Observations on the trypanosomosis problem outside the tsetse belts of Sudan

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Summary
Entomological and trypanosomosis surveys were conducted in the Blue Nile area between Admazien and Khartoum. The surveys showed the area to be tsetse free. The only species of trypanosome found to infect cattle in this study was Trypanosoma vivax, which infected some of the local cattle that had no history of entering tsetse belts. The prevalence of disease varied with the season. High disease prevalence coincided with the periods when tabanid and stomoxy flies were abundant. The study showed that the months when biting flies were most numerous coincided with trypanosomosis outbreaks, but even minimal numbers of these flies may cause the cycle of mechanical transmission to continue in stable enzootic conditions.

Keywords

Introduction
Tsetse flies in Sudan are active in a total area of about 300,000 km² of fertile land. Lewis (19) described this belt as a horseshoe around the Nile swamps with three gaps: the valley of Bahr Al Gazal, the arid country east of Kapoeta, and the Sobat area where the tsetse fringe passes through Ethiopian territory (Fig. 1). Many efforts have been made to control tsetse flies in Sudan (2, 26).

Trypanosomosis among all species has, since the beginning of the 20th Century, been regarded as the most serious animal disease problem in Sudan (5). Trypanosoma vivax occurs in most parts of the country, and has been diagnosed in sedentary cattle up to the 14th parallel in Dueim Province (G. Uilenberg, unpublished report). There is a long history of major mass treatment campaigns that have attempted to control bovine trypanosomosis in Sudan (11, 23).

During the period from 1972 to 1983, the level of bovine trypanosomosis in South Darfur remained stable, as discussed by Hall et al. (15), who attributed this to the use of trypanocidals by the cattle owners. However, a serious trypanosomosis problem developed as trypanosomes became increasingly resistant to the available trypanocidals (21). Recent studies conducted in different parts of Sudan showed that the disease is spreading throughout the country (3, 4, 7, 24).

Material and methods
Three major entomological surveys were made during this study. The first was conducted during the dry season (from March to June) of 1992. In this survey, over 1,500 head of cattle were examined at eight base camps. These localities included Khartoum, where 400 cattle were examined in the dairy farms of Soba, Khartoum North (Hillat Kuku) and Jabal Awlia on the White Nile. All these cattle were resident animals owned by the villagers living around the base camps, and some were a cross between imported Friesian and local breeds.

The second survey was conducted during the late rainy season and early dry season (September, October and November) of 1993, in the same areas as the first survey.
and examining much the same herds. (However, the Um Darfa and Magaja areas could not be reached due to waterlogged conditions.)

The third survey, which was conducted in 1994 and in which 800 head of cattle were examined, coincided with an outbreak of bovine trypanosomosis among cattle in the Blue Nile Provinces. The affected areas extended from Khartoum to Wad El Nayar, midway between Sinjah and Admazien (Fig. 2). In all, 13 localities around Sinjah station were infected, and references in this paper to Sinjah’s rate of infection should be taken as the overall rate of all these localities. Two of these were sites of national importance:
– the Blue Nile University Dairy Farm, where trypanocidal chemoprophylaxis is practised
– the Sudan Arab Kinaf Company.

The two sites are about six km apart.

All the 16 cows on the dairy farm of the Blue Nile University were treated at monthly intervals with ethidium bromide during the rainy season. The herd of the Arab Kinaf Company was composed of 180 lactating cows of a cross-breed (Friesian/local Kenana). The herd was created as the start of a national milk production project planned for the agricultural irrigated schemes of the Blue Nile states.

**Entomological sampling methods**

**Standard fly rounds by screen patrol**

In this method, fly surveys were conducted by a patrol team of four members. Using hand nets at stopping points every 100 m, the team captured flies that were attracted to a black screen held vertically between two of the members, while a third chose the route and the fourth recorded catch data and information on host availability (animals and their spoor) and vegetation cover. The team collected samples over a transect of 10,000 metres on each round of their patrol. During the first survey conducted along the Blue Nile, four fly patrol transects were studied, to the north, south, east and west of the base camp where the survey team was camping. The same transect procedure was repeated during the following seasons.

