from trypanosomiasis to different categories of livestock. Survey results such as these could be used to assess whether control measures to reduce tsetse challenge are likely to be economically viable by using techniques such as insecticide-impregnated targets, pour-ons or
The daily flight activity patterns of one of the main vectors of animal trypanosomiasis in West Africa, *G. m. submorsitans*, were assessed using four different methods. Results from all the methods showed that there was some flight activity nearly every hour in all seasons but they differed in the level of contact between grazing cattle herds and *G. m. submorsitans*. In the late dry season, trap data indicated that there was negligible activity from midday to late afternoon, whereas observations of tsetse contact with cattle herds or hand-net collections on herd followings showed no fall in attack rates on the cattle by *G. m. submorsitans*. Differences between trap and animal-baited collection data may be attributable to the type of *G. m. submorsitans* sampled by each method. Male *G. m. submorsitans* captured by traps were more fat-depleted than those caught on ox-baited flyrounds or by hand-net collections on herd followings. All methods showed that male *G. m. submorsitans* were most fat-depleted in the late dry season and least in the early dry season. It was concluded that the traps were mainly sampling the spontaneous flights of *G. m. submorsitans*. Hunger and endogenous rhythms increase the likelihood of spontaneous flights towards dusk, particularly in conditions such as those at midday in the very hot, late dry season. However, the presence of cattle herds in infested habitats probably activated nearby *G. m. submorsitans* and the continual movement through the grazing areas ensured contact with tsetse throughout grazing. The data indicated that strategic management of herd grazing times cannot eliminate the risk of trypanosomiasis transmission occurring, irrespective of the harshness of the dry season climate. An assessment of the level of this risk could only be measured suitably by collecting tsetse using animal-baited methods, not from trap data.
Methanolic extracts of body wash from the neck and back of cattle were separated into ethyl acetate-insoluble, phenolic, acidic, neutral and basic fractions and used in behavioural studies with teneral male *G. m. morsitans* in a wind tunnel. An olfactory response to kairomones present in the extracts activated the flies and initiated upwind flight and increased activity such as landing and probing. Significantly fewer flies (*P* < 0.05) became activated at 40 cm from the odour source than from 10 or 20 cm. Active components occurred in all the cattle wash fractions, with the phenolic fraction eliciting most activity and the basic fraction the least. This suggests the presence of a series of different compounds which may act synergistically to affect tsetse behaviour at close range. Examination of the phenolic fraction showed that all the phenols present in buffalo and cattle urine were present in the skin with the addition of several other components, suggesting that body phenols may play an important role in host identification and that these may be more important than those derived from urine. Close range kairomones may also be responsible for the selection of particular feeding sites on a host animal.


*Tsetse Programme, ICIPE, P.O. Box 30772, Nairobi, Kenya; ibid.; ibid.; ILRAD, P.O. Box 30709, Nairobi, Kenya.*

*G. swynnertoni* has a limited distribution in northern Tanzania and southern Kenya. Routine sampling of *G. pallidipes* in March–May 1992, using NG2G traps on the Nguruman escarpment, showed that up to 4% of the tsetse caught were *G. swynnertoni*. The coexistence of *G. swynnertoni* with *G. pallidipes* and also *G. longipennis* in this area was previously unsuspected and could be a recent phenomenon. The suppression of the *G. pallidipes* population to approximately 1% of its previous level may have allowed for an influx of *G. swynnertoni* from either Tanzania or the Maasai Mara population about 50 km to the west. *G. swynnertoni* has been implicated as a vector of animal trypanosomiasis and the vector competence of this species at Nguruman should be studied in parallel with that of the associated *G. pallidipes* and *G. longipennis*. The differentiation of female *G. pallidipes* and *G. swynnertoni* is illustrated.

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Association, 66: 30–34.
Tsetse Control Senanga West, Veterinary and Tsetse Control Service, P.O. Box 920034, Senanga, Zambia.

Trap and bait-ox surveys were conducted in the Holdenby Communal Land in the eastern region of Zimbabwe following the appearance of trypanosomiasis in the area. Three species of tsetse fly were found: *Glossina pallidipes*, *G. morsitans morsitans* and *G. austeni*. The infestation appears to have originated from Mozambique and its distribution in the Holdenby Communal Land is mapped.


RTTCP, P.O. Box A560, Avondale, Harare, Zimbabwe.

The analysis of host-orientated behaviour of *Glossina morsitans morsitans* and *G. pallidipes* has led to a ten- to 1000-fold improvement in the cost-effectiveness of baits for surveys and control. The principles of behavioural analysis are discussed and include the interpretation of catches and activity indices. Three criteria are necessary for data analyses: overall activity must be split into its component responses; overall stimulus from baits must be divided into its constituents; and individual responses must be measured. Aspects of response measurement are discussed. Two common factors are that the number of responding insects must be counted at the instant of transition between two behavioural phases and that it is analytically meaningless to count the number of flies doing one thing without counting the numbers that do other things. Objective sampling devices of measured efficiency are essential and these include the use of electric nets and video recording. The history of research into bait-orientated behaviour is reviewed, with reference to the development of practical baits, trap and target design, and changes in cost-effectiveness and practical use. Areas for further research include the identification of additional attractants, use of sterilising hormones, improving the placement of baits, investigating long distance stimulus-response relationships, and developing new techniques such as radar tracking to monitor continuously the behaviour of individual flies.

The use of computers and remote sensing techniques has made it possible to determine accurately the temperature, rainfall and vegetation of inaccessible regions and to estimate the suitability of these regions for tsetse flies. Climatic and vegetational data from Zimbabwe have been correlated with the historical distribution of tsetse flies, and used to develop an efficient methodology for the analysis of such data and a model to predict the distribution of tsetse in other parts of Africa. The potential and limitations of these methods were discussed.

3. tsetse control (including environmental side-effects)

[See also 17: nos. 8451, 8461, 8463.]


CIRAD-EMVT, Centre ORSTOM de Montpellier, 911 avenue Agropolis, 34032 Montpellier Cedex 1, France; Département de Santé et des Maladies Infectieuses et Parasitaires, Université de Pau et des Pays de l'Adour, Pau, France; Mission Française de Coopération et d'Action Culturelle, Bangui, Central African Republic; ibid. and ANDE, B.P. 1509, Bangui, Central African Republic.

Trypanosomiasis transmitted by *Glossina fuscipes fuscipes* is a major problem among the 2.6 million Zebu cattle in the Central African Republic, where cattle numbers have increased as a result of the migration of Mbororo herders from the Sahel. Control is by costly chemotherapy with risk of the development of resistant strains. Tsetse eradication is considered impractical but trapping has successfully reduced vector pressure. A low-cost blue and black bipyramidal trap has been developed using everyday materials, such as recycled bottles, wooden struts and polyethylene sheeting. Field trials at Ouro-Djarfoun showed that the apparent density of *G. fuscipes* was significantly reduced after 2 months in the rainy season and after 1 month in the dry season, with a concomitant reduction in *Trypanosoma congolense* and *T. brucei brucei* infections in cattle. From 1988 to 1990 traps were distributed free to herders, who demonstrated their ability to use them efficiently.
under supervision. It is hoped that the herders will eventually take full responsibility for the cost and maintenance of the traps. Long-term success will depend on the herders becoming completely sedentary: at present their cattle are protected for only 6-7 months of the year.

