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Sudan Veterinary Service Khartoum.

Some Observations on *Glossina morsitans ugandensis* Vanderplank in the Sudan.

By E. T. M. Reid.

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CONTENTS

INTRODUCTION.

History.

The distribution of tsetse flies in the Sudan has been described by BEDFORD (1933) and by LEWIS (1949, 1950). P. A. BUXTON visited the Sudan in 1949 and made recommendations for survey and reclamation. He suggested that the Ghabat-el-Warrana tsetse islands be a first consideration. These islands are hereafter referred to as the Jur Narrows Islands (Fig. 1). They are infested with *Glossina morsitans* Westwood and are of economic importance. Surveys of this area started in 1951-52 under the direction of T. W. CHORLEY. Reclamation was begun in Galual and Nyang Islands in 1953. This paper describes the tsetse position there before reclamation started.

Status of sub-species.

There are seven species of tsetse in the Sudan. They are *Glossina palpalis fuscipes* Newstead, *G. tachinoides* Westw., *G. longipennis* Corti, *G. fusca* Walker, *G. fuscipleuris* Austen, *G. pallidipes* Austen and *G. morsitans* Westw. The latter species is very widespread. Dr. F. J. VAN EMDEN has very kindly examined a series of male genitalia slides from various places in the Southern Sudan and finds them to be *G. morsitans ugandensis* Vanderplank in the east tending towards *G. morsitans submorsitans* Vand. in the west. The specimens from the Jur Narrows islands he describes as being "more or less typical *G. morsitans ugandensis*".

Distribution and Habitat Requirements.

The requirements of *G. morsitans* differ considerably; vegetation regarded as suitable for fly in East Africa would not be suitable under Sudan conditions. This is due to a number of factors, chiefly dependent on climatic conditions and on the availability of their principal food host—game. The conditions in the Sudan seem to be remarkably similar to those described for West African tsetse (NASH, 1948), although they differ to some extent in detail.

Climatic conditions are unusually severe towards the northern and drier limits of the fly belt; compare the monthly temperature, relative humidity, and saturation deficit, recorded at Galual with those of other stations within the main fly belt (Table 1). To enable the flies to survive at the height of the dry season, compensating factors are essential in the form of cool microclimates and a readily obtainable food supply.

The main foci of *G. morsitans* are in the ironstone belt in the southern extremity of the country. The bush in this area is largely

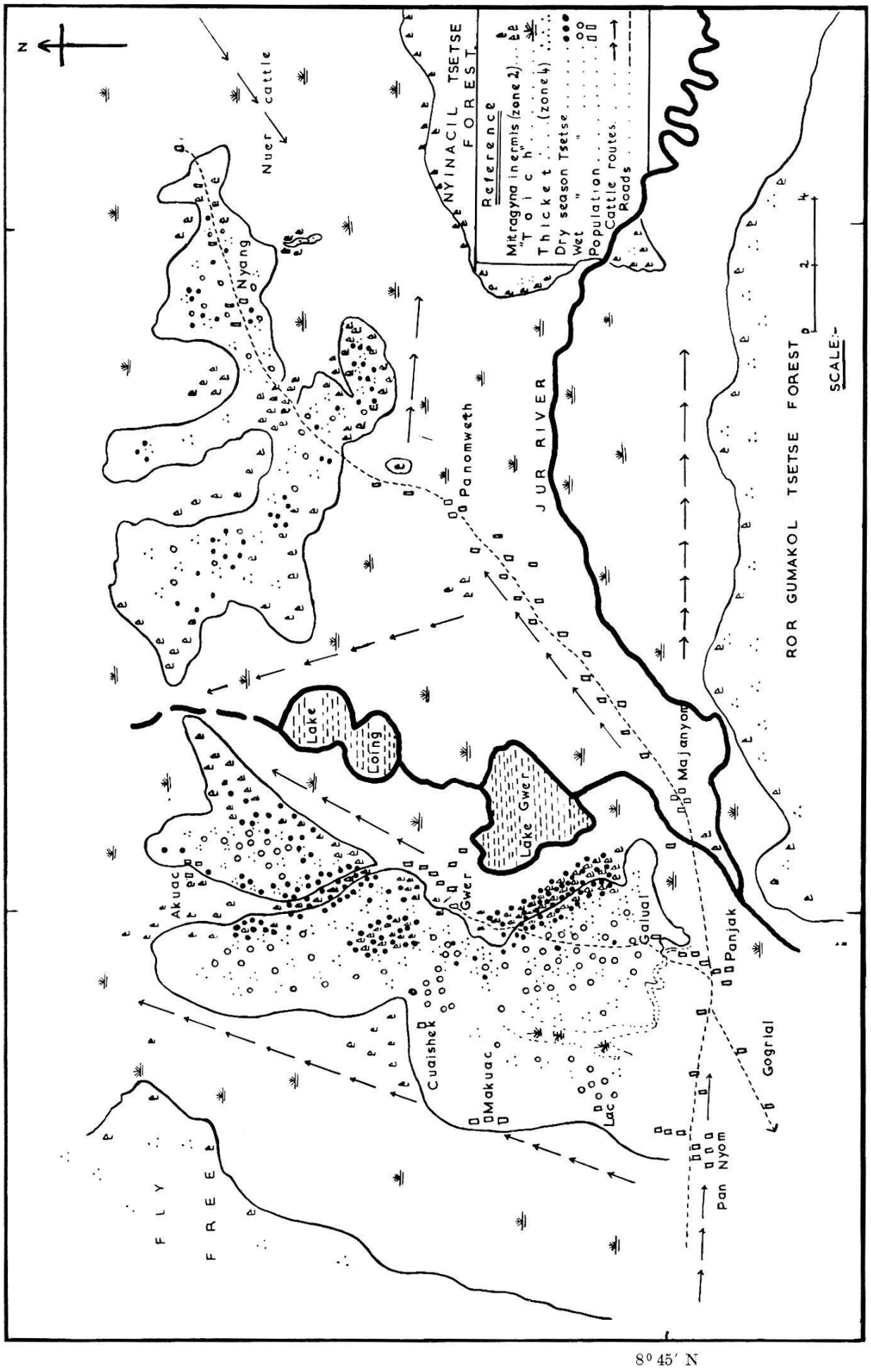


Fig. 1. Map of Galual and Nyang, showing tsetse distribution 1952. (Scale in miles.)

