Trop Anim Health Prod (2006) 38: 29–34
DOI 10.1007/s11250-006-4343-2

ORIGINAL ARTICLE

Evaluation of a preliminary title to protect zero-grazed dairy cattle with insecticide-treated mosquito netting in Western Kenya

B. Bauer · D. Gitau · F.P. Oloo · S.M. Karanja

Accepted: 28 September 2005

Abstract The incidence of trypanosome infection was monitored in dairy cattle during a 6-month trial in Busia and Teso districts, western Kenya, to assess the efficacy of insecticide-treated netting for protection against tsetse flies. Frequently, the fragile netting did not last longer than 2 months because of destruction by strong wind or animal movements. Also, many farmers let their cattle graze freely outside the units during the day, despite technical advice, resulting in exposure of the free-ranging animals to habitats suitable for tsetse and thereby an increased risk of trypanosome infections. The trial groups thus comprised 34 animals from 11 dairy units that were continuously protected, and 153 animals from 46 dairy units that were partially protected. The control group consisted of 162 animals in 42 unprotected units. The phase-contrast buffy-coat technique was used for parasitological monitoring. The mean hazard rate for trypanosomes was significantly lower in protected cows, with a value of 0.007 as opposed to 0.02 for the control animals. Mean packed cell volumes (PCV) were significantly higher in protected cattle (29.7%) than in unprotected ones (27.6%). Farmers with protected animals also reported fewer nuisance flies and mosquitoes in their compounds.

Keywords Dairy cattle · *Glossina* spp · Insecticide-treated netting · Trypanosome infections · Western Kenya · Zero-grazing units

Abbreviations

BCT	buffy-coat technique
bw	body weight
MHR	mean hazard rate
PCV	packed cell volume

Introduction

Small-scale farmers keep more than 80% of the three million dairy cows in Kenya, producing between 75% and 90% of all milk (Government of Kenya, 1986). Many of these cows are confined to zero-grazing units with all their feed and water carried to them. This reduces the exposure of the valuable cows to many vector-borne diseases (Muraguri, 2000). In tsetse-infested areas such as western Kenya, the flies can enter the units and feed on these animals, which may then become infected, resulting in trypanosomosis. Attempts to control the disease are based on the use of trypanocidal drugs: diminazene aceturate (Berenil, Intervet) for therapy or

B. Bauer (✉)
Institute for Parasitology and International Animal Health, Free University of Berlin, Berlin, Germany
e-mail: burkhard.bauer@gmx.net

B. Bauer · D. Gitau · F.P. Oloo · S.M. Karanja
Farming in Tsetse Controlled Areas–Kenya (FITCA-K), African Union (AU/IBAR), Nairobi

S.M. Karanja
Kenya Agricultural Research Institute, Trypanosomiasis Research Centre (KARI-TRC), Kikuyu, Kenya

isometamidium chloride (Samorin, Merial) for prophylaxis. The frequent and continuous use of trypanocidal drugs can result in drug resistance of the exposed trypanosome populations.

Farmers still need to spend a considerable amount of money on trypanocidal drugs even where there are low densities of tsetse. Treatment may cure the cows but will not always prevent abortions or stillbirths and reduced milk production. Death in untreated cows is an inevitable consequence. Two tsetse species occur in western Kenya: *Glossina fuscipes fuscipes* and *G. pallidipes*. At present the tsetse densities are generally below 1 fly per trap per day—this is the case in most parts of the districts. The divisions of Funyula and Budalang'i in Busia District still have relict populations of *G. pallidipes* and densities of *G. f. fuscipes* sometimes reaching 5 flies per trap per day. This is due to the proximity of the fringing vegetation, which borders the shores of Lake Victoria (Karanja *et al.*, 2003). Localized tsetse control efforts (treatment of exposed dairy animals with an insecticide, deployment of traps in the vicinity) have only marginally improved the situation. As a result, many farmers have given up dairy farming in tsetse-infested areas owing to the disease risk and the ensuing losses.