ORSTOM, B.P. 893, Bangui, Central African Republic.

Using the example of a community-based tsetse control project carried out in the Congo from 1984-87, the influence of supernatural beliefs on the attitude of local people to disease and to their participation in public health programmes is discussed. Belief in the spirit world and in the role of the ndoki or witch doctor is of great social importance in African communities and has a considerable effect on their response to disease. Projects involving the community, such as tsetse control, must therefore take into account the possible influence of these beliefs, including symbolic cannibalism, the interaction of different cults (such as Christianity, Islam and local religions), lack of scientific understanding of primary health care, the ambivalence and richness of African thought, and ethical problems which may arise. The African way of thinking is very different from Western thought and must not be ignored.


Hussain: Agrochemicals Unit, Joint FAO/IAEA Programme, IAEA Laboratories, A-2444 Seibersdorf, Austria.
A range of formulations of deltamethrin was prepared, some containing an ultraviolet (UV) absorber compound or a combination of the UV absorber and an oil, and applied to blue cotton tsetse fly target samples which were then exposed to the effect of simulated sunlight and water in the laboratory. The residue of insecticide remaining on the targets and the activity of the latter against tsetse flies were determined. Formulations containing the UV absorber and coconut oil or silicone oil remained the most effective against tsetse flies. A coconut oil formulation of the insecticide was selected for field evaluation in comparison with a commercial deltamethrin formulation,
`Glossinex 200' S.C., which contains 10% UV absorber. Target samples treated with these formulations were exposed to natural tsetse fly habitat in Ghana for a period of 5 months and evaluated for deltamethrin residues and activity against four species of tsetse fly. After 5 months, 4-13 times more deltamethrin remained on the targets treated with the coconut oil formulation than on those treated with `Glossinex', and consequently the former were more active against tsetse flies than the latter. Target samples sequentially dipped in the coconut oil formulation resulted in uniform insecticide concentration on the targets, whereas those dipped in `Glossinex' contained gradually decreasing deltamethrin concentrations.


Sleeping sickness is undergoing a resurgence in Uganda following the political disturbances since 1970. Sudanese refugees have reintroduced Trypanosoma brucei gambiense sleeping sickness into the northern focus: this is being controlled by diagnosis and treatment. Insecticide campaigns had almost eliminated Glossina fuscipes, vector of T. b. rhodesiense sleeping sickness, in the south-eastern focus by 1970 but the disease reached epidemic levels again in 1987 when 8000 new cases were diagnosed in Busoga Province alone. ORSTOM then introduced the use of deltamethrin-impregnated traps through the cooperation of locally recruited fieldworkers and village committees. The modified Challier-Laveissière trap is cheap and easy to use, consisting of a blue and black tent-like structure with a conical top of white gauze suspended from a tree. Tsetse attracted by the colour combination fly up into the cone where they are poisoned and collected for counting. In 1987 15,000 traps were set at a rate of 10/km². Within 10 months the fly population had been dramatically reduced and the disease had declined by 90%. Trap density was halved and over 5 years the project has been extended to cover an area of 3000 km², protecting 600,000 people at a cost of 0.5 US$/person/year. The programme is now maintained by the Ugandan government and local communities.

Tsetse and Trypanosomiasis

The prevalence of trypanosomiasis was determined by thick blood smears in three herds of cattle in Petauke District, Eastern Province, Zambia. All cattle were treated with diminazene aceturate at 3.5 mg/kg body weight and 1 week later were dipped in deltamethrin (Butox 5% w/v) at an estimated concentration of 0.00375%. Two herds (Chimtowe, North Nyamphande) were dipped at 14-day intervals and one (Kachusi) was dipped at 7-day intervals. Thick blood smears were examined monthly during the dipping period (January–July 1986), when no clinical infections requiring treatment were diagnosed. A substantial reduction in the incidence of trypanosomiasis and an increase in productivity were indicated in all three herds.


Aerial spraying of an endosulfan/deltamethrin formulation was successfully used during the 1980s to control tsetse in the Okavango Delta, although mortality to fish and other aquatic organisms occurred under certain conditions. The toxicity of various insecticide formulations to fish has now been tested and recommendations made for minimising environmental side effects. The research programme showed that it is safer to spray during the cooler winter months when fish are physiologically less active and the tsetse population is lowest. It was recommended that endosulfan should be replaced, and use of u.l.v. deltamethrin in 1991 gave adequate tsetse control and no apparent fish kills or gross damage to the aquatic environment. Two surface-feeding fish, *Aplocheilichthys johnstoni* and *Barbus haasianus*, showed signs of temporary disorientation. The use of deltamethrin also resulted in a 50-fold reduction in the total amount of a.i. applied. Aerial spraying using smaller aircraft flying just above the tree canopy was recommended to reduce drift and the ProNav satellite navigational system was
first used in 1991 with greatly improved accuracy. Traps and targets may be appropriate in more accessible areas.


Okello-Onen: Animal Health Research Centre, P.O. Box 24, Entebbe, Uganda.

The effect of treating cattle with deltamethrin to control tsetse flies and ticks was investigated on two ranches 8 km apart in central Uganda where there was a high risk of trypanosomiasis. This area had a moderate challenge of *Glossina pallidipes*, and a very low challenge of ticks due to regular treatment of the cattle with dioxathion. On one ranch a dip was charged with deltamethrin to treat cattle regularly for 3 months. The other ranch was used as a control for the tsetse population, but the animals continued to be treated regularly with dioxathion using hand sprays. On the ranch using deltamethrin treatment a reduction of 96.9% in the tsetse population was recorded after two treatments at 2 week intervals. Total (100%) control of tsetse was achieved from the fourth treatment up to the end of the trial period. The ranch with dioxathion treatment experienced an overall tsetse reduction of 19.15% during the thirteenth to fifteenth weeks and the factors contributing to this are discussed. However, the mean apparent tsetse density of 4.83 flies/trap/day recorded at the control ranch was significantly different from the mean of 0.81 flies/trap/day (*P* < 0.001) at the ranch using deltamethrin treatment. It was difficult to assess the effect of this product on ticks because of lack of controls. However, there are indications that deltamethrin can also reduce tick populations and the incidence of tick-borne diseases. The possible limitations and practical implications associated with large-scale use of this product in the country are discussed.


UTRO, P.O. Box 96, Tororo, Uganda.

*Glossina morsitans*, *G. pallidipes* and *G. fuscipes fuscipes* were fed on cattle or pigs that had been dipped in 0.00375% deltamethrin in water 0-31 days previously. The knock down and survival of the tsetse were then followed in
the laboratory. Although mortality was generally less
the longer after the dip the flies were fed, all those
that fed on the animals within 7 days of the dipping
were killed and all those that fed within 21 days were
at least knocked down. *G. morsitans* was slightly more
susceptible than the other two species tested.