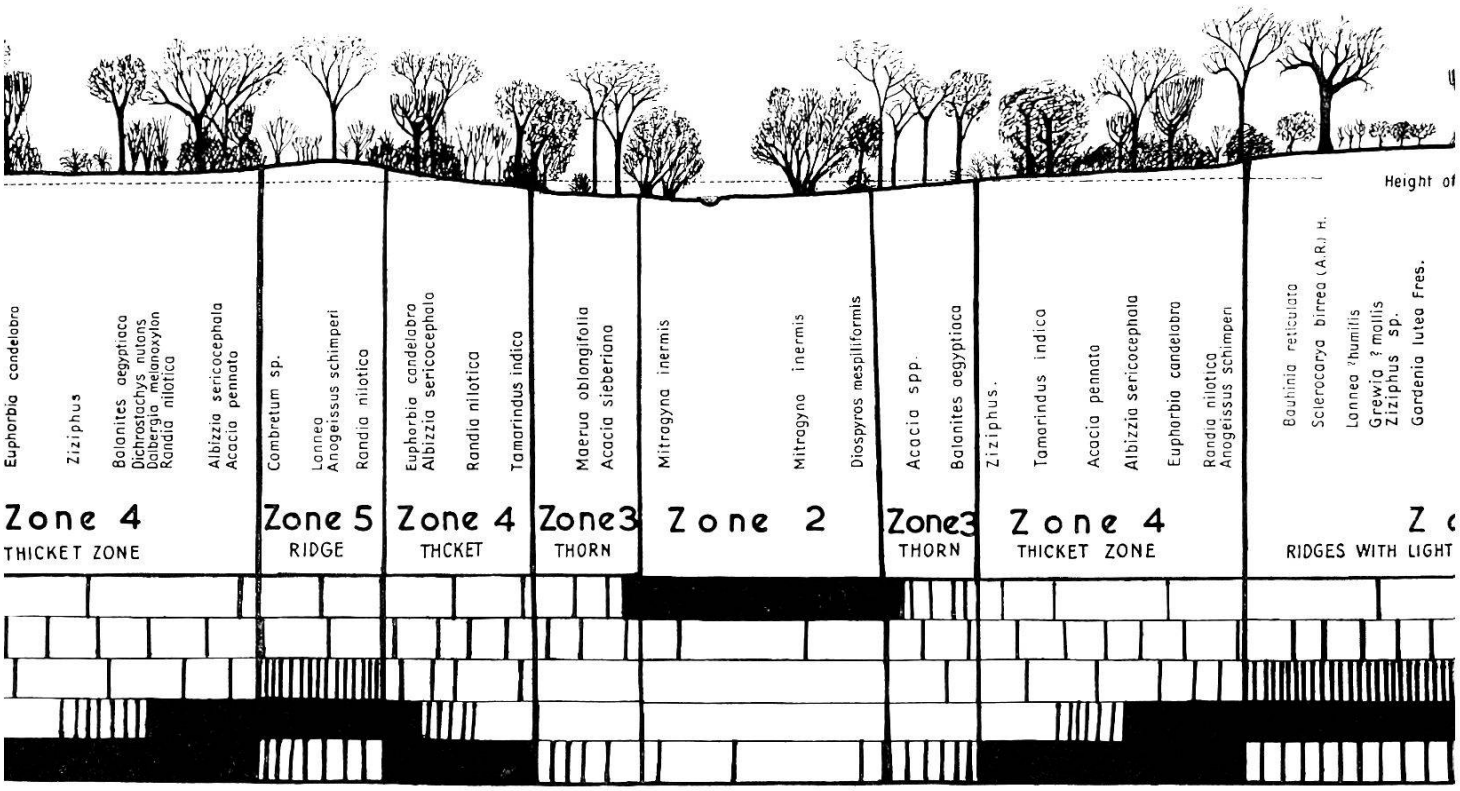


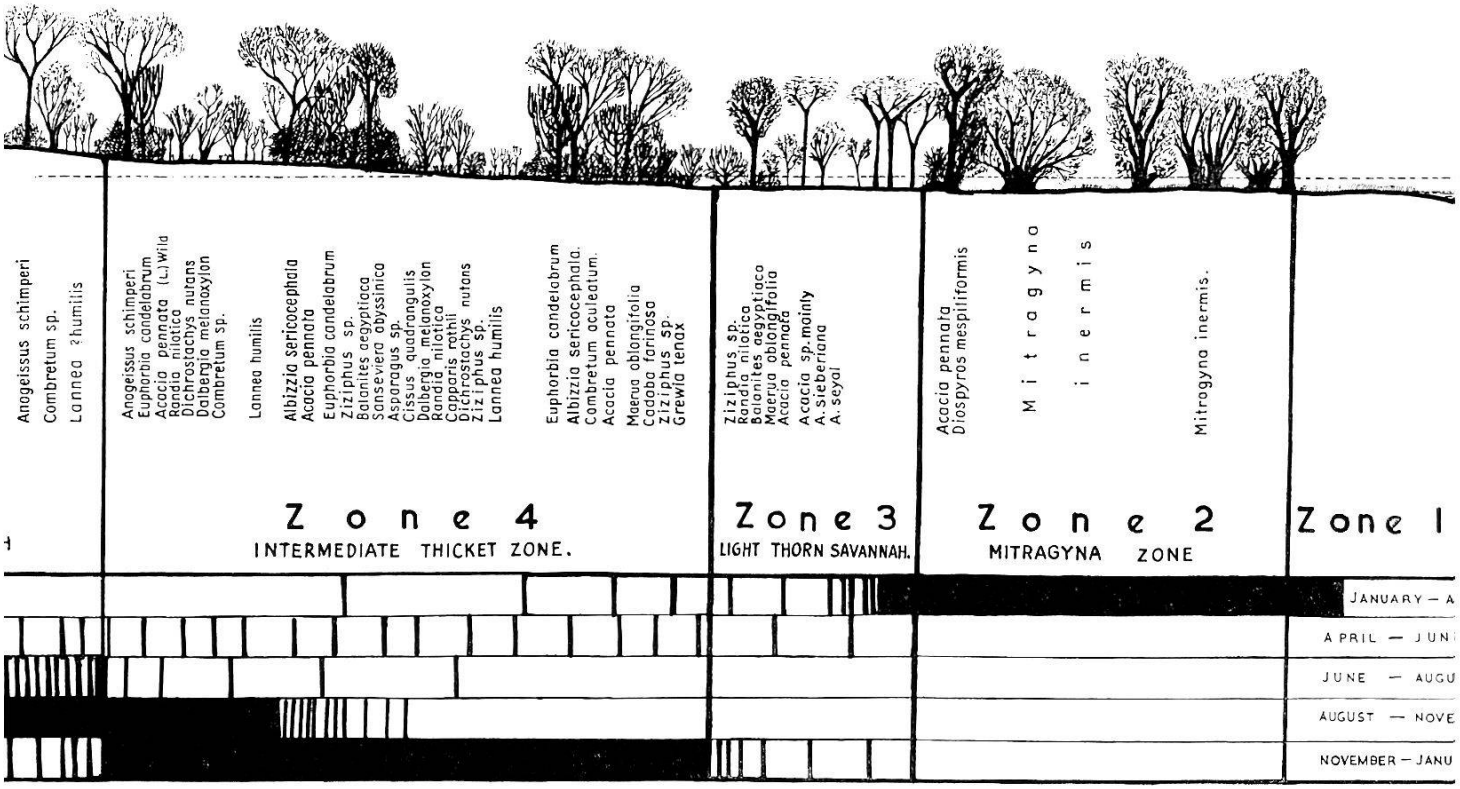
Fig. 2. GALUAL—NYANG. Diagrammatic profil

composed of *Isoberlinia, Terminalia, Anogeissus* and *Khaya* species, with *Combretum, Bauhinia, Acacia* and widespread thicket species. These are largely confined to the ridges, whilst in the innumerable valleys and drainage lines a much more dense and varied vegetation is found. This becomes thicker and more luxuriant as the Nile-Congo watershed is reached. In addition to *G. morsitans,* the other species *G. palpalis, fusca, fuscipleuris* and *pallidipes* can be found in this area while to the east of the Nile *G. longipennis* and *G. pallidipes* are also present.

In the cooler, more southernly reaches of the fly belt *G. morsitans* is normally found during the wet season on the lightly wooded ridges, where large, widely spaced trees provide them with suitable conditions for finding their hosts when the grass is long. In the dry season, when the grass and undergrowth is largely burnt, they move back to the drainage lines where sufficient cover remains to provide a haven during the hot weather, and where they are close to the game which congregate there for the sake of grazing and water. Breeding is apparently widespread during the rains, but confined to the drainage lines during the dry season. This seasonal movement of fly is consistent with the findings of other workers elsewhere.

Economic Importance of Jur Narrows Islands.

Further north from the main fly belt are five small "islands" of fly. Conditions in the Koalib Hills were described by BEDFORD and



vegetation with seasonal tsetse concentrations.

by RUTTLEDGE (1934). Their economic importance is, at present, slight. The other four islands together form the Jur Narrows group. They are Rorgumakol, Nyinacil, Galual, and Nyang (Fig. 1). LEWIS (1953) gives excellent sketch maps of the Southern Sudan, especially Figs. 2, 27, and 28. Reference to these indicate the area as a whole.

These islands are separated from each other by low lying plains which are annually flooded, and from the main southern fly belt by tsetse free bush. To the east of the islands are vast stretches of open grass plains. They are annually inundated by flood waters of the Nile tributaries.

The receding floods leave suitable grazing for the local cattle. During the dry season cattle migrate to these flood plains from all directions and often intermingle. At this time they are bitten by large numbers of *Tabanidae* and *Stomoxydinae*. (In January 1954 over 2000 *Stomoxys nigra* Macq. were taken from a pony in 20 minutes.) During this period Trypanosomiasis caused by *Trypanosoma congolense* and *T. vivax* becomes widespread, and it is almost certain that these biting flies cause the spread of the disease by mechanical transmission (LEWIS 1953).

The Jur Narrows islands are situated in the path of the main west to east migration. The flood conditions at the beginning of the migration are such that the cattle have to pass through the edge of the fly bush; on their return they are habitually grazed there by some of the tribes who are unaware of the tsetse situa-

tion. The cattle, after passing through this fly area, mingle with cattle from other areas and pass on the disease which they have contracted. It has been estimated that upwards of 400,000 cattle come into direct or indirect contact with the tsetse in these islands at some time of the year (P. Z. MACKENZIE).