Various authors have used pyrethroid-treated cloth for traps or targets to control tsetse (Laveissière *et al.*, 1985; Vale *et al.*, 1988; Bauer *et al.*, 1999). Mosquito netting can also be treated with a pyrethroid. Of particular significance to the control of tsetse flies is one facet of their behaviour: tsetse usually attack at a height of less than 100 cm above ground level. Hence, surrounding the zero-grazing units with insecticide-treated mosquito netting to a height of 150 cm should protect the cows by killing the flies. To test this hypothesis a trial using this strategy was undertaken in the districts of Busia and Teso in western Kenya.

Materials and methods

Description of the study area

Busia District lies between latitudes 0°1′36″ S and 0°33′ N and longitudes 33°54′32″ and 34°25′24″ E. The district is bordered by Butere-Mumias District to the east, Bungoma to the north-east, Teso District to the north, Siaya to the south-east, Bondo District to the south, and Lake Victoria and the Republic of Uganda to the west. The district lies within the Low Midland (LM) zone. It is divided into four agroecological zones and has an altitude ranging between 1130 and 1375 m above sea level. The long rains occur between March and May and the short rains start in late August and continue into October. The mean annual rainfall amounts to 1500 mm, with most parts of the district receiving between 1270 mm and 1790 mm (Ministry of Finance and Planning, 2002).

The total human population of Busia District is 370 608 (Ministry of Finance and Planning, 2002). A recent livestock census survey indicated that there were 74 818 cattle, 50 141 goats, 28 194 sheep, 21 280 pigs and 2118 donkeys (FITCA-K, 2000, 2001).

Design of the trial

Fifty-seven randomly selected dairy units were protected with netting and another 42 randomly selected units served as controls. The dominant cattle breeds in the trial were Holstein-Friesian and Ayrshire. Black mosquito netting of 75 denier mesh (Vestergaard Frandsen A/S, Disease Control Textiles, Kolding, Denmark), was soaked in a 0.6% solution containing the residual pyrethroid insecticide beta-cyfluthrin, (Tempo SC, Bayer East Africa Ltd, Nairobi, Kenya, 125 g/L of active ingredient). Bands of the treated mosquito netting were attached with pieces of wire to the poles of the zero-grazing units to a height of 150 cm above the ground, completely surrounding the pens. The persistence of the insecticide in the net was evaluated regularly during the trial period. Based on an exposure for 30 s to the net, the flies were expected to enter a state of paralysis within the next 15 min, all insects showing the classic signs of pyrethroid poisoning.

All cattle (except those in late-stage pregnancy) were given a therapeutic dose of diminazene aceturate, (3.5 mg/kg bw). After the initial treatment, all animals were monitored at monthly intervals to determine the incidence of trypanosomosis, using the phase-contrast buffy-coat technique (BCT) (Murray *et al.*, 1977). A 'case' of trypanosomosis was defined as 'positive detection of trypanosomes (*T. vivax*, *T. congolense*, *T. brucei* or mixed infections) in a buffy-coat smear by microscopy'. Only trypanosome-positive or suspect cases with a packed cell volume (PCV) below 25% were given a new trypanocidal treatment with diminazene aceturate. The trial started in September 2001 and lasted until March 2002.

Wind and movement of cattle inside the pens led in many cases to the destruction of the fragile netting material in less than 2 months. Protection of the net with chickenwire – as was done by some farmers – proved effective in keeping the netting intact for up to 12 months. Some farmers did not leave the netting in place or kept their cattle on a free-grazing range during much of the trial period.

Data analysis

Data were coded and entered into Microsoft Access. Statistical analyses were carried out using Epi Info 2000 and Microsoft Excel. *p*-Values were set at 5% (two-sided).

The total animal-time at risk was calculated and expressed as animal-weeks at risk. The animal-weeks at risk were then summed up for the entire 6-month trial period, stratified according to trial groups. Based on the 14-day prophylactic activity of diminazene aceturate (Karanja *et al.*, 2002), treated animals were considered not at risk of trypanosome infection for the first 14 days post treatment. The incidence density was then determined as:

$$\text{Incidence density} = \frac{\text{Number of new trypanosome infections within 24 weeks}}{\text{Total animal-weeks at risk during the 24 weeks}}$$

The trypanosome incidence density in cattle was expressed as a mean hazard rate (MHR). The mean hazard ratio was then computed to compare the risk of new trypanosome infections between the unprotected and protected cattle. This was determined as the reciprocal of the ratio of MHR in protected to that in control animals. Student's *t*-test was used to assess the differences between the PCV profiles for protected versus unprotected cattle. The differences in willingness to invest by farmers owning protected versus those with unprotected units was assessed in a randomized study of the 'real options theory of investment' (Habyarimana, 2002).