8481 Regional Tsetse and Trypanosomiasis Control Programme and
monitoring of tsetse control operations in Zambia and Zimbabwe. Impact of
Saarbrücken, Germany; Institut für Biogeographie, Universität des Saarlandes. 125 pp.
SEMG, Institut für Biogeographie, Universität des
Saarlandes, Saarbrücken, Germany.
Environmental monitoring of endosulfan application in
Zimbabwe and Zambia is described with reference to the
study area and spraying operations, effects on
terrestrial and aquatic vertebrates and invertebrates,
and residue analyses. The environmental impact of
deltamethrin application by fixed-wing aircraft and
helicopters, and of odour-baited insecticide-
impregnated targets, in Zimbabwe is also described with
reference to effects on non-target organisms. Control
operations in Zimbabwe were considered to be successful
with regard to the eradication of *Glossina morsitans* (but
not *G. pallidipes*) using 14-24 g a.i./ha endosulfan, 0.25 g
a.i./ha deltamethrin or odour-baited targets. These
dosages had little effect on the non-target fauna.
However, it is recommended that delta-methrin should be
used in preference to endosulfan in areas with
fisheries and that care should be taken with
deltamethrin where aquatic crustaceans are of economic
importance. Insecticide residues in the food chain
were either not detectable or were considered to be low
risk. Adverse effects on humans were not detected.
Odour-baited targets were found to attract Stomoxyinae,
Muscinae and Tabanidae in addition to tsetse flies and
future studies are necessary to determine any effects
on their populations. Similar control operations could
be extended to other areas with comparable climate,
land use and vegetation patterns, although it might be
necessary to increase the insecticide dosage to control
*G. pallidipes* effectively.

using odour-baited trees to control tsetse flies
(Diptera: Glossinidae). *Bulletin of Entomological Research, 84*
(1): 123-130.
RTTCP, P.O. Box A560, Avondale, Harare, Zimbabwe;
Field studies in Zimbabwe elucidated the responses of *Glossina morsitans morsitans* and *G. pallidipes* to natural and artificial trunks of trees baited with odours of acetone, 1-octen-3-ol and phenols. The numbers of tsetse electrocuted in flight near the base of the trunk increased 2-12 times when the trunk was shortened from 7.2 m to 0.9 m and its diameter was increased from 25 cm to 5 m, when the base was coloured blue or black to contrast with the upper trunk, or when the upper trunk was separated from the base by a gap of 2.7 m. A swarm flying near short trunks was more compact than near tall trunks. Electrocuting grids to catch alighting tsetse indicated that only about 20% of the attracted tsetse alighted on the base of the trunk, whether this was blue or blue/black. Since there is presently no apparent means of cost-effectively avoiding the inhibitory effects of tall trunks, the use of odour-baited trees as baits for tsetse control seems uneconomical.


A successful community-based tsetse control programme has been set up on a Maasai ranch at Nguruman in south-west Kenya, using odour-baited traps. The development of this programme involved several years of research into trap design, tsetse ecology and disease epidemiology, and the local community was involved from the start. The Nguruman tsetse control project was used as a case study to examine the feasibility of extending this approach to other parts of Africa.

4. epidemiology: vector-host and vector-parasite interactions

[See also 17: nos. 8464, 8467, 8468, 8503, 8537.]


Researchers are investigating the possibility of isolating genes which might confer resistance to trypanosomes and inserting them into symbiotic bacteria in the tsetse gut to produce vectors that are `immune'
to trypanosomes. Cells in the tsetse midgut secrete a lectin that kills trypanosomes but which is inhibited by N-acetyl-D-glucosamine, produced when a chitinase secreted by the symbionts breaks down the lining of the tsetse gut. Flies carrying more symbionts are therefore more susceptible to trypanosomes: this could be counteracted if the symbionts are genetically altered to produce tsetse lectin or to mop up the glucosamine. Another group is working to isolate the gene that produces an antibody fragment that attacks a trypanosome antigen called procyclin: splicing this into the symbiont should produce a bacterium capable of killing trypanosomes. Difficulties in introducing and spreading the altered symbionts through the tsetse population might be overcome by using *Wolbachia* *pipientis*, a maternally inherited bacterium which infects tsetse ovaries, to drive engineered symbionts throughout a population.

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ORSTOM, B.P. 893, Bangui, Central African Republic; CIESPAC, Brazzaville, Congo; Université des Sciences et Techniques du Languedoc, Montpellier, France; UPPA, Pau, France; DMPGE, Bangui, Central African Republic; ibid.

A sample of 142 sleeping sickness patients from the Nola-Bilolo focus was studied to ascertain their probable places of infection. The localities where infection was highest within the focus are M’Poyo (18% of cases), Bilolo (9%), Mékara (8%), Modigui-Kouna, Ziendi and Domissili (all 7%). The main places and times of human-tsetse contact were determined by agricultural activities: coffee-growing for men and steeping cassava in the river for women. The patients were either detected passively (average age 30 ± 3 years) from medical records or actively (average age 22 ± 3 years) during a survey carried out in January-February 1991. During the survey, patients supplied information about their points of contact with flies, not just their homes but during their daily movements and at places of work. There was considerable movement between villages. The results showed that poorly
targeted vector control is unlikely to succeed and priority areas should first be defined by trapping.


P.O. Box 25021, Nairobi, Kenya; ICIPE, P.O. Box 30772, Nairobi, Kenya.

Wildlife disease research in Kenya is reviewed with reference to animal health management. The wildlife–livestock interface is here defined as an area where wildlife and livestock coexist and conflict for food, disease control and predation. The attractiveness of domestic and wild Bovidae to tsetse was compared by penning one Boran cow together with one buffalo, eland, oryx or waterbuck and observing the number of flies landing and engorging on the animals. Buffalo and cattle were equally attractive to tsetse and 20–25% of the flies engorged; eland attracted only half the number of flies as cattle and only 10% engorged; oryx attracted one sixth the number of flies and only 3% engorged; and waterbuck attracted very few flies, none of which engorged. Studies of the responses of African buffalo to tsetse infection are reviewed. The isolation from buffalo of serum proteins with trypanocidal activity against all common species of trypanosomes could be important for the development of genetic control methods for trypanosomiasis in domestic bovines. The relatively close genetic relationship between buffalo and cattle makes buffalo an excellent model for the study of trypanotolerance relevant to the development of disease control strategies in cattle.


ICIPE, P.O. Box 30772, Nairobi, Kenya.

Midgut protease activity in *G. m. centralis* and *G. m. morsitans* at 48 h post bloodmeal averaged 1.8 IU of trypsin-like activity. These two tsetse subspecies differ in their susceptibility to trypanosome infection. Except for low levels in flies fed on waterbuck blood (0.7 IU), activity did not differ in flies fed a variety of host bloods (goat, pig, cow, buffalo, eland) and trypanosome species (*T. congolense*, *T. brucei*, *T. simiae*). Protease activity was also not correlated with infection rates, despite large differences in infection rates among experiments. Nevertheless, addition of 0.06 M D(+)–glucosamine to
parasitaemic blood resulted in a three-fold reduction in protease activity, coincident with a large increase in infection rate. This effect did not occur when parasites or D(+) -glucosamine were added alone to the bloodmeal, suggesting that the effect was due to metabolism of D(+) -glucosamine by parasites.