Description of area.

The four islands consist of low ridges with a light mixed deciduous vegetation. It is highly likely that they were at one period interlinked by bush which has since given way to habitation. They must have also been linked to the main southern fly belt.

Within the forests are depressions which hold water for a greater part of the year, and except for scattered *Mitragyna inermis* (Willd.) O. Kuntze there are usually very few trees in them, though an almost permanent grass cover attracts much game. These depressions are comparable to "vlei's" (JACK, 1912); they play an important part in the tsetse economy in Galual.

Mitragyna inermis (Willd.) O. Kuntze as a tsetse habitat.

Galual and Nyang differ as to the extent which the fly apparently rely on different aspects of the vegetation for their survival. Galual, totalling some 100 square miles, is on slightly higher ground than Nyang which lies to the North-east. The latter island is some 45 square miles in area. The slight difference in height, a matter of probably only a few feet, leads to Nyang having a comparatively higher water table. This in turn affects the vegetation. In the drier Galual, tsetse are forced to rely on the presence of the almost evergreen tree *Mitragyna inermis* during the hot dry months, while in Nyang this is not so. The situation in the other two islands is not sufficiently well known for description but it is apparent that their conditions differ considerably. The reliance of tsetse on *M. inermis* has not been observed in any other areas of the Sudan.

Native population in the area.

The local populace consists almost entirely of semi-nomadic pastoral Dinka. They live mainly round the edges of the forests and on the raised plain between them. They do very little hunting, and their cultivations are small. They have thus done nothing to disturb the balance of nature in the forest. Within the past two years settlement has been encouraged in Nyang, and it would eventually eradicate fly there without recourse to other means. The Dinka often graze or tether their cattle near the edge of the bush, and used to drive them through.

Fig. 3.

Fig. 4.

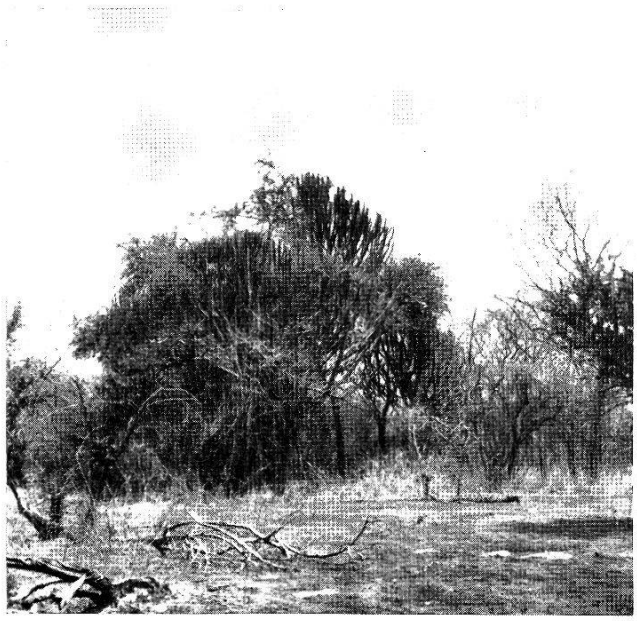


Fig. 5.

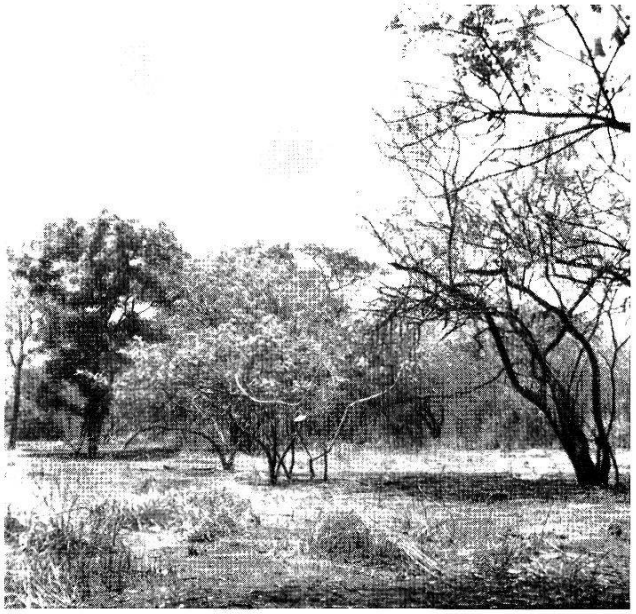


Fig. 6.

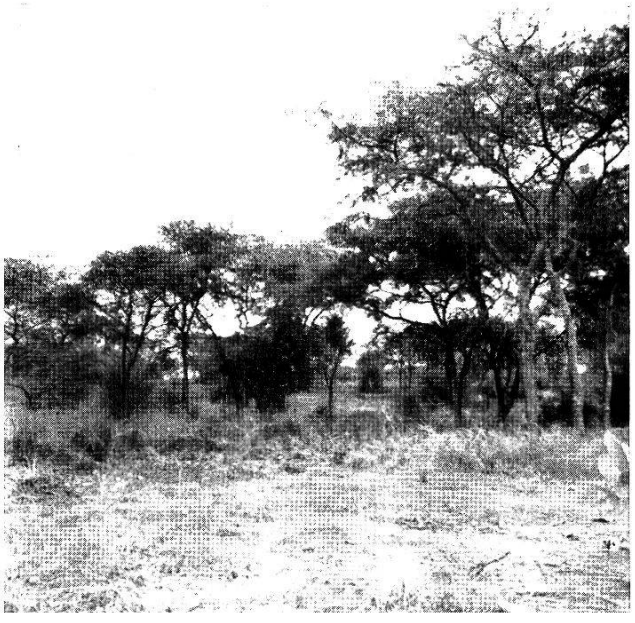


Fig. 3. A general view of *Mitragyna inermis* Willd. O. Kuntze. Referred to as Zone 2.

Fig. 4. Bases of large *M. inermis* showing many stemmed bole with possible breeding sites.

Fig. 5. Zone 4, showing isolated thickets of *Albizzia, Euphorbia* and various rambler species. Denuded of leaves during dry season.

Fig. 6. Zone 5, with open bush including *Combretum* and various large trees. Some small thickets.

Fig. 7. Zone 3 with large *Acacia* species and thorn scrub.

TABLE 1. *Showing climatological data recorded at Galual from April 1952*

Month	GALUAL				RUMBEK			
	Mean Maximum Temp. ° C	% Relative Humidity	S. D. mmb.	Rainfall mm.	Mean Maximum Temp. ° C	% Relative Humidity	S. D. mmb.	Rainfall mm.
April	39.0	34.8	44.9	29	36.6	37	35.3	90
May	36.8	51.0	32.5	86	33.3	53	22	250
June	34.1	48.0	26.6	89	31.6	58	18.3	205
July	33.0	56.0	21.2	148	30.7	63	15.6	107
August	32.1	54.0	19.6	203	30.3	66	13.7	206
September	32.5	58.5	20.1	118	31.3	61	15.8	172
October	34.5	40.0	30.6	30	33.1	54	21.4	156
November	35.0	41.0	33.2	—	33.8	43	28.8	7
December	34.3	54.0	25.7	—	35.5	35	36.5	—
January 1953 . . .	35.0	27.5	36.3	—	36.5	27	43.0	—
February	36.0	22.0	39.0	5	37.5	29	43.1	1
March	38.0	25.0	48.0	5	38.1	26	46.1	6
Remarks	Lat. 8° 42′ N / 28° 35′ E Minimum Temperature seldom less than 16° C, usually 19-20° C.				Lat. 5° 50′ N / 29° 40′ E Rumbek is on the northern limit of fly on the edge of ironstone country to the south-east of Galual.			

Meteorological data.

There are two main seasons in Galual. The wet season lasts, usually, from April to October. The lower lying parts of the bush and the surrounding plains are flooded by waters of the river Jur which rises further south. The weather is comparatively cool. From October till the following rains the weather becomes hotter and drier, although the humidity is kept raised for the first few months of the dry season by the flood waters which only recede slowly.

The records of temperature which have been kept are not strictly accurate, though sufficiently so to show reasonably accurate means. The highest temperatures recorded were 41.7° C. on two occasions and 40° C. on numerous occasions. The relative humidity at this time was below 20%, though never as low as NASH's 7%. Saturation deficit figures may be a little low as the observer was not always reliable.