Results

The insecticide-treated netting significantly reduced the risk of trypanosome infection in cattle. The probability of contracting trypanosome infections expressed as MHR was significantly higher for unprotected than for protected cattle (Table 1). The MHR also indicated that unprotected animals had a 2.9 times higher risk of trypanosome infection than protected animals. The overall mean PCV in the control group was significantly lower than in the protected group (Table 1). PCV values are useful indicators of health. Figure 1 shows the trend of PCV profiles. At the beginning of the trial, the mean PCV values in both groups were slightly lower than 28%. In the course of the trial, the mean PCV for the protected animals increased to significantly higher values (between 30% and 32%) than those recorded for the control group (26–28%). Incomplete protection due to physical damage to the nets or time-bound protection (free-range grazing during daytime) increased the infection risk when compared to animals under continuous protection but still offered an advantage in comparison to a system with no protection.

Table 1 Mean hazard rate of trypanosome infection and percentage overall mean packed cell volume (PCV) of 162 unprotected and 187 protected zero-grazed cattle from Busia District during a 6-month follow-up period (September 2001–March 2002)

	Unprotected	Protected
Mean hazard rate	0.02^{a}	0.007^{b}
Overall mean PCV (%)	27.6 ± 0.6^{a}	29.7 ± 0.4^{b}

[a,b]Different superscript letters denote significant differences within a row of comparison

Less than 1 h after the attachment of the net, no nuisance flies were detected in the protected pens. This, together with the reduction in disease risk, contributed to improvements of the PCV profiles, as shown in Table 1 and Figure 1. Defensive movements of the protected cattle became less frequent in consequence, leading to undisturbed fodder uptake and sufficient resting of the animals. The farmers also observed that their cows remained calm during milking. Exposure of freshly caught flies to treated netting material confirmed a persistence of insecticide on the nets for more than 6 months.

t-Test comparison of trypanocidal treatments of unprotected cattle with protected cattle in Budalang'i and Funyula divisions revealed that unprotected animals had significantly higher mean costs ($p < 0.05$) for treatment.

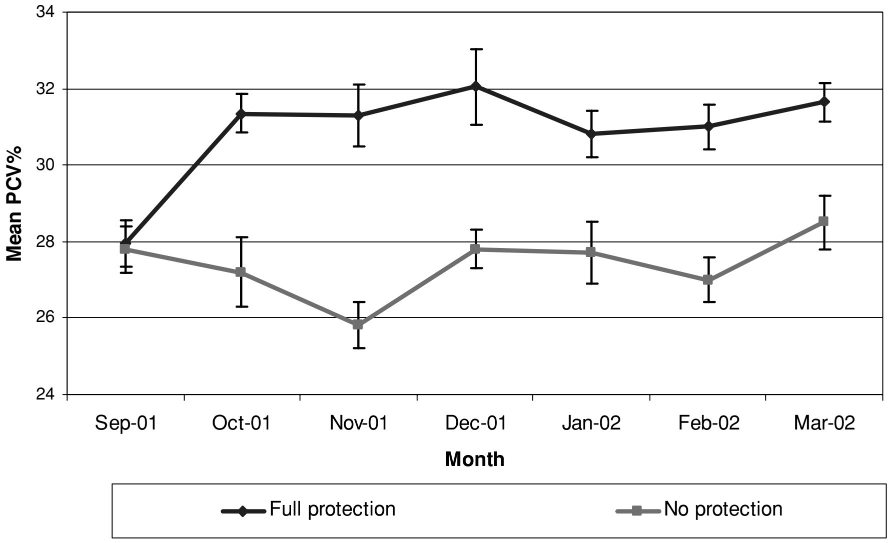

Fig. 1 Mean monthly PCV% and 95% confidence intervals for fully protected and unprotected cattle at the onset of the trial and during the 6-month follow-up period