Olubayo: ICIPE, P.O. Box 30772, Nairobi, Kenya.
The pattern of infection in G. m. morsitans and G. m. centralis membrane-fed on eland, buffalo or goat blood mixed with T. congolense or T. brucei was studied from day 1 to day 10. Tsetse were initially permissive vectors with most flies harbouring infections of 10⁴-10⁵ parasites on day 3. However, after a second blood meal on day 3, flies cleared many infections, with G. m. morsitans clearing more infections than G. m. centralis. Infective feeds of goat blood consistently increased final infection rates by limiting the number of infections lost between days 3 and 6. In further experiments with G. m. morsitans only, this effect was replicated by feeding flies on erythrocytes but not on serum. These results suggest that compounds from some mammalian erythrocytes match the target specificity of G. m. morsitans midgut lectins and, therefore, have a protective effect on trypanosome establishment in the fly.


IClPE, P.O. Box 30772, Nairobi, Kenya.
Biochemical interactions between trypanosomes and their tsetse vectors are being investigated in the search for novel control methods. Factors that influence the differentiation of trypanosomes in the tsetse midgut have been identified as trypsin, lectins, agglutinins and lysins. These factors appear to be related as they are inducible by bloodmeals, they are specifically inhibited by glucosamine or soya bean trypsin inhibitor, and their activities peak at the same time and co-elute on HPLC ion-exchange columns. It is suggested that these factors may reside on the same protein.

The importance of a recent study of tsetse bias towards *Trypanosoma congolense*-infected cattle in the field (see *TTIQ*, 16 (4): no. 8069) is acknowledged. However, the mechanism of the bias was not determined and this is attributed partly to experimental design: for example, that it was not possible to separate infection from anaemia as possible causes of tsetse feeding success. It is recommended that future field studies should develop a strict reductionist approach. Attraction should be evaluated independently of probing, probing should be separated from ingestion and so on, so that each step is evaluated and not just the overall process. Elucidating the mechanism of tsetse bias towards infected hosts may be of great consequence in the development of new control techniques. In a reply, one of the authors of the original article reasserts that there was no indication of a role for anaemia in determining tsetse bias.

8491 **Schaub, G.A., 1992.** The effects of trypanosomatids on insects. (Review.) *Advances in Parasitology*, 31: 255-319. Department of Special Zoology and Parasitology, Ruhr University, D-4630 Bochum, Germany. The author divides his review into: behavioural alterations, disturbances of organ systems, effects on pre-adult development times and mortality rates, effects on adult life span and reproduction rate, and synergistic effects of trypanosomatids and other stressors. The article includes a section on the modification of feeding behaviour in tsetse flies infected with *Trypanosoma*; there are other references to African trypanosomes throughout the text but the author concentrates mainly on Stercoraria.


The local migration of village N'Dama cattle between two study sites, Niamina East and Bansang, 40 km apart in the inland region of The Gambia, is described. The consequences of seasonal variations in local stocking densities on the epidemiology of African animal
trypanosomiasis are reported. Tsetse abundance at each study site was monitored throughout the study period from trap catches, and cattle censuses at each site were carried out on a monthly basis. Detailed ecological, productivity and health data, including dietary intake and trypanosomiasis prevalence, were collected from selected study herds resident at the two sites and from a third group of (four) herds that migrated annually between the two areas to spend the late dry season period in Niamina East. It was shown that the migration strategy allowed migrants to maintain a high level of green grazing in the diet throughout the year. Cattle were moved to the area of highest tsetse density in the region to obtain this grazing, but it appeared that individual risk of trypanosome infection was diminished by a dilution effect created by locally high livestock densities. Trypanosomiasis prevalences in resident cattle at Niamina East were best correlated with the tsetse catch/trap/day 2 months previously, once this index of tsetse abundance had been corrected to allow for changes in relative stocking density. *Glossina morsitans submorsitans* was the only tsetse species present in significant numbers in the study areas.

8493 Welburn, S.C., Maudlin, I. and Molyneux, D.H., 1994. Midgut lectin activity and sugar specificity in teneral and fed tsetse. *Medical and Veterinary Entomology*, 8 (1): 81-87. Tsetse Research Group, Department of Veterinary Medicine, University of Bristol, Langford House, Langford, Bristol BS18 7DU, UK; ibid.; Liverpool School of Tropical Medicine, Pembroke Place, Liverpool L3 5QA, UK.

Midgut infection rates of *Trypanosoma congolense* in *Glossina palpalis palpalis* and of *T. brucei rhodesiense* in *G. pallidipes* are potentiated by the addition of D+ glucosamine to the infective feed, but not to the levels of superinfection reported for *G. m. morsitans*. *G. p. palpalis* and *G. pallidipes* are shown to possess two trypanocidal molecules: a glucosyl lectin which can be inhibited by D+ glucosamine and a galactosyl molecule inhibited by D+ galactose. Addition of both D+ glucosamine and D+ galactose to the teneral infective feed promotes superinfection of the midgut of *G. p. palpalis*. The glucosyl lectin is specific for rabbit erythrocytes and is present in guts of fed *G. m. morsitans* and *G. p. palpalis*. Titres of lectin activity do not increase substantially after the second bloodmeal. The galactosyl-specific molecule does not show any erythrocyte specificity, although haemolytic
activity is observed only in *G. p. palpalis* and not in *G. m. morsitans*. The presence of two trypanocidal molecules in some species of tsetse may account for the innate refractoriness of these flies to trypanosome infection. As D+ glucosamine also inhibits the killing of procyclic trypanosomes taken as an infective feed, it is suggested that the midgut lectin is normally responsible for the agglutination of trypanosomes in the fly midgut by binding to the procyclic surface coat, prior to establishment in the ectoperitrophic space.

5. human trypanosomiasis
(a) SURVEILLANCE
[See also 17: nos. 8454, 8476, 8538.]
Coopération Médicale Belge, B.P. 457, Niamey, Niger; Bureau Central de la Trypanosomose, Kinshasa, Zaire; ibid.; Secteur Médical, Ambassade de Belgique, Kigali, Rwanda.
The authors report results obtained after combination of a serological diagnostic test and the early treatment of suspected cases (a person with a positive serological test without parasitological confirmation) in an area in Zaire where sleeping sickness caused by *T. b. gambiense* is endemic. The serological test used was Testryp CATT, which has a very high sensitivity and quite a high specificity, is easy to handle in the field and permits results to be obtained on the spot. The treatment employed was diminazene aceturate which is active in the first stage of the disease (haematolymphatic stage), has few side effects and is easy to administer. This strategy was applied for 1 year in the Fankana-Kalakitini focus in the Bandundu region of Zaire. The entire population was examined with the classical methods and with Testryp CATT every 6 months. Individuals positive for the serological test (but negative for the parasite) received one
injection of diminazene aceturate while those in whom parasites were found received classical treatment, i.e. suramin and pentamidine in the haematolymphatic stage and melarsoprol in the nervous stage. After this period, there was a clear decline in the incidence rate of new cases (parasite positive) and also in seropositivity rates in the general population. The authors believe that in a circumscribed area where the disease is endemic, the combination of a serological test and early treatment of suspected cases can rapidly diminish the incidence of the disease to an acceptable level.