Description of investigation.

I have visited the area at various times between December 1951 and April 1953. CHORLEY, WILD, and myself carried out a thorough

compared with that from other stations within the G. morsitans *fly belt.*

RAGA				LI YUBO				LIRA			
Mean Maximum Temp. ⁰C	% Relative Humidity	S. D.	Rainfall mm.	Mean Maximum Temp. ⁰C	% Relative Humidity	S. D.	Rainfall mm.	Mean Maximum Temp. ⁰C	% Relative Humidity	S. D. mmb.	Rainfall mm.
36.7	72		89	31.5	84		205	38.3	48	18.5	196.8
35.6	80		125	30.8	88		218	29.6	64	21.9	198.1
32	90		171	29.3	92		319	29.3	60	23.5	78.7
30.6	92.5		189	28.3	87		188	29.0	62	23.4	106.7
30.5	92.5		141	28.3	93		339	29.3	59	23.6	146.6
31	92		192	29.5	90		145	29.4	59	23.6	332.5
33.9	87		50	30.5	85		93	29.5	68	26.8	174.0
34.1	70		8	31.9	77		35	29.9	57	24.3	97.8
34.9	60		—	33.0	72		13	31.5	55	24.1	—
36.8	47		—	33.6	48		29	31.0	56	24.4	63.7
37.3	40		—	34.6	59		21	35.8	48	24.5	—
?	?	?	?	39.0	73		47	36.5	46	25.1	23.4
Long. 25⁰30′ E / 8⁰30′ N Raga is situated nearly due W of Galual in hilly ironstone country with *G. morsitans.*				Lat. 4⁰20′ N / 27⁰20′ E Li Yubo is on the southeastern border of the Sudan. *G. morsitans* is common nearby while *palpalis, fusca,* and *fuscipleuris* are also found.				Lira is in the northern part of Uganda in ironstone country and is typical of the type of area infested with *G. morsitans ugandensis.*			

survey; and later (March, till May 1952), I carried out detailed searches for pupal sites and a vegetation survey. Fly routes were established in 1952 and are being continued during reclamation, as is distribution data; extracts are given in Table 3. The remarks on the area are based mainly on observational data which are not subject to statistical analysis.

GALUAL ISLAND.

Vegetation.

The vegetation varies between scattered *Mitragyna inermis* on the lower-lying areas to patches of dense thorny thicket on slightly higher ground. The vegetation is comparable to that generally classified as "light savannah woodland", though differing in composition to that growing in the ironstone country further south. The vegetation in Galual can be zoned, conformably with the type of soil and the relative height of the wet season water table. The latter factor has a considerable effect, by indirect means, on the seasonal tsetse movements. The relationship of the zones is shown diagramatically in Fig. 2.

Zoning of Vegetation.

Zone 1. *Flood Plain.*

The flood plain extends between the four islands and eastwards. It is almost treeless and forms a perfect natural barrier to spread of tsetse.

It consists mainly of black cotton soil and supports a dense grass cover, most of which is *Echinochloa* sp. It is under water for a greater part of the year, the receding floods leaving grass suitable for grazing. In the dry season thousands of cattle concentrate here; they are owned by nomadic Dinka and Nuer tribesmen. The only common game are kob and Mrs. Gray's lechwe *(Onotragus megaceros).* Biting flies are common, especially *Tabanus taeniola* Pal. de B. and *Stomoxys* sp. On the edges of the forests the flood plain is slightly higher and supports *M. inermis* in zone 2.

Zone 2. *"Mitragyna inermis"* (figs. 3, 4).

M. inermis grow in a zone varying in width from up to half a mile to only a few yards round the edges of the forest, and in small tongues penetrating into the lower lying parts of the forest, as well as round the inland depressions.

The *M. inermis* are large (up to 50 feet), many stemmed trees which grow either in a closely spaced community or else far apart. They do not have any undergrowth round them. They remain in leaf for a greater part of the year, a new growth usually taking place before the old one has completely fallen; however, on the western side of Galual which is on comparatively high ground this rapid regrowth does not take place; doubtless it is too dry. There are numerous buttressed roots and rot holes near the bases of the trees; the bark is horizontally ridged and tsetse flies have been seen resting in these crevices.

The trunks may be submerged at the height of the floods to a depth of three or four feet, which is over nearly all available pupal sites. Dead trees are rarely seen and the tree is little affected by fire.

Occasional *Mitragyna* are found on high ground near temporary water holes, but these are generally dwarfed and leafless for the greater part of the dry season.

Small patches of *Mitragyna* have been found well away from the forest edge but these are uninhabited by tsetse, indicating that it is essential that they have a second habitat to fall back to at the height of the floods.

Interspersed between the *Mitragyna* are very occasional termite

mounds with *Diospyros mespiliformis* Hochst ex A. DC. growing on them.

The grass growth is luxuriant in this zone and remains green throughout the year, green shoots regenerating very rapidly after burning.

Zone 3. *Light Thorn Savannah* (fig. 7).

Between the *Mitragyna* and the thicketed areas of higher ground is a zone of varying width having a cover of different thorn species. There is a light brown clayey soil which is waterlogged for half the year. It is devoid of humus and has a less dense grass growth than the other areas. It is narrow on the eastern edge of Galual but is widespread to the west.

The vegetation consists mainly of *Balanites aegyptiaca* (L.) Del., *Acacia sieberiana* D.C. and *Acacia* spp. None of these lose their leaves for any long period, but they are clean stemmed and provide little shade. Scattered thorny thickets of *Ziziphus* sp., *A. pennata* (L) Willd., *Maerua oblongifolia* Forsk. A. Rich., and *Randia nilotica* Stapf are present, often associated with *Tamarindus indicus* L. and *Diospyros mespiliformis* which are occasionally to be found in this zone, or with the *B. aegyptiaca.*

The area is much frequented by giraffe, oribi and wart hog during the early dry season, and also by buffalo and roan as the forest begins to dry up. Tsetse are often caught here at this time, and if the zone is narrow may be sometimes caught during the dry season when they are using it as a feeding ground. During the wet season it is not used by tsetse, nor during the dry season in the extensive western area. It is never used as a permanent habitat.

Zone 4. *Intermediate Thicket Zone* (fig. 5).

Between the lowest areas and the higher ridges is the widespread "intermediate thicket zone". It becomes waterlogged during the height of the rains, but dries out quickly once the floods recede. The zone is characterised by large patches of thicket on a light-brown clayey soil. These thickets are made up of the following main species: *Principal trees: Albizzia sericocephala* Benth., *Anogeissus schimperi* Hochst ex H. and D., *Euphorbia candelabrum* Trem. ex Kotschy, *Tamarindus indica* Linn. *Occasional trees: Balanites aegyptiaca* Del., *Acacia* spp. *Creepers: Cissus quadrangulus* Linn. *Thicket species* and *ramblers: Acacia pennata* (L) Willd., *Maerua oblongifolia* A. Rich., *Cadaba farinosa* Forsk., *Asparagus* sp., *Ziziphus* sp., *Grewia tenax* Forsk. (Fiori), *Sanseviera* sp. Occasional large *Ficus* spp. and *Kigelia aethiopica* Decne are some-

times found in the lower parts of this zone. Between the thickets the following are commonly found:

Subsidiary trees and shrubs: *Dichrostachys nutans, Dalbergia melanoxylon* G. and P., *Lannea humilis* (Oliv. D.) Engl., *Randia nilotica* Stapf., *Ziziphus* sp., *Cadaba farinosa* Forsk., *Asparagus* sp., *Combretum* spp., *Grewia mollis* Juss. and *Capparis rothii* Oliv.

This area with its numerous thickets provides an ideal tsetse haunt until the thickets lose too many leaves to provide sufficient cover for tsetse breeding sites.

Zone 5. *Deciduous Savannah Ridges* (fig. 6).

There are several higher ridges running through the forest and these have a light deciduous vegetation with occasional scattered thickets. There is a light sandy soil which is very fertile. A grass cover of *Hyparrhenia* sp. reaches up to 7 or 8 feet in the late wet season and burns very fiercely soon after. This fierce burn helps prevent thickets forming.

Less than 50% of the area falls within this zone, although tsetse and game have to congregate here when the floods cause water-logging of much of the lower ground.