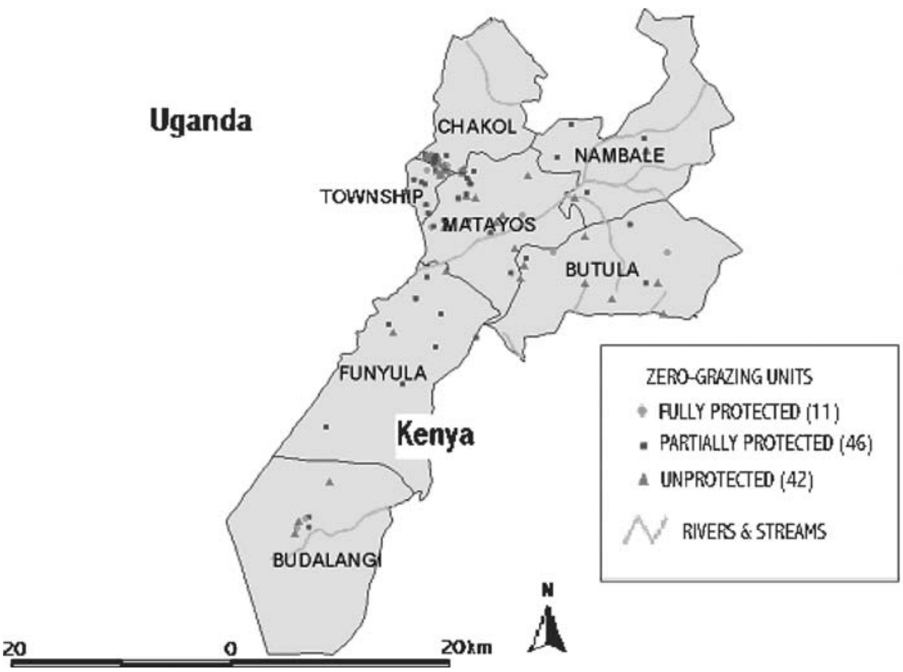

Fig. 2 Geo-referenced distribution of protected and unprotected zero-grazing units, Busia District and Chakol Division, Teso District

Discussion

Insecticide-treated targets have been widely used for tsetse control, particularly against savannah (*morsitans* group) species. In this case the effects of protected units on the surrounding area appeared to benefit other, unprotected livestock. Given the spatial distribution of the randomly selected pens (Figure 2), these externalities might have occurred over a larger area, thus also benefiting unprotected pens. Most of the units are located in a cluster-like distribution in township division of Busia district. It remains to be seen whether in areas of high tsetse densities protected zero-grazing units are working as 'super targets'—the perimeter of an average unit measuring 30–45 m^2 compared to a target with a width of just 2 m^2. Protecting valuable livestock as a private good with insecticide-treated netting would not only result in productivity increases and lower morbidity and mortality but would also support tsetse control campaigns, thus achieving a public good. Farmers further reported a reduction in the number of biting flies, mosquitoes and houseflies in their homesteads, warranting additional quantitative assessments of insect population changes in the vicinity of protected units. The role of nuisance flies and mosquitoes in the transmission of zoonoses, for instance enteric and viral diseases by house and latrine flies, or arbovirus infections transmitted by mosquitoes, has been described elsewhere (Curtis, 1998; Reeves, 1990). The results also indicate that partial protection as a consequence of free-range grazing during the day or incomplete protection due to net damage still appeared to offer some advantages when compared with unprotected animals. This observation should be further evaluated, particularly in extensive cattle management schemes as practised by pastoral communities where cattle are kept near the settlements from late afternoon until the next morning when milking has been completed.