**Trapping**

Two kinds of traps were used in these studies.

**Collapsible canopy trap**

The canopy trap of Axtell et al. (6) was modified into a collapsible pyramidal frame of four metal pipes, with a pyramidal cloth cover and a removable non-return collection cage (Fig. 3). A black cloth was attached to the netting on the upper edge of the cloth to improve the efficiency of the trap.

**Modified F3 trap**

This trap is a locally made variant of the F3 trap developed in Zimbabwe. The design differs from the F3 trap in its three-walled triangular shape (12). The cone, the central pole and the non-return collecting cages were similar to those of the biconical trap (Fig. 4).

Four traps were used in the surveys, two of each type. In each place surveyed, the trapping period lasted seven days, and the mean catch per trap per day was calculated for each locality. In Sennar, the seasonal abundance of biting flies was studied over a one-year period by means of an
F3 trap. Daily catches, from a single trap deployed permanently near the experimental animal fence of Sennar Veterinary Research Laboratory, were recorded and the monthly total catches for the year were assessed.

**Parasitological examination**

Blood samples were collected early in the morning (07.30 am to 10.30 am) from the ear veins of the animals examined. The samples were collected into heparinised microhaematocrit centrifuge capillary tubes and centrifuged for five minutes at 12,000 r.p.m. using a microhaematocrit centrifuge. Then the Buffy layer and neighbouring red blood cells in each sample were extruded on a glass slide, covered with cover slips (22 mm × 22 mm) and examined under a light microscopic with 40 phase contrast objective for the presence of motile trypanosomes, which could be differentiated by their motility (22).

**Entomological results**

No tsetse flies were caught during these surveys by either the screen fly patrol teams or the traps. The biting flies that were identified at the different survey stations are listed in Table I.

The first trypanosomosis survey was conducted along the Blue Nile from Khartoum to a point near the Sudanese-Ethiopian border. As mentioned earlier, the survey was conducted during the months of the hot dry season (March to June). The sugar-factory area of northwest Sennar showed the highest trypanosomosis infection rate (Table II).

The second trypanosomosis survey, conducted during the late rainy season and early dry season, examined the same localities mentioned in Table II, apart from some that were inaccessible (Table III). The infection rates were much higher during this season than those of the hot dry season.

The third trypanosomosis survey was conducted during the early dry season of 1994 after a T. vivax outbreak in Sinjah area (Table IV).
Among the cows in the dairy herd of the Arab Kinaf Company, 70% were found to be infected with T. vivax; 12 died of the disease and 100% of the infected cows aborted their calves. The farm (both the land and the cattle) was sold.

The monthly prevalence of disease among dairy cattle in Sennar town is shown in Figure 5. The prevalence is high during the months of the rainy season and early dry season (the cool season). Table V shows the overall trypanosome infection rates in the years 1991 to 1994 in Sinjah station and the annual rainfall of the same years. In the year 1994, when the rainfall was almost twice the normal amount, there was a trypanosomosis outbreak.

The total monthly catches of tabanid and stomoxy flies collected from an area around Sennar Regional Veterinary Research Laboratory showed that both the tabanid and stomoxy populations fluctuated, with the stomoxys reaching a peak in September and the tabanids in November (Fig. 6).

Table III
Trypanosomosis infection rates during the late rainy season and early dry season, 1993 (October to November) along the Blue Nile (second survey)

<table>
<thead>
<tr>
<th>Locality</th>
<th>Number of animals examined</th>
<th>Number of Trypanosoma vivax infections</th>
<th>Infection rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Khartoum</td>
<td>108</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Sennar</td>
<td>110</td>
<td>22</td>
<td>20</td>
</tr>
<tr>
<td>Sugar-factory area (northwest Sennar)</td>
<td>32</td>
<td>10</td>
<td>32</td>
</tr>
<tr>
<td>Sinjah</td>
<td>150</td>
<td>9</td>
<td>6</td>
</tr>
</tbody>
</table>

Note: The other areas studied in the first survey were not accessible at the time of this survey.