The principal trees in order of predominance are: *Anogeissus schimperi, Albizzia sericocephala, Sclerocarya birrea* (A. Rich.) Hochst., *Cassia sieberiana* DC., *Euphorbia candelabrum, Kigelia aethiopica, Tamarindus indica.*

Secondary large trees and shrubs with a little thicket form a greater part of the vegetation. They consist mainly of *Combretum* spp., *Gardenia lutea* Fres., *Bauhinia reticulata, Grewia tenax, G. mollis* Juss., *Ziziphus* spp., *Lannea humilis, Acacia pennata, Dichrostachys nutans, Randia nilotica, Dalbergia melanoxylon, Cissus quadrangulus* and *Asparagus* sp.

Although the species of trees in this zone are similar, in the main, to those in zone 3, they form fewer thickets round the bases of the large trees. The smaller trees between are not so close set. The whole aspect of this zone is more open.

Annual Burning.

Burning takes place from October or November till March. It is most severe in the flood plain areas where the grass growth is greatest, and also in the small inland depressions. In these areas, however, regeneration of young grass is rapid, since the water is seldom far from the surface.

In the "light thorn zone" and "intermediate thicket zone" where grass growth is slight, patchy burning results, but on the ridges

where *Hyparrhenia rufa* (?) reaches 7 or 8 feet, the burn is fierce and complete.

Some seasonal aspects of the vegetation.

The *Combretum* come into leaf early in the dry season. There are light rains in March which bring on a flush of green grass. These rains are followed by three to four weeks of dry spell and the first young growth of grass may die off. The heavy rains set in about the middle of April and soon fill up water holes. The trees and shrubs come quickly into leaf and the grass soon reaches a height of four or five feet. By mid-May most of the trees are in full leaf and start flowering. On the higher ground the grass reaches seven or eight feet by August. The floods reach their height at this time and grass on the plains is still not very tall. As the floods recede the grass shoots up to about nine feet in many parts by November.

Leaf fall begins in Galual by mid-December but may be much later in the lower lying Nyang. The above remarks are not strictly applicable to the *M. inermis* which retain foliage throughout most of the year, and regain fresh leaves as soon as the old ones fall; this is usually by April.

Game.

Food hosts of *G. morsitans.*

JACKSON (1949) summarises the principal food hosts of *G. morsitans.* With the exception of occasional meals, generally less than 10% of the total, *G. morsitans* derives most of its food from the larger mammals.

Tsetse have to feed at regular intervals. In East Africa with an average temperature of 23° C. the time between meals was four days. Since the time between meals is governed by temperature and the dessicating power of the air, in Galual, with a temperature of 35° C. in the dry season, the period must be much shorter.

It is logical to suppose that when the tsetse are hungry they will feed to a greater extent on the more available animals than on the less available ones. Availability might be said to depend on the degree of potential contact (SWYNNERTON's term) between the host and the fly. For example, large gregarious animals within a fly area would have a greater potential contact than single ones of the same species since they would have a greater sight and scent attractivity. The attractiveness of different animals doubtless varies, but doubtless even the least attractive ones are fed on in times of scarcity. The potential contact varies at different seasons with the

same animal or in the same habitat since their habits differ during different times of the year.

The survival of tsetse within an area is not entirely dependent on having a large game population there, although when conditions become severe readily available hosts might mean the difference between survival and extinction of the population. GLASGOW and WILSON (1953) were able to demonstrate an enormous *pallidipes* population thriving on very few animals. In the case of *morsitans* it has now been conclusively shown that game eviction from an isolated area will lead to tsetse eradication within that area. MORRIS (1946) and POTTS and JACKSON (1952) have shown that *morsitans* could not survive in the absence of animals larger than reedbuck (*Redunca* sp.), though LLOYD and JOHNSON (1924, paper not seen in original) showed the reverse. It is apparent, although *morsitans* will not normally survive in the absence of larger animals, that when conditions are not too severe and smaller animals are readily available, then it can survive on them alone. When conditions are severe the reverse is true.

The following observations made in Galual and Nyang show that *morsitans*' tastes are diverse.

a) *Humans:* Flies can always be caught feeding on humans passing through either forest. In fact, *morsitans* is always readily attracted to people.

b) *Domestic stock.* Contrary to instructions cattle are often taken near the forests. Tsetse have been caught feeding on them and also on bait donkeys.

c) *Game.* Tsetse have been seen probing blood from the following freshly killed animals: buffalo, giraffe, baboon, waterbuck, wart hog, and tiang.

d) Freshly gorged flies have been caught near a herd of waterbuck and tiang grazing in the *Mitragyna.* No other animals had been in the area for at least an hour.

Blood smears from 50 beasts have been sent to Dr. WEITZ at the Lister Institute in order to determine the food hosts.

Table 2 is an attempt to show the relationship between the various species of game and the tsetse. It is based on observations of the tsetse and game at different seasons.

Hunting.

The Dinka tribesmen do not hunt, and do not disturb the game; the animals thus often congregate in large herds and form ideal tsetse hosts. Their movements are not forced by fear but are governed only by natural means.

TABLE 2.

Showing the main game in Galual and their probable importance as tsetse hosts.

Common name	Specific name	Habitat: Degree of potential contact between Fly and Game (P. C.)
Buffalo	*Syncerus caffer* Sparmann.	About 500 head in large herds. Live in thickets or long grass in day, frequent regular areas and routes to *Mitragyna* at night. High P.C.
Baboons	*Papio* sp.	Very widespread, especially in the thickets near water. High degree of P.C. and probably one of the most important hosts.
Waterbuck	*Kobus defassa* Ruepell	Small parties mainly in thickets. Regular habits. High P.C.
Tiang	*Damaliscus korrigum* Ogilb.	In small parties in *Mitragyna* or nearby thicket. High P.C.
Wart Hog	*Phacochoerus aethiopicus* Pall.	Often found in *Mitragyna,* thicket or zone 3. Common. Widespread. High P.C.
Giraffe	*Giraffa camelopardalis* L.	Small herds in more open areas especially where Acacia found. High P.C.
Roan	*Egoceros equinus* Desmarest.	Small herds on drier ground; keep away from main tsetse area in dry season; more important in wet. Medium P.C.
Kob	*Adenota kob.*	Herds on flood plains and depression. Important only when in *Mitragyna* which they visit at times. Medium P.C.
Bushbuck	*Tragelaphus scriptus* Pall.	Scattered in thicket areas. Recluse in habit. Few in number. Medium P.C.
Duiker	*Sylvicapra grimmia* L.	Few in number, recluse, mainly in drier areas. Medium P.C.
White Rhino	*Ceratotherium simum* Burchell.	Two or three, peripatetic, but mainly in thicket or *Mitragyna.* Medium P.C.
Reedbuck	*Redunca arundinam* Boddaert.	Few in low lying areas. Low P.C.
Oribi	*Ourebia ourebia* Zimm.	Few, on higher dry ground. Low P.C.

TABLE 2 (Continued).

Common name	Specific name	Habitat: Degree of potential contact between Fly and Game (P. C.)
Monkey-Grey	*Cercopithecus* sp.	Few, scattered, near water. High P.C. but little importance.
Carnivora Hyenas Jackals		Nocturnal, therefore little P.C. when moving but high during day if living in a tsetse habitat.
Mrs. Gray's Lechwe	*Onotragus megaceros* Heugl	In flood plains, well away from bush. No P.C.
Small mammals	(Ground squirrels, Bats Lemurs, Mongoose, Hedgehogs, etc.)	Of little importance though tsetse may feed on them at times.
Birds and Reptiles	Guinea fowl, Partridge, Vultures, Storks; Lizards, Snakes, etc.	Of little importance though P.C. at times is high.

Seasonal Fly Movements.

The distribution of the tsetse changes during different times of the year. The reason for this movement is not clear; either the tsetse follow the game to new habitats or else both move for similar reasons, namely the threat of flooding or dessication. For example at one period game and tsetse were common round a small water hole situated well away from the *Mitragyna* zone. They remained there until the water hole dried up; the game left almost immediately and very soon after no tsetse could be caught there, although the vegetation was apparently unchanged to any extent. Similar observations were made on several occasions.

Without fencing off game movements and marking of the tsetse it would not be possible to say whether the tsetse followed the game away from the water hole, or whether they "realised" it was getting too dry and that they could find better conditions in the *Mitragyna* zone. It is, however, clear that the main tsetse habitats at the various seasons coincide very closely with those favoured by the majority of the game at that time.

Fly Route Data.