Mean differences in milk production between the experimental and control groups were not significant despite immediate increases in milk production in individual cows. Breed differences, different animal husbandry management skills and systems, as well as varying physiological stages of lactation did not allow for a between-group comparison of milk production. The results further suggest that the disease risk of trypanosome infections is only one constraint for optimal milk production in western Kenya, nutrition probably being another important factor. But the impact of constant harassment of dairy cattle by nuisance flies can be considered as a constraint to production. Measuring the daily amount of blood uptake by African Stomoxyinae (Mihok *et al.*, 1995), it was found that the average blood-meal of a single *Stomoxys* amounted to 13.7 ± 0.6 mg. One hundred flies successfully feeding in a single day would not be exceptional, representing a total loss of 1370 mg/day or more than 40 g per month. Perhaps more importantly, continuous disturbance by biting flies distracts the cows from feeding and resting. The same authors (Mihok *et al.*, 1995) also confirmed the potential role of African Stomoxyinae in the mechanical transmission of *Trypanosoma* spp. Another way to obtain information about the impact of the intervention is to ask farmers about their perceptions. The willingness of farmers to invest is an appropriate way to assess these changes. Investment could be defined, for instance, as purchasing a pregnant heifer, taking a cow for service, having the animals vaccinated or increasing the amount of high-quality feed offered (Habyarimana, 2002). Preliminary results suggest that farmers with netted units invested more than farmers in the control group.

Acknowledgements

FITCA-Kenya was a project funded by the European Union (EU) and implemented through the African Union/Inter-African Bureau for Animal Resources (AU/IBAR). The authors acknowledge the support of the Ministry for Livestock and Fisheries Development. Bayer AG and Vestergaard Frandsen provided the project with the necessary material for the trial. The authors also acknowledge the support of Peter-Henning Clausen for his advice and helpful comments on the manuscript.

References

Bauer, B., Amsler-Delafosse, S., Kabore, I. and Kamuanga, M., 1999. Improvement of cattle productivity through rapid alleviation of African animal trypanosomosis by integrated disease management practices in the agropastoral zone of Yalé, Burkina Faso. *Tropical Animal Health and Production*, **31**, 89–102

Curtis, C., 1998. The medical importance of domestic flies and their control. *Africa Health*, **20**(6), 14–15

FITCA-K, Farming in Tsetse Controlled Areas, 2000. *First Annual Progress Report and Financial Statement of Project Activities, March 1999–March 2000*. Delegation of the European Commission, Nairobi, Kenya

FITCA-K, Farming in Tsetse Controlled Areas, 2001. *Second Annual Progress Report and Financial Statement of Project Activities. March 2000–March 2001*. Delegation of the European Commission, Nairobi, Kenya

Government of Kenya, 1986. *Publication on Economic Management for Renewed Growth, Sessional Paper no. 1*, (Government Printer, Nairobi, Kenya)

Habyarimana, J., 2002. *Real options theory of investment: evidence from a randomised study*, (Paper presented at a World Bank meeting in Washington DC, oral presentation)

Karanja, W.M., Mdachi, R.E. and Murilla, G.A., 2002. A competitive enzyme-linked immunosorbent assay for diminazene. *Acta Tropica*, **84**, 75–81

Karanja, SM., Karanja, J.N., Murekefu, W.K., Oloo, F.P., Bauer, B., Clausen, P.-H. and Zessin, K.H., 2003. A survey of trypanosomosis, helminthosis and tick-borne diseases in Busia district, Kenya. *Proceedings of the 27th ISCTRC Meeting* (*29 September–3 October 2003*), Pretoria, South Africa. Delegation of the European Commission, Nairobi, Kenya

Laveissière, C., Couret, D. and Traore, T., 1985. Tests of efficacy and persistence of pesticides used for cloth impregnation in traps for tsetse fly control. 1: Experimental protocol – the knock down action of pyrethroids. *Cahiers ORSTOM, Série Entomologie Médicale et Parasitologie*, **23**(1), 61–67

Mihok, S., Maramba, O., Munyoki, E. and Kagoiya, J., 1995. Mechanical transmission of *Trypanosoma* spp. by African Stomoxyinae. *Tropical Medicine and Parasitology*, **46**, 103–105

Ministry of Finance and Planning, 2002. Effective management for economic growth and poverty reduction. *District Development Plan, 2002–2008*. Government Printer, Nairobi, Kenya

Muraguri, G.R., 2000. *Epidemiology and financial impact of vector-borne diseases on productivity of smallholder cattle in the coastal lowlands of Kenya*, (PhD thesis, Department of Agriculture, University of Reading, UK)