Table IV
Trypanosomosis infection rates during the early dry season of the year 1994 (October to December) along the Blue Nile (third survey)

<table>
<thead>
<tr>
<th>Locality</th>
<th>Number of animals examined</th>
<th>Number of Trypanosoma vivax infections</th>
<th>Infection rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Khartoum</td>
<td>200</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td>Sennar</td>
<td>180</td>
<td>18</td>
<td>10</td>
</tr>
<tr>
<td>Sinjah</td>
<td>300</td>
<td>81</td>
<td>27</td>
</tr>
<tr>
<td>Damazin</td>
<td>120</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>

Table V
Annual rainfall and trypanosomosis infection rates in cattle in Sinjah Area, 1991 to 1994

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of animals examined</th>
<th>Trypanosomosis infection rate (%)</th>
<th>Rainfall (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1992</td>
<td>200</td>
<td>1</td>
<td>475.3</td>
</tr>
<tr>
<td>1993</td>
<td>150</td>
<td>6</td>
<td>423.0</td>
</tr>
<tr>
<td>1994</td>
<td>300</td>
<td>27</td>
<td>938.3</td>
</tr>
</tbody>
</table>

Fig. 5
Monthly infection rate of trypanosomosis in Sennar town in 1993 and 1994
Discussion

The results of the surveys conducted during this study confirm that \textit{T. vivax} is enzootic in wide areas of Sudan more than 2,000 km away from the known tsetse belts of the country (25). Uilenberg (unpublished report) found \textit{T. vivax} infecting cattle along the White Nile in localities parallel to those mentioned in this study. Previous outbreaks of bovine trypanosomosis were reported to be due to \textit{T. congolense} (11, 17); Buxton (9) reported \textit{T. congolense} as far north as the Kosti area along the White Nile, more than 1,000 km north of the tsetse belts. He related the transmission of the disease to the enormous populations of Tabanidae and biting flies. Gardiner et al. (14) observed that, although tsetse flies are found only in Africa, it is nonetheless clear that transmission of \textit{T. vivax} between animals also occurs in other continents, for example in South and Central America. \textit{Trypanosoma vivax} has also been reported from Indonesia (8) and from the Caribbean Islands (10).

The prevalence of the disease was found to be high following seasons of high rainfall and when biting flies were abundant (G. Uilenberg, unpublished report). Karib (16) was of the opinion that bovine trypanosomosis in Sudan is mainly a problem of mechanical transmission. He reported that use of drugs meant that very few cattle die from trypanosomosis nowadays. Before the widespread use of trypanocidals, however, some trypanosomosis outbreaks caused heavy losses among cattle herds in Sudan, which may have been perpetuated by biting flies (11). John Ford (13) during his consultancy visit to the country drew the attention to the importance of Tabanidae, which spread infection widely among migrant and non-migrant cattle and camels by mechanical means.

The survey conducted during the hot dry season showed a low incidence of trypanosomosis when compared with the results obtained in the same localities in the late rainy season and early dry season (October to February). Abdel Salam (3) reported similar findings from the Sinjah area, where he found a positive correlation between trypanosomosis and the seasonal abundance of biting flies in the area.

The results showed that the high rainfall in the year 1994 was followed by a high prevalence of the disease in the Sinjah area. This correlation is a known epidemiological fact in Sudan: when there are floods, the populations of biting flies increase and there are more chances for mechanical transmission to occur. Karib (16) noted that exceptionally heavy rains in 1946 produced more extensive flooding than usual; bovine trypanosomosis in that year reached a peak unknown in previous history. Deaths among Shilluk cattle, mostly located along the White Nile far from tsetse infestations, were estimated at 50% of the total population. A temporal association between the rainy season – when biting flies, particularly tabanids, are abundant – and an increase in prevalence of \textit{T. vivax} infections in cattle in South America has been observed (10).