The diagrammatic profile in Fig. 2 is an attempt to show the relationship of the tsetse to the main zones of vegetation at different times of the year. Table 3 shows extracts from fly routes which were started in April 1952. Catches are made along two East-West routes by three fly boys each. They stop every 100 yards and note

TABLE 3.

Fly Route figures for Period April 1952 to January 1953.

Zone / Month	*Zone 5.* Ridges with light deciduous savannah. Total 1000 Yards					*Zone 4.* Intermediate Thicket. Total 1000 Yards					*Zone 2. Mitragyna inermis.* Total 1000 Yards					Remarks
Jan. Feb. March 1952	No Fly route records available. Diary extracts for this period record: "90% of tsetse caught in *Mitragyna* area. Only very few flies in rest of island, of these most were caught in thicket areas."															Details of catches not recorded; but 10 or more flies could be seen resting on or near any one man in the *Mitragyna* zone at any time.
	Catches for one Fly-Boy on 14. 3. 1953 were															
	1 male. 1 female					6 males. 7 females					77 males. 28 females					
Sex	M	F	T÷	G÷	Total	M	F	T	G	Total	M	F	T	G	Total	
April	0	0	0	0	0	0	0	0	0	0	354	214	12	2	582	
May	49	11	4	2	66	86	18	7	7	118	159	24	11	2	196	
June	73	28	12	9	122	70	14	5	0	89	26	6	4	1	37	None in Zone 2 after 13. 6. 1952
July	75	18	9	7	109	55	10	4	5	74	0	0	0	0	0	
August	100	18	12	7	147	50	5	6	6	67	0	0	0	0	0	
Sept.	*No records available*															
October	86	20	10	10	126	34	4	0	5	43	0	0	0	0	0	
Nov.	188	80	17	18	303	26	9	2	3	40	0	0	0	0	0	
Dec.	148	57	16	10	241	61	41	14	12	128	2	1	0	0	3	
Jan.	124	62	6	9	201	151	71	11	9	242	67	27	5	9	108	Game eviction campaign begins
Totals	863	294	86	72	1315	533	172	49	47	801	608	272	32	14	926	

÷ T = Teneral or Young Fly ÷ G = Gravid Female

1952 was an exceptionally wet year and floods reached record heights. This had a marked effect on the tsetse distribution observed in the previous "normal" year, and though the figures given in Table 3 are those for 1952-53 the remarks are based on observations of what happens in a normal year.

fly caught. These records are not accurate and are only indicative of conditions; for example in September the fly boys stopped work completely knowing it was unlikely that they would be visited.

Seasonal summary.

a) *January to April:*

90% of the flies caught during this period in 1952 were in Zone 2, the *M. inermis*. At this time the dry season is at its most severe, and both game and tsetse congregate in this zone as the trees and thickets in the remainder of the forest have lost their leaves. Larviposition is extensive under the *Mitragyna*.

b) *April to June.*

The rains bring on a strong growth of green grass and refill the water holes in the forest. The humidity is raised and at the same time the temperature falls. The game disperses rapidly once the rains begin, both to escape the water which collects in zone 2 and 3, and to take advantage of the fresh grazing. The tsetse are able to fly further afield since more cover is available and conditions are not so severe. They spread out to the full extent of the forest which is not under water. By mid-June they have deserted the *Mitragyna* completely and by July are found more on the highest ground than in zone 4. Any pupae which were left in the *Mitragyna* sites are killed by the first heavy rains.

c) *June to August.*

Tsetse at this time are to be caught only in zone 4 and 5 and all the game now concentrates in this area to escape the water. The bush becomes very thick indeed, and in zone 5 the grass may attain 8 feet. At this time the tsetse probably rely on those animals which are easily found; most likely the bigger ones, and on the baboons which may be attacked in the trees. It is believed that larviposition is widespread throughout zone 5, even under tussocks of grass. Only very few pupae and cases have been found, and these were in classical sites.

d) *August to November.*

The grass begins to dry off and is burnt in November. The fiercest burn is on the high ground and the thicket is burnt only in patches. The tsetse are able to retreat there while the burn is in progress. In a normal year the floods begin to recede in November and the game begins to enter the *Mitragyna* and even the flood plains. The tsetse begin to fall back to the thicketed areas and even

reach zone 3. In 1952 the floods were abnormal and this movement was delayed till the end of December.

e) *November to January.*

The water holes begin to dry up and the game starts to fall back to the *Mitragyna*. The tsetse desert the ridges and thicket zones completely by the end of January (in 1953 this was delayed till February or March).

NYANG ISLAND.

Vegetation.

Nyang Island is much lower laying than Galual. The vegetation is able to retain its foliage for a greater part of the year as the water table is comparatively higher than it is in Galual. The species of vegetation are the same as in Galual but the zones of vegetation are much less pronounced. The *Mitragyna* is only in a narrow zone round the edge of the bush. The thicketed area is more dense, and the ridges which bear a light deciduous bush in Galual are nearly all populated in Nyang. Towards the eastern end of the island are a number of termite mounds bearing dense thicket, and finally a small grove of *Borassus aethiopum* Mart. and *Hyphaene thebaica* Mart. palms; the latter are of no importance.

Game distribution.

Game is very scarce in Nyang. A few tiang and waterbuck are found, and on the outskirts are kob and Mrs. Gray's lechwe. Baboon and wart-hog, on the other hand, are extremely common and inhabit the thicketed areas. This shortage of game is probably because the local inhabitants are not pure Dinkas, and do hunt to some extent.

Tsetse position.

G. morsitans is scarce in Nyang. The shortage of game and the disturbance of the bush by settlers, who are annually becoming more numerous, makes the flies' position there precarious. It is apparent that they survive almost entirely on baboon and wart-hog, and perhaps on the cattle and humans who live in the forest.

Their habits are different to those in Galual; the retention of thicket foliage for a greater part of the year enables tsetse to survive and breed in the thicket without recourse to the *Mitragyna* and no pronounced seasonal movements are apparent.

COMPARISON OF TSETSE SITUATION IN GALUAL AND NYANG.

In Galual the tsetse and game are unable to obtain suitable habitats within the forest during the hot dry season and concentrate in the zone of *M. inermis*. Some animals, such as the buffalo only go to the *Mitragyna* zone for water and then return to the thicket for shelter. The tsetse do not normally follow these away but remain in the *Mitragyna* and feed there on the tiang, waterbuck and baboon which remain throughout the dry season. When the rains begin the tsetse desert the *Mitragyna* and return to the thickets and higher ground.

In Nyang the thicket retains its foliage for the whole of the dry season and the tsetse are able to live and breed there. The only common animals, baboon and wart-hog, remain in this thicket and provide a readily available food supply.

Tsetse would not be able to survive in Galual if it were not for the suitable dry season conditions provided by *M. inermis*.

OBSERVATIONS CARRIED OUT IN M. INERMIS, ZONE 2.

Reasons for Suitability as Habitat.

The tree *M. inermis* is important to the tsetse in Galual as without it they would not be able to survive the hot dry season. The *Mitragyna* (figs. 3, 4) grow in a low lying area which retains moisture. The trees remain green during almost the whole dry season; even if they do not their bases are so large that they can provide shade and breeding sites when all leaves have fallen—which is only for a very short time. Game shelter under the *Mitragyna,* and remain nearby throughout the dry season. When conditions are severe the tsetse are able to obtain breeding sites, resting sites and blood meals without flying more than a few yards from any one tree. This is most important when the temperatures are in the region of 100° F. Some air and soil temperatures taken within breeding sites are tabulated in Table 4.

Once the rains begin the tsetse are forced to desert the *Mitragyna* as it soon floods to a depth of 3 to 4 feet.

Freshly gorged Flies.

Freshly gorged flies (JACKSON's Hunger Stage 1) are not often caught by fly boys since immediately after feeding the flies rest on trees while their meal is digesting. T. W. CHORLEY suggested searching the bases of *Mitragyna* for resting flies. We carefully ap-

TABLE 4.

Some Records of Temperature from tsetse breeding sites in Mitragyna Zone.
16. 4. 1952.