The future of sleeping sickness control in Africa is questioned: at the present time the disease is in resurgence, mobile surveillance and control teams are not fully operational and field work is limited by economic constraints. It is proposed that instead of mobile teams surveillance networks should be established, using community health workers who are motivated and trained to undertake serological surveys and to assess the level and extent of the disease. The intervention of specialised services would be more effective if it could be aimed at areas at particular risk. If necessary, the services of community health workers could also be used for vector control. A trial network was set up in the rural health zone of Issia in the forest zone of Côte d'Ivoire in October 1992. A screening laboratory was established and 24 community health workers were trained to undertake a population census, trypanosomiasis surveillance (using Testryp CATT) and confirmation and treatment of suspected cases. A rapid evaluation of the prevalence and distribution of trypanosomiasis in the Issia area was achieved.


Olaho–Mukani: KETRI, P.O. Box 362, Kikuyu, Kenya.
rhodesiense and undergoing treatment were analysed for circulating trypanosomal antigens using a sandwich antigen-trapping ELISA. Trypanosomal antigens were detected in 83 (84%) of the patients. Post-treatment antigen profiles in 67 patients showed five distinct patterns: in 48% of the patients, antigen levels remained elevated throughout the time of hospitalisation and follow-up; in 31%, antigens had dropped to the negative value by the second month; in 7.5%, antigens dropped to the negative level and became elevated afterwards; in 7.5%, antigen levels were negative initially but later became elevated and remained so throughout the observation period; in 6%, antigen levels remained below the negative value throughout. All patients who relapsed on follow-up had earlier shown evidence of elevated antigen profiles. There were no cases of relapses among 21 patients whose antigen levels dropped subsequent to treatment. This ELISA trypanosome antigen detection test could be useful in evaluating treatment success, when used together with parasitological diagnostic techniques.

(b) PATHOLOGY AND IMMUNOLOGY


Reincke, Alloio: Department of Medicine, University of Würzburg, Josef-Schneider-Strasse 2, D-97080 Würzburg, Germany; Petzke, Heppner, Vollmer, Winkelmann: Department of Medicine II, University of Köln, Köln, Germany; Mbulamberi: Uganda National Sleeping Sickness Control Programme, P.O. Box 1241, Jinja, Uganda; Chrousos: Developmental Endocrinology Branch, National Institute of Child Health and Human Development, Bethesda, Maryland, USA.

The function of the hypothalamic-pituitary-thyroid axis was evaluated before, during and after therapy in haemolympathic sleeping sickness patients receiving suramin i.v., in cerebral cases receiving melarsoprol and in controls in Uganda. All subjects were injected with 400 µg thyroid releasing hormone (TRH) i.v. and blood samples were examined for fT3, fT4, serum thyroid hormone level (TSH), reverse T3, tumour necrosis factor (TNF-α), interleukin-1 (IL-1) and IL-6 at 0 min, and for TSH at 60 min. Baseline TSH was elevated in unmedicated patients whereas fT3 and fT4 concentrations
were low. Stimulated TSH concentrations did not differ significantly from controls. Reverse T3 concentrations were normal. During treatment, baseline TSH, fT3 and fT4 concentrations slowly returned to normal. Plasma concentrations of TNF-α and IL-6, but not IL-1β, were elevated when thyroid impairment and disease activity were maximal but gradually decreased with therapy. Unmedicated sleeping sickness appears to be associated with a significant impairment of thyroid function which is reversed with therapy. Increased TSH concentrations and low fT3 and fT4 concentrations suggest primary hypothyroidism but an additional pituitary and/or hypothalamic component may be involved. This impairment may be due to elevated plasma cytokine concentrations or it may be the result of parasitic thyroiditis.


The function of the hypothalamic-pituitary-adrenal axis in Ugandan sleeping sickness patients before, during and after therapy was investigated. The standard adrenocorticotropic hormone (ACTH) stimulation test was used to assess the maximal adrenocortical responsiveness of patients: this demonstrated paradoxically subnormal cortisol responses before suramin therapy which improved with suramin and/or melarsoprol therapy. A human corticotropin releasing hormone (hCRH) test was performed on a different group of patients: ACTH and cortisol responses to hCRH were blunted, suggesting the presence of secondary adrenal insufficiency. First cortisol and then ACTH responsiveness improved with therapy, indicating an additional primary component of adrenal dysfunction.
Plasma concentrations of tumour necrosis factor (TNF)-α and inter-leukin (IL)-6, but not IL-1β, were elevated in patients but decreased with therapy. Unmedicated sleeping sickness appears to be associated with impairment of the adrenocortical function, which may be due to elevated plasma cytokine concentrations and may represent a natural adaptation to inflammatory states.

(c) TREATMENT
[See also 17: nos. 8494, 8496.]


The results of treating 32 gambiense sleeping sickness patients (five new cases, one reinfection and 26 cases of primary or secondary resistance or relapse) are reported. Twenty-six patients were given only oral DFMO (300 mg/kg/day for 4 weeks) while the other six received i.v. DFMO (400 mg/kg/day for 2 weeks) followed by oral DFMO (300 mg/kg/day for 3 weeks). Side effects were never serious enough to necessitate discontinuation of treatment. Twelve cases were followed for a period of 24 months, 16 for a period between 1 and 18 months, and four patients died during the study (three during treatment and one 8 months afterwards), but DFMO was not thought to be the cause of death. Out of the 12 cases followed for 2 years, 11 were in perfect health at the end of this period (one case may have been a secondary resistance to DFMO, but could have been a reinfection). All the 16 cases followed for a period of less than 2 years showed a very fast disappearance of trypanosomes from ganglia, blood and CSF immediately after the beginning of treatment, and a rapid and often impressive improvement in clinical signs. DFMO given orally appeared to provide as good results as DFMO given in a combined therapy, and seems much easier to administer in rural areas.


Laboratoire de Psychologie Expérimentale et Comparée, Faculté des Lettres et des Sciences Humaines, Université de Nice Sophia-Antipolis, 98 boulevard Édouard-Herriot, B.P. 369, 06007 Nice Cedex, France; Laboratoire de Physiologie Animale et de PsychophysioLOGie, Faculté des Sciences et des Techniques d'Abidjan, B.P. 582, Abidjan 22, Côte d'Ivoire.

The aim of the study was to assess the effects of DFMO on the waking electroencephalogram (EEG) of 25 patients at the meningoencephalitic stage of human African gambiense trypanosomiasis, six of whom had been previously treated with and were considered refractory to melarsoprol. DFMO was administered i.v. at a dose of 400 mg/kg/day for 14 days, followed by oral treatment at a dose of 300 mg/kg/day for 21 days. EEG data were performed before, then 15 days after the end of the therapy. Initially tracings presented diversified abnormalities which have been classified into four groups: intermittent delta waves, generalised delta waves, low voltage background, and paroxistic activities. After treatment, recordings showed an improvement but, as with melarsoprol, tracings did not return completely to normal patterns. In most of the patients, therapy was associated with clinical improvement and in all but one with disappearance of trypanosomes. Marked improvement in the recordings of the patient who presented trypanosomes in his CSF samples suggest he was responsive to the treatment and would perhaps have benefited from continuation of therapy. The use of EEG investigation as a means of monitoring treatment of patients with trypanosomiasis is discussed.