The intensive entomological surveys conducted for this study showed that the area of the Blue Nile from the Sudanese-Ethiopian borders to Khartoum is tsetse free. This confirms previous findings that the Khor Yabus riverine habitat is the only tsetse-infested area in the Blue Nile states (19, 20). The entomological surveys described here confirm the presence of tabanids and stomoxys in all the areas surveyed. The analysis of the seasonal abundance of biting flies made during this study showed that stomoxys are most abundant during the rainy season, reaching a peak in September, while the peak of the tabanids is in November. This agrees with the findings of Suliman (24) and Abdel Salam (3), who also found (in Sennar and Sinjah respectively) that stomoxys peak in September, although both authors found that tabanids peaked in October. Abdel Karim (1) in Nyala, South Darfur, found tabanid flies to be most abundant in October, while Hall et al. (15) reported tabanid flies from Radom, South Darfur, to reach their peak of abundance in November. This difference in peaks between Nyala and Radom was attributed to differences in the amount of annual rainfall in the two localities: rainfall in Radom is almost double that in Nyala.

The monthly prevalence study of trypanosomosis in Sennar shown in this study correlated very well with the abundance of tabanids in the area; the peaks of tabanid abundance and trypanosomosis prevalence both occurred in November. This finding is compatible with the study by Suliman (24), who also found a high prevalence of trypanosomosis in October/November, suggesting that tabanid flies may play an important role in the mechanical transmission of the disease in the area.
The epizootiology of cattle trypanosomosis in Sudan evidently cannot be studied or understood except in the context of various types of transhumance (13). During the early rainy season, the nomads slowly move with their herds from the tsetse areas of the south, following the rains and avoiding the numerous biting flies of the south, and usually reach the study areas (Sinjah, Sennar) by September. Their herds intermingle with the local cattle in the area until they move south again, either in November, when the dry season begins in the study area, or in December in the case of herds that remain to graze the post-harvest products of the agricultural projects (3).

Studies conducted in these migratory herds showed that the cattle harboured all the species of the pathogenic trypanosomes in their blood (T. vivax, T. congolense and T. brucei) and may act as sources of infection to local cattle (18). Since the tabanid and stomoxy flies reach their peak of abundance at the time the nomadic cattle, some of which are harbouring trypanosomes, are present in the area, the optimal conditions exist for mechanical transmission to take place between migratory and local cattle. Trypanosoma vivax that is mechanically transmitted in herds outside the tsetse areas can cause chronic infections in some of the animals. The disease may be self limiting (Rahman, unpublished data), and animals may be infected for more than eight months without succumbing to the disease. Therefore a cycle of infection can be maintained, propagated by biting flies – especially tabanids, due to their intermittent pattern of feeding.

For a better understanding of the epidemiology of T. vivax, many areas need to be investigated, including the pathology of T. vivax stocks to ruminants and their sensitivity to the available trypanocidals. The susceptibility of the local and foreign cattle breeds to T. vivax infection, and the effect on the production of ruminants outside the tsetse zone, should also be investigated. For future investigations into T. vivax, the use of molecular tools such as polymerase chain reaction is recommended.

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Observaciones sobre el problema de la tripanosomosis fuera de los cinturones de la mosca tse-tsé del Sudán

A.H.A. Rahman

Resumen
En la zona del Nilo Azul, entre Adamazin y Jartum, se llevaron a cabo estudios entomológicos y de la tripanosomosis que demostraron que la mosca tse-tsé estaba ausente de ese territorio. Se comprobó que la única especie tripanosómica que infectaba al ganado era *Trypanosoma vivax*, presente en ejemplares bovinos locales que nunca se habían adentrado en los cinturones de la mosca tse-tsé. La prevalencia de la infección variaba según las estaciones. Los periodos de elevada prevalencia coincidían con épocas de abundancia de tabánidos y de moscas del género *Stomoxys*. El estudio sirvió para demostrar que los brotes de tripanosomosis coincidían con los meses de mayor presencia de moscas picadoras, aunque una cantidad ínfima de esas moscas puede ser suficiente para perpetuar el ciclo de transmisión mecánica en condiciones enzoóticas estables.

Palabras clave

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