No.	*Description of Site* Note 1. Mean of 3 records in each site were taken with a whirling Hygrometer. Note 2. Beginning at 10.15 a. m. and ending at 12.30 p. m. All readings were taken in the *Mitragyna* zone, 2 miles North East of Galual within the main tsetse concentration.	Soil Temperature at depth of 1'' °F.	Dry bulb Temperature Whirling Hygrometer °F	Wet Bulb Temp. °F	% Relative Humidity	Saturation Deficit	Remarks
1	Stevenson screen at Galual, which is at the southern end of the forest situated on a slight ridge.	99	83.3	58	18	32.9	08.00 a. m. 16. 4. 52
		120	99.5	68	18	54.2	14.00 p. m. 16. 4. 52
	Vegetation is similar to that of Zone 3	120	100.4	77.9	34.8	44	Mean for April
2	Hole 3′ above ground in *M. inermis*	72	86	69	42	26	Pupae sites
3	Under fallen *M. inermis*	75	91	70	32	31.9	10.00 a. m.
4	In bole of large *M. inermis*	75	90	70	37.5	31.7	10.00 a. m.
5	At base of *M. inermis*	76	92	73	40	33.2	10.00 a. m.
6	In bole of *M. inermis*	81	95	76	41.5	34.3	10.00 a. m.
7	Enormous *M. inermis,* readings in its shade only	73	89	72	47	27.3	10.15 a. m.
8	Recording in open in *Mitragyna* zone	99	94	73	33	37.1	10.15 a. m.
9	Recording ditto	100	92	70	43	37.8	10.30 a. m.
10	ditto	120	95	70	41.5	42	11.00 a. m.
11	ditto	120	98	79	43	36.4	12.00 p. m.
12	Thicket nearby *Mitragyna* zone *(Albizzia, Euphorbia, Cissus, A. pennata)*	88	97	77	40.5	38.2	10.20 a. m.
13	Thicket ditto	84	98.5	78	41	23.9	10.20 a. m.
14	Thicket ditto	79	87	61	45	34.8	10.20 a. m.

These thickets adjacent to *Mitragyna* and used as a breeding site

proached trees nearby to where a mixed herd of tiang and waterbuck had been standing, and soon found many freshly gorged flies resting within four feet of the ground, often in crevices of the bark. The flies had red blood in them; the time was 3 p.m.

Male and female flies are often caught at the bases of the *Mitragyna* when one is searching for pupae. They can be seen sitting either on the trunk of the tree, or flying out from rot-holes at the base of the tree in equal numbers.

Larviposition under Mitragyna.

Pupal searches in various parts of Galual and Nyang were made between January and May under the immediate supervision of Mr. VINCENT ACHUGA who was both proficient and reliable in his

TABLE 5.

Showing numbers of pupae and pupal cases collected in 1952.

Month	Site	Number of sites searched	Number Pupae	Number pupal cases
January	various, by fly-boys alone	unknown, about 30 to 40	19	81
February	*Mitragyna* by fly boys alone	unknown 30 to 40	6	80
March 18th-26th	Thickets supervised	11 thorough search	8	3
March 31st	*Mitragyna* supervised	22	48	160
April	Thickets supervised	15	6	20
April	*Mitragyna* supervised	55	288	567
May	Thickets supervised	20	5	45
May	*Mitragyna* supervised	90	454	1526
Total			834	2482

searches and records. A total of 834 pupae and 2482 pupal cases were found under *Mitragyna* and a few in nearby thickets.

From the figures it may perhaps be assumed that breeding is more extensive towards the end of the dry season. This is not necessarily so. The increased number of pupae found is mainly due to their concentration in small well-defined sites. At the same time the skill of the searchers was improving.

The searches showed that extensive and increasing numbers of larvae are deposited under *Mitragyna* as the dry season progresses, and that there is also occasional larviposition under thickets near-by the *Mitragyna* zone during the dry season, but more extensively during the wet season as vouchsafed by the presence of old cases. In Nyang tsetse and pupae are scarce, but those that were found were under thickets, and only one under *Mitragyna*.

Pupae which were found after heavy rains had fallen, were, in nearly every case, rotten and non-viable. Other workers have shown that *morsitans* pupae will not stand waterlogging or wetting for more than a few days, and that is apparently the case in Galual, i.e. no pupae can survive in the *Mitragyna* sites once the rains fall and flooding starts.

Suitable pupal Sites.

Most of the pupae found were within an inch of the soil surface in a shady place that was protected from strong winds at some time of the day. Records of soil temperature in these sites varied between 72° and 88° F. at the hottest time of day. Suitable conditions are normally found under fallen logs, in rot holes at the bases of trees, in the boles of trees and under buttressed roots. Most of these conditions are available under *Mitragyna* during the dry season. Pupae can also be found scattered in thickets or at random in the humus under very large *Mitragyna*. Thicket sites are only suitable during the wet season when foliage provides a shade. In the dry season there is insufficient shelter. Wet season breeding sites are apparently widespread and difficult to find. One pupa was found in a rodent burrow in a termite mound.

Duration of pupal Period.

Over 300 pupae were redeposited in suitable sites. Of these 88 emerged, mostly within 16 days, the remainder were killed by heavy rain. One pupa remained 59 days before emergence, having been deposited on 1. 4. 52 and emerging on 29. 5. 52. One remained 54 days, and three 30, 44 and 48 days respectively.

Of the 834 pupae collected 10% were non-viable, the cause of death apparently being either dessiccation or excess moisture.

Parasitisation.

Only 8 pupae were found to be parasitised. Three parasites emerged and proved to be *Thyridanthrax abruptus* Lw., the other five died before emergence but were apparently *Thyridanthrax* spp.

Behaviour of Flies.

The old males bite on the back, arms and legs, but are normally met with sitting on the ground and grass nearby. The teneral flies bite eagerly; I consider their bite to be more painful than that of old flies. The females do not appear as readily to man as do males but more seemed to bite on hot days than on cool ones, possibly this is indicative that they are more active because of a shortening hunger cycle.

Tsetse have been caught biting before dawn, and after sunset in full moon. They bite actively all day, even when the screen temperature is 106° F., especially in the shade of *Mitragyna,* but are most active in the morning and evening, and were unbearable just after the first shower of rain.

Trypanosomiasis infection.

Fifty old flies, male and female, captured in the *Mitragyna* in April, were dissected. Two had trypanosomes in the proboscis, and three had them in the salivary glands and ducts. A 10% infection.

Summary.

1. There are seven species of tsetse fly in the Sudan. *Glossina morsitans ugandensis* is widespread throughout the south where conditions are suitable.

2. There are five small islands to the north of the main tsetse belt. The four comprising the Jur Narrow's group are situated in the path of cattle which migrate annually to the flood plains of the Bahr el Ghazal for grazing.

3. Cattle passing these islands contract trypanosomiasis caused by *T. congolense* and *T. vivax,* from the tsetse there. Of 50 tsetse dissected 5 had proboscis or salivary gland infections.

4. Trypanosomiasis apparently increases during the rainy season and when the cattle are in their grazing grounds. As some of them are never in direct contact with tsetse the disease is probably spread mechanically by *Tabanidae* or *Stomoxydinae.*

5. Climatic conditions are severe towards the northern limit of tsetse distribution, temperatures of 41° C. being attained during the dry season, which is from October to April. The rainy season lasts the rest of the year, while floods occur from June to November.

6. Tsetse are enabled to survive during the dry season by the presence of suitable microclimates under *Mitragyna inermis,* if these retain their foliage; and by the presence of a readily available food supply.

7. Vegetation in the islands is comparatively undisturbed by population. Five main zones are recognisable. They are: 1. Flood Plain, 2. *M. inermis,* 3. Light thorn savannah, 4. Intermediate thicket zone, 5. Deciduous savannah ridges.

8. Game is plentiful. Potential fly-game contact is greater between buffalo, baboon, tiang, warthog, waterbuck and giraffe than it is between the other animals present. It is concluded that the tsetse are more likely to feed on the animals of high potential contact. Humans and other animals are considered to be of secondary importance as hosts.

9. In Galual flies show a seasonal movement; during the dry season they concentrate towards the *M. inermis* zone, and during the rains they return to the ridges and higher thickets. This movement is thought to be strongly correlated with that of the game which show the same trends. This has not, however, been statistically proved.

10. Fly route data is recorded in support of these movements.

11. Vegetational and other conditions in Galual and Nyang islands are discussed and it is concluded that the tsetse are able to survive in Nyang in the thickets only as they retain foliage for a long period, but that in Galual the seasonal change of habitat is required for survival, *M. inermis* being essential at the height of the dry season.

12. Records of conditions under *M. inermis* are given; conditions there are considerably cooler and more humid than on the higher ground which includes zones 3, 4 and 5.