6. animal trypanosomiasis
(a) SURVEY AND DISTRIBUTION

Dargie, J.D., Ooijen, C.J.P.G. and Plaizier, J.C.B., 1993. The FAO/IAEA DGIS coordinated research programmes on trypanosomiasis diagnosis and animal production in
In 1987 the Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture was funded by the Netherlands Directorate General of Development Cooperation (DGIS) to implement two coordinated research programmes, one of which (entitled `Improving the diagnosis and control of trypanosomiasis and other vector-borne diseases of African livestock using immunoassay methods') brought together staff from ten African national research centres, ILRAD and CTVM. The aims of this programme were to validate antigen-detection ELISAs (Ag-ELISAs) against other techniques for the diagnosis of bovine and camel trypanosomiases and then to use the tests to monitor the effectiveness of national control programmes. The main achievements of the programme are reviewed. The provision of standardised equipment and reagents in kit form, training and other inputs greatly improved the efficiency of national control systems, particularly in situations where the presence of trypanosomes could not be detected by conventional parasitological techniques. On Zanzibar island, for example, Ag-ELISA indicated a 12% prevalence of infection in an area reported as trypanosomiasis-free for 3 years as a result of control activities.


An epidemiological study of trypanosomiasis was conducted in the rearing areas of dromedary camels in Mali. According to the parasitological and clinical surveys performed, the overall infection rates were 9.5% (29/305) in Western Sahel (region I) and 4.5% (28/627) in the areas of Tombouctou and Gao (region II). The proportion of contaminated herds was 55% in region I and 68% in region II and in some herds the
infection rate exceeded 50%. The surveys showed a trend for increasing parasitological prevalence with age. While it was almost nonexistent in young camels less than 1 year old, it increased with age and reached a maximum in 2 to 5 year old camels. The infection was shown to have a significantly negative effect on PCV and on the overall status of the animals, confirming the pathogenicity of *Trypanosoma evansi* in dromedary camels. This trypanosome is almost the only species detected in the dromedary camel in Mali and it does not seem to cause infections in other animals reared in the same environment.


Majiwa: ILRAD, P.O. Box 30709, Nairobi, Kenya.

Relatively simple protocols employing non-radioactive DNA probes have been used for the detection of African trypanosomes in the blood of mammalian hosts and the saliva of live tsetse flies. In combination with the polymerase chain reaction (PCR), the protocols revealed trypanosomes in buffy-coat samples from antigenaemic but aparasitaemic cattle and in the saliva of live, infected tsetse flies. Furthermore, the protocols were used to demonstrate concurrent natural infections of single tsetse flies with different species of African trypanosomes.


Brentec Diagnostics, P.O. Box 42477, Nairobi, Kenya.

Suratex, a simple field-orientated latex agglutination test, detected *T. evansi* antigens in 53 of 60 (88.3%) serial blood samples collected from experimentally infected rabbits. By comparison, theuffy coat technique and wet blood film examination diagnosed the infection in only 22 (36.7%) and two (3.3%) of the samples respectively. The analysis of field sera from camel herds experiencing a *T. evansi* outbreak demonstrated the superior sensitivity of Suratex: 30 of a herd of 32 (94.0%) tested positive for antigens, compared with only five (15.6%) which were diagnosed by the buffy coat technique. In a second herd of 60 camels, Suratex showed all 60 to be infected whereas mouse inoculation diagnosed infection in only 28
(46.7%). There was a high degree of correlation between parasitological results and those obtained with Suratex.

(b) PATHOLOGY AND IMMUNOLOGY

Departments of Veterinary Pathology (Egbe-Mwiyi) and Veterinary Physiology and Pharmacology (Onyeyili), University of Maiduguri, P.M.B. 1069, Maiduguri, Borno State, Nigeria; Antia: Department of Veterinary Pathology, University of Ibadan, Ibadan, Nigeria.

Twenty adult mongrel dogs of both sexes were used to assess hepatic dysfunction. Ten of the dogs were splenectomised while the rest were not. Five dogs each from the splenectomised and intact groups were inoculated i.v. with *Trypanosoma brucei brucei* strain 8/18 while uninoculated dogs served as controls. All the infected animals developed trypanosomiasis from day 4 to day 7 p.i. Splenectomy was observed to shorten the pre-patent period and enhanced parasitaemia. The plasma fibrinogen and cholesterol levels were increased in the infected groups. Treatment of the infected dogs with diminazene aceturate at a dose rate of 7.0 mg/kg body weight on day 21 p.i., although effective in eliminating the infection within 24 h, did not immediately reduce the elevated fibrinogen and cholesterol levels which were attributed to hepatic dysfunction.


Faculty of Veterinary Medicine, Cairo University, Cairo, Egypt.

Lymphadenitis was diagnosed in 64 of 107 (59.8%) Egyptian camels. Haematological examination of the affected animals revealed leukocytosis and neutrophilia in acute, suppurative and chronic lymphadenitis, leukocytosis and lymphocytosis in chronic lymphadenitis, a decrease in erythrogram in addition to leukocytosis, neutrophilia, and monocytosis in parasitic lymphadenitis. *Trypanosoma evansi* was recorded in 2.8% of the investigated camels. *Theileria* species
and a variety of bacteria were also isolated from camels showing different types of lymphadenitis.


Flynn: Department of Veterinary Pathology, University of Glasgow, Bearsden Road, Glasgow G61 1QH, UK.

Alterations in the phenotype and function of cells isolated from bovine afferent lymph were studied following tsetse-transmitted *T. congolense* infection. Little alteration was observed in the output of the CD2+ T cells in the lymph, and within this population the CD4:CD8 ratio remained relatively constant. By contrast, a marked decrease was observed in the output of γδ T cells over the first 7 days following infection. The number of B cells increased between 2 and 6 days p.i. and thereafter returned to pre-infection values. Little change was observed within the afferent lymph veiled cell population. Examination of activation markers on the lymphocyte fraction of afferent lymph revealed a decrease in the number of cells expressing the interleukin-2 receptor α-chain from day 5 p.i. At this time the expression of ACT 1, another early activation marker, was seen to increase. Afferent lymph cells collected pre-infection and on the first 4 days p.i. proliferated in response to stimulation with concanavalin A in vitro. This response to mitogenic stimulation was completely abrogated from day 5 p.i. However, these cells were not capable of suppressing the capacity of normal peripheral blood mononuclear cells to respond to mitogenic stimulus in co-culture assays. These studies suggest that although a degree of lymphocyte activation occurs in the afferent lymph following tsetse-transmitted infection with *T. congolense*, this may be sub-optimal owing to the immunosuppression which appears to operate at the level of the skin and the lymph nodes.


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The effect of *T. evansi* infection on oestrous cycling was
studied in 12 Friesian Holstein heifers. In phase 1 of the investigation, six heifers were infected with *T. evansi*; the remaining six acted as uninfected controls. Daily body temperature, PCV and parasitaemia measurements were obtained from each animal for 90 days. The animals were examined for external signs of oestrous activity twice daily, blood samples were taken three times a week and subjected to an enzyme-linked immunosorbent assay to detect plasma progesterone. Body weights were measured weekly. Parasites were eliminated by trypanocidal drug treatment 90 days after infection. In phase 2 of the trials, the uninfected heifers were injected with a different stock of parasites and monitoring was continued as before. Infection with *T. evansi* resulted in a marked reduction in the rate of weight gain, an increase in body temperature and a fall in PCV value. Eleven of the heifers continued to cycle normally for the duration of the study, irrespective of their infective status. One animal which stopped cycling lost 16.2% of its pre-infection body weight as a result of the infection and cessation of oestrous activity was considered to have been due to weight loss.