Murray, M., Murray, P.K. and McIntyre, W.I.M., 1977. An improved parasitological technique for the diagnosis of African trypanosomiasis. *Transactions of the Royal Society of Tropical Medicine and Hygiene*, **71**, 325–326

Reeves, W.C. (ed.), 1990. *Epidemiology and Control of Mosquito-borne Arboviruses in California, 1943–1987*, (California Mosquito and Vector Control Association, Sacramento, CA)

Vale, G.A., Lovemore, D.F., Flint, S. and Cockbill, G.F., 1988. Odour-baited targets to control tsetse flies, *Glossina* spp., in Zimbabwe. *Bulletin of Entomological Research*, **78**, 31–49

Évaluation d'un essai préliminaire visant à protéger le bétail non mis en pâturage avec un voile à moustiques traité par un insecticide dans l'Ouest du Kenya

Résumé – L'incidence d'une infection à trypanosomes a été surveillée sur des vaches laitières au cours d'un essai de six mois entrepris dans les districts de Busia et de Teso, dans l'Ouest du Kenya, afin d'évaluer l'efficacité d'un voile traité par un insecticide à titre de protection contre les mouches tsé-tsé. Bien souvent, le voile fragile ne durait pas plus de deux mois en raison de sa destruction par un vent fort ou par les mouvements des animaux. De nombreux cultivateurs laissent en outre leur bétail paître librement hors des unités durant la journée, en dépit des conseils techniques qui leur sont donnés, ce qui entraîne l'exposition des animaux de ferme à des habitats appropriés aux mouches tsé-tsé et de ce fait, à un risque accru d'infections à trypanosomes. Les groupes de l'essai se sont donc composés de 34 animaux de 11 unités de vaches laitières qui étaient continuellement protégées et de 153 animaux de 46 unités de vaches laitières qui étaient partiellement protégées. Le groupe témoin a consisté en 162 animaux dans 42 unités non protégées. La technique de couche leucocytaire par contraste de phase a été utilisée pour le contrôle parasitologique. Le taux moyen de risque de trypanosomes a été considérablement plus bas chez les vaches protégées avec une valeur de 0.007 par opposition à 0.02 pour les animaux témoins. Les volumes moyens des hématies concentrées (PCV) ont été considérablement plus élevés dans le bétail protégé (29.7%) que dans le bétail non protégé (27.6%). Les fermiers ayant des animaux protégés ont également signalé moins d'embêtement par les mouches et les moustiques dans leurs enclos.

Evaluación de un estudio preliminar para proteger al ganado lechero que no ha pastado con red de mosquito tratada con insecticida en Kenia Occidental

Resumen – Se monitorizó la incidencia de infección por tripanosomas en el ganado lechero durante una prueba de seis meses en los distritos de Busia y Teso, en Kenia occidental, para evaluar la eficacia de una red o malla tratada con insecticida para la protección contra las moscas tse-tsé. Con frecuencia la frágil red no duraba más de dos meses debido a la destrucción por fuertes vientos o al movimiento de animales. Además, muchos granjeros dejaban a su ganado pastar libremente fuera de las unidades (de no pastos) durante el día, a pesar del asesoramiento técnico, resultando con ello en exposición de los animales que se mueven libremente a hábitats idóneos para los mosquitos tsetsé y por consiguiente de un riesgo incrementado de infecciones por tripanosomas. Los grupos de estudio comprendieron 34 animales de 11 unidades lecheras que estaban continuamente protegidas, y 153 animales de 46 unidades lecheras que estaban parcialmente protegidas. El grupo control consistió en 162 animales en 42 unidades no protegidas. Para el seguimiento parasitológico se empleó la técnica de contraste de fase del "buffy coat" o extracción de la capa leucoplaquetaria. La tasa media de riesgo para tripanosomas fue significativamente más baja en las vacas protegidas, con un valor de 0.007 en comparación con 0.02 para los animales control. Los volúmenes celulares empaquetados (PCV) medios fueron significativamente más altos en el ganado protegido (29.7%) que en el no protegido (27.6%). Los granjeros con animales protegidos también informaron sobre menos molestias de moscas y mosquitos en sus recintos.