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Plasma of cattle infected with *T. vivax* IL 2337 was analysed for the presence of bovine tumour necrosis factor (TNF) by EIA in which TNF was captured by a monoclonal antibody (MoAb BC9) and detected by a rabbit polyclonal antiserum. At week 2-3 p.i. only a low activity was detected. Therefore, an alternative approach was used in which TNF production was measured *ex vivo*. Monocytes from *T. vivax* IL 2337-infected cattle manifested a strong TNF production which peaked around week 2.5 p.i. Monocytes from pre-infection controls did not produce significant concentrations of TNF. In contrast to the strong production of TNF by monocytes from cattle infected with *T. vivax* IL 2337, TNF production was not detected from monocytes of cattle infected with *T. congolense* ILNat 3.1. Trypanosomiasis due to these parasites differs in the degree of anaemia as indicated by PCV. *T. vivax* IL 2337 causes a severe, acute PCV fall whereas *T. congolense* ILNat 3.1 causes a
more gradual fall in PCV.

(c) TRYPANOTOLERANCE

[See also 17: nos. 8450, 8486.]


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Owing to increasing scientific and agricultural interest in the disease-resistant (trypanotolerant) indigenous cattle breeds of West and Central Africa, there is a need for a rational genetically based description of populations in the region. The greatest threat to the invaluable genetic resource represented by these animals is that of extensive genetic introgression of distantly related zebu cattle from northern populations which do not share their inherited tolerances. Southern blotting with a chromosome Y-specific probe, btDYZ-1 (locus DYZ1), is shown to be a sensitive assay to detect such introgression. Evidence of historical crossbreeding is reported in two important N'Dama populations previously classed as purely taurine.


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This volume is a continuation of volumes 1 and 2 of the study which were published both as ILCA Monograph no. 2, volumes 1 and 2 (1979), and as FAO Animal Production and Health Paper nos. 20/1 and 20/2 (1980) (see TTIQ, 4: nos. 1548 and 1549). Volume 1 presented the study area and its livestock and a description of trypanotolerant cattle and their productivity. Recommendations and possible locations for further evaluating the production potential and the management and conservation of these livestock breeds were also presented. Volume 2 presented detailed information on trypanotolerant livestock found in each of the 18 countries of the study area. Volume 3 is based on data collected in 1985 and thus presents major results
obtained since the publication of the earlier volumes and updates national data on trypanotolerant livestock. Part 1 analyses populations and their trends between the two surveys, reviews research and development activities, and gives recent information available on the potential and utilisation of trypanotolerant livestock. Part 2 presents recent data for the 18 study countries, as well as for Equatorial Guinea, and highlights major developments since 1977. In 1985 there were an estimated 9.8 million head of trypanotolerant cattle in the 19 West and Central African countries of the study area (4.9 million N'Dama, 2 million Savannah Shorthorn, 0.1 million Dwarf Shorthorn and 2.8 million Zebu Shorthorn crossbreds). The trypanotolerant sheep and goat populations were estimated at 12 and 20 million respectively. The trypanotolerant cattle population increased at an annual rate of 3.2% over the last 8 years (due mainly to N'Dama) while the small ruminant population remained apparently static. Unexpectedly, a relatively slow rate of crossbreeding increase between Zebu and Shorthorn cattle was seen, despite fears of possible dilution of pure breeds. During the study period, national governments have become increasingly aware of the value of their trypanotolerant livestock populations, and national research policies have focused on the development of pure breeds and traditional livestock production systems.


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Vector control and the use of trypanocidal drugs are effective but non-sustainable control methods for trypanosomiasis. The trypanotolerance of N'Dama cattle is reviewed and the use of trypanotolerant livestock is envisaged as an additional and sustainable method of control. N'Dama cattle currently comprise about 6% of the African cattle population and have been shown to have a higher productivity potential at village level than was previously assumed. N'Dama trypanotolerance is an innate characteristic which can be enhanced by improving rearing conditions. The analysis of a large
data base has shown PCV values to be a useful selection criterion for trypanotolerance. Economically sound breeding programmes for increased productivity and trypanotolerance are now feasible. It should soon be possible to accelerate selection by the use of genetic markers and by the introgression of trypanotolerance genes to improve the resistance of other breeds.


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The high ability of African buffalo, as compared to domestic cattle, to control infections with *Trypanosoma brucei brucei* ILLat 1.4 organisms did not correlate with the timing or magnitude of parasite surface coat-specific antibody responses and may have resulted from the constitutive presence in buffalo blood of a novel trypanocidal factor. Buffalo plasma and serum contained material that killed bloodstream stage *T. b. brucei*, *T. b. rhodesiense*, *T. b. gambiense*, *T. evansi*, *T. congolense* and *T. vivax* organisms during 4 h of incubation at 37°C in vitro. Serum from eland was also trypanocidal whereas serum from oryx, waterbuck, yellow-back duiker, cattle, horse, sheep, goat, mouse, rat and rabbit was not trypanocidal. The buffalo serum trypanocidal material was not lipoprotein or IgG and had the following properties: (i) a density of > 1.24 g/ml determined by flotation ultracentrifugation; (ii) insolubility in 50% saturated ammonium sulphate; (iii) non-reactivity with anti-bovine IgM and anti-bovine IgG; (iv) non-reactivity with protein G and protein A; (v) a relative molecular mass of 152 kDa determined by chromatography on Sephacryl S 300 and of 133 kDa determined by chromatography of the 50% SAS cut of IgG-depleted buffalo serum on Superose 12; (vi) no associated cholesterol; and (vii) inactivation by digestion with proteinase K that was immobilised on agarose.


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Differences in the distribution and concentration of \( O \)-acetyl and glycolyl groups in erythrocyte sialic acids of trypanotolerant N'Dama and trypano-susceptible Zebu cattle were investigated. Erythrocyte surface sialic acid concentrations were 25.4 \( \pm \) 5.5 mg/dl and 5.9 \( \pm \) 0.97 mg/dl in N'Dama and Zebu animals, respectively. In N'Damas, \( O \)-acetyl and glycolyl groups were present in concentrations of 16.4 \( \pm \) 4.3 mg/dl and 12.8 \( \pm \) 2.9 mg/dl, respectively, whereas the corresponding values in Zebus were 2.8 \( \pm \) 5.0 mg/dl and 7.6 \( \pm \) 1.7 mg/dl, respectively. The differences between N'Dama and Zebu cattle in surface sialic acids and in \( O \)-acetyl and glycolyl groups were significant (\( P < 0.01 \) to \( < 0.001 \)). N'Dama erythrocyte sialic acids had more \( O \)-acetyl than glycolyl groups while those of Zebus had less \( O \)-acetyl than glycolyl groups. These findings may be relevant to the trypanotolerance of N'Dama cattle.


This popular article describes the research carried out by ILRAD and other members of the African Trypanotolerant Livestock Network to produce trypanotolerant cattle. Breeding trypanotolerant strains such as N'Dama cattle by conventional means will not produce sufficient numbers of resistant stock. Geneticists working on bovine genome projects aim to identify 200 genetic markers for trypanotolerance and other traits that will increase productivity. To produce the cattle needed for gene mapping, trypanotolerant N'Dama bulls were crossed with susceptible Boran cows using embryo transfer technology. The F2 generation will be exposed to trypanosomes and its DNA analysed. The identification of genetic markers will involve 'bulked segregant analysis' using random amplified polymorphic DNA markers (RAPDs). The possible trans-ference of trypanotolerant traits from an N'Dama foetus to a Boran foetus simultaneously implanted in a Boran cow is being investigated.

(d) TREATMENT
[See also 17: no. 8477.]


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Fifteen Boran cattle from a trypanosomiasis-free area were injected i.m. with isometamidium chloride at a dose of 1 mg/kg body weight. Thereafter, the cattle were challenged at monthly intervals with *Glossina morsitans centralis* infected with one of three populations of *Trypanosoma conglobense* (IL 3893, IL 3889 or IL 1180) until all animals became infected. Isometamidium concentrations in the sera of these cattle were measured using a competitive enzyme-linked immunosorbent assay over the first 105 days following treatment. All cattle challenged with IL 3893 or IL 3889 developed infection following the first challenge, at which time the mean serum drug concentration in all treated cattle was 6 ng/ml. Cattle challenged with IL 1180 became infected following six to eight monthly challenges. The mean serum drug concentration in these cattle at the time of their third monthly challenge with IL 1180 was 0.75 ng/ml. Trypanosome populations IL 3893 and IL 3889 were considered to be highly resistant to isometamidium, while IL 1180 was relatively sensitive. It was therefore concluded that *T. conglobense* persisting at serum isometamidium concentrations greater than 0.75 ng/ml can be considered moderately resistant, while those persisting at concentrations greater than 6 ng/ml can be considered markedly resistant. These results will be most valuable in the investigation of isometamidium resistance of *T. conglobense* in the field.


ILRAD, P.O. Box 30709, Nairobi, Kenya. (Correspondence to Peregrine.)

Goats infected with *T. conglobense* (IL 3274) were cured when given a single 7.0 mg/kg dose of diminazene aceturate i.m. on day 1 of infection but not on day 19, approximately 3 days after the appearance of trypanosomes in the peripheral blood. The parasitaemic profiles of this latter group were similar to those observed when relapse occurs after the survival of parasites in drug inaccessible foci. Lumbar CSF was collected daily by cannulation from 3 days before infection until 3 days after trypanosomes had
reappeared following treatment on day 19 (days 25–27 p.i.). None of the samples contained trypanosomes or trypanosomal antigen, suggesting that the reappearance of *T. congolense* in these goats after treatment was not due to reinvasion from the CNS. The findings do not exclude the possibility that trypanosomes may have survived in sites such as the microcirculation, lymph nodes, spleen, heart or bone marrow.

7. experimental trypanosomiasis

(a) DIAGNOSTICS


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Modern biotechnology has provided new techniques for veterinary medicine which are applicable to trypanosomiasis control. These include the use of monoclonal antibodies in diagnostic assays, and DNA probes for the detection of *Trypanosoma* species. The use of these techniques is briefly described. The development of a new generation of subunit vaccines, including anti-idiotypic vaccines, may provide effective vaccines for many parasitic diseases. Immunisation with an anti-idiotypic vaccine has protected mice against infection with *T. brucei rhodesiense*, but these vaccines are limited by their specificity and low immunogenicity.

(b) PATHOLOGY AND IMMUNOLOGY

[See also 17: nos. 8519, 8533, 8544.]

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(c) CHEMOTHERAPEUTICS

[See also **17**: nos. 8546, 8550, 8554.]


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The relationship between the host immune system and
Chemotherapy in the treatment of trypanosomiases is reviewed. In animal models suramin and quinapyramine appear to require an intact immune system for the rapid removal of trypanosomes from the bloodstream, but the precise mechanism remains unclear. The immune system has also been shown to play a significant role in the effectiveness of DFMO chemotherapy in African trypanosomiasis: the drug was unable to clear *Trypanosoma brucei* spp. infections in immunosuppressed mice. It was concluded that antibody was necessary to remove DFMO-treated trypanosomes from the bloodstream and the successful treatment of athymic mice showed the antibody response to be T cell-independent. The inhibition of macromolecular synthesis, including VSG, by DFMO could be an important component of the relationship between DFMO and an effective antibody response. An antibody response may also be important in treatment with melarsoprol (Mel B) or oxophenarsine. Repeated subcurative treatment with Cymelarsan, Berenil or isometamidium led to the development of drug resistant trypanosomes only in immunosuppressed animals, suggesting that the state of the host immune system is important in the development of drug resistance.


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8. trypanosome research

(a) CULTIVATION OF TRYPANOSOMES

[See also 17: no. 8578.]


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Procyclic trypanosomes from wild tsetse flies were membrane-fed to Glossina morsitans centralis in order to develop an optimal technique for propagating field isolates. A 70% success rate was achieved in isolating Trypanosoma simiae and a variety of genotypes of T. congolense originating from G. pallidipes, G. brevipalpis and G. swynnertoni. Parasites matured into forms infective for mammals, and could be maintained by passage of gut forms to new groups of flies. In experiments with laboratory stocks, we also passaged immature gut infections of T. congolense and T. brucei from various tsetse species to G. m. centralis. The optimal technique was investigated for procyclic T. congolense through addition of various compounds to goat blood using G. m. centralis and G. m. morsitans as recipients. From these experiments, many approaches to procyclic expansion appeared possible. However, a simple and practical method based on the use of fresh goat blood for rapid feeding of G. m. centralis is recommended. Application of this technique should aid in the resolution of questions relating to the cryptic diversity of Nannomonas trypanosomes in diverse host and vector communities.

(b) TAXONOMY, CHARACTERISATION OF ISOLATES
[See also 17: no. 8570.]


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8540 Waitumbi, J.N. and Young, J.R., 1994. Electrophoretic karyotyping is a sensitive epidemiological tool for studying Trypanosoma evansi infections. Veterinary Parasitology,
Thirty-six isolates of *Trypanozoon* trypanosomes collected from camels in northern Kenya during the dry season sporadic infections of 1986 and during the wet season epidemic infections of 1987 were identified as *T. evansi* by the homogeneity of their kinetoplast DNA minicircles. Although the minicircles of all the isolates were indistinguishable, polymorphism in chromosome-sized DNA molecules detected by electrophoresis was extensive. The isolates could be grouped into eight distinct electrophoretic karyotypes which could be distinguished from three additional karyotypes identified among earlier *T. evansi* isolates. In one camel herd with a long history of trypanocide application, which was continued during the present study, all isolates bar one belonged to one karyotype group. From a second herd, in which trypanosomiasis management was by individual treatment of proven parasitaemic cases, isolates with diverse karyotypes were obtained. Some of the karyotypes identified during the dry season sporadic infections were re-isolated in the subsequent wet season epidemic. These observations indicate that distinguishing *T. evansi* isolates by molecular electrophoretic karyotypes is more discriminating than kDNA analysis. Observations of karyotype patterns recurring in isolates from herds kept under chemoprophylaxis could help in the identification of drug-resistant parasites.

(c) LIFE CYCLE, MORPHOLOGY, BIOCHEMICAL AND MOLECULAR STUDIES


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