13. Pupae and pupal cases were collected in large numbers under *M. inermis.* It is thought that during the wet season breeding is widespread on the higher ground. 10% of the pupae were found to be non-viable due to dessiccation.

14. Parasitisation is rare, only 1% of viable pupae found were parasitised. Three *Thyridanthrax abruptus* emerged.

15. Freshly gorged flies were found resting near the bases of *M. inermis*.

16. The percentage of females in catches is high. It is thought that this is due to high temperatures shortening the feeding cycle.

17. The length of the pupal period in one case was 59 days.

Résumé.

1° Il y a, au Soudan, 7 espèces de Glossines ; *Glossina morsitans ugandensis* est largement répandue au sud du pays, où les conditions climatiques sont particulièrement favorables pour cette espèce.

2° Au nord de la zone à Glossines proprement dite se trouvent 5 petites colonies de ces mouches sous forme d'enclaves isolées. Quatre de celles-ci, formant le groupe Jur Narrow, sont situées près d'une piste que le bétail utilise chaque année pour se rendre sur les pâturages de Bahr el Ghazal dans les plaines inondées.

3° Le bétail qui passe par ces régions est infecté par les tsé-tsés avec *Trypanosoma congolense* et *T. vivax*. Parmi 55 Glossines disséquées on a trouvé 5 dont les glandes salivaires ou la trompe étaient infectées de trypanosomes.

4° Les cas de trypanosomiase vont manifestement en augmentant en période des pluies et pendant que le bétail se trouve sur les pâturages. Cependant, comme beaucoup de ces animaux ne viennent pas en contact avec les Glossines, il faut admettre que l'infection peut également être propagée par des Tabanides et des Stomoxes.

5° Dans la partie septentrionale de l'aire de répartition des Glossines, les conditions climatiques sont défavorables, car en période sèche (octobre à avril) des températures jusqu'à 41° C sont atteintes. La saison des pluies s'étend sur le reste de l'année et les inondations ont lieu de juin à novembre.

6° Grâce au microclimat favorable qui règne sous les arbres de l'espèce *Mitragyna inermis*, tant que ceux-ci sont feuillés, les Glossines peuvent y passer indemnes la période de sécheresse. Les populations de tsé-tsés sont aussi favorisées par la présence d'un nombre suffisant de donneurs de sang.

7° Dans les régions décrites, la végétation a encore été peu endommagée par la population indigène. On peut distinguer 5 zones :

1. Régions inondées (plaine) ;
2. Région à *M. inermis* ;
3. Savane à légère broussaille épineuse ;
4. Zone intermédiaire de broussaille ;
5. Savane mésophile à collines.

8° Le gibier y abonde. Les possibilités de contact entre mouches et gibier sont plus grandes dans le cas du buffle, du babouin, de l'antilope Topi *(Damaliscus korrigum)*, du phacochère, du cobe à croissant et de la girafe qu'avec l'autre gibier. Il faut admettre que les mouches préfèrent prendre leurs repas de sang sur des espèces de gibier leur offrant les plus grandes possibilités de contact. L'homme et les autres espèces animales jouent un rôle secondaire comme donneurs de sang.

9° Dans la région de Galual, les Glossines effectuent des migrations saisonnières ; en saison sèche elles immigrent dans les zones à *M. inermis*, en saison des pluies elles retournent dans les zones plus élevées des broussailles et des collines. Ces déplacements semblent être étroitement liés à l'émigration du gibier ; cependant cela n'a pas pu être démontré avec exactitude jusqu'à présent.

10° A l'appui de ces observations, on a enregistré les migrations saisonnières des mouches.

11° En tenant compte de la végétation à Galual et à Nyang, et des autres conditions qui y règnent, on arrive à la conclusion qu'à Nyang les Glossines peuvent survivre seulement dans les broussailles, vu que celles-ci retiennent longtemps leur feuillage ; à Galual, par contre, les mouches, pour subsister, doivent effectuer une migration saisonnière, la présence de *M. inermis* seule pouvant leur permettre de supporter la longue période de sécheresse.

12° Des dates récoltées sur le microclimat dans la zone à *M. inermis*, montrent qu'il y fait plus frais et plus humide que dans les zones 3, 4 et 5, situées plus haut.

13° Sous des arbres *M. inermis*, on a pu récolter des pupes et des puparium vides en grand nombre. Il semble qu'en saison des pluies les gîtes s'étendent largement dans les altitudes. Cependant 10 % des pupes n'étaient pas viables pour cause de dessèchement.

14° Le parasitisme est rare et pouvait être constaté seulement dans 1 % des pupes viables. 3 exemplaires de *Thyridanthrax abruptus* ont fait éclosion à partir de pupes de Glossines.

15° Des mouches fraîchement gorgées ont l'habitude de se poser à la base des *M. inermis*.

16° Dans les captures le pourcentage des femelles est élevé. Cela doit être dû aux hautes températures qui écourtent les intervalles entre les repas de sang.

17° Dans un cas particulier la durée d'une période nymphale était de 59 jours.

Zusammenfassung.

1. Im Sudan kommen 7 verschiedene Glossinen-Arten vor. *Glossina morsitans ugandensis* ist überall im Süden, wo die Bedingungen günstig sind, weitverbreitet.

2. Nördlich des eigentlichen Tsetse-Gürtels finden sich 5 kleine, von Tsetse besiedelte Enklaven. Vier von diesen, die sog. Jur Narrow's Gruppe, liegen an einem Pfad, über welchen alljährlich das Vieh zu den Überschwemmungsgebieten auf die Weide von Bahr el Ghazal zieht.

3. Vieh, welches diese Gebiete passiert, wird von den dort vorhandenen Tsetsefliegen mit *Trypanosoma congolense* und *T. vivax* infiziert. Von 55 untersuchten Tsetsefliegen konnten bei 5 Exemplaren Trypanosomen in Speicheldrüse oder Rüssel nachgewiesen werden.

4. Die Trypanosomiasis-Fälle nehmen offensichtlich während der Regenzeit und während das Vieh auf seinen Weideplätzen ist, zu. Da viele Tiere nie mit Glossinen in Kontakt kommen, muß angenommen werden, daß die Infektion wahrscheinlich auch mechanisch durch Tabaniden oder Stomoxyinen übertragen werden kann.

5. Die klimatischen Verhältnisse sind im nördlichen Verbreitungsgebiet der Tsetsefliegen ungünstig, da während der Trockenzeit (Oktober bis April) Temperaturen bis zu 41° C erreicht werden. Die Regenzeit erstreckt sich über den Rest des Jahres, während die Überschwemmungen von Juni bis November erfolgen.

6. Dank dem günstigen Mikroklima unter *Mitragyna inermis*-Bäumen, solange diese beblättert sind, können die Glossinen die Trockenzeit überstehen. Der Bestand der Tsetsefliegen wird auch durch das Vorhandensein reichlicher Futterquellen begünstigt.

7. Die Vegetation in den beschriebenen Gebieten ist von der Bevölkerung noch verhältnismäßig wenig beeinträchtigt worden. Man kann 5 Zonen unterscheiden:

1) Überschwemmungsgebiete (Ebene);
2) *M. inermis*-Gebiet;

3) Lichte Dornbusch-Savanne;
4) Dickicht-Zwischenzone;
5) Mesophile hügelige Savanne.

8. Wild ist reichlich vorhanden. Die Kontaktmöglichkeiten zwischen Fliegen und Wild sind größer für Büffel, Pavian, Topi-Antilope, Warzenschwein, Wasserbock und Giraffe als für andere Wildarten. Es muß daraus geschlossen werden, daß die Tsetsefliegen wohl eher an solchen Wildarten saugen, die ihnen größere Kontaktmöglichkeiten bieten. Menschen und andere Tierarten sind wohl nur von sekundärer Bedeutung als Futterquelle.

9. Im Gebiet von Galual zeigen die Glossinen jahreszeitliche Wanderungen; während der Trockenzeit wandern sie in die Zonen, welche mit *M. inermis* bestanden sind, während der Regenzeit kehren sie zu den höher gelegenen Dickichten und Hügelzonen zurück. Diese Ortsveränderung scheint eng mit einer entsprechenden Abwanderung des Wildes zusammenzuhängen. Dies konnte jedoch noch nicht eindeutig nachgewiesen werden.

10. Zur Unterstützung obiger Behauptung wurden die jahreszeitlichen Wanderungen der Fliegen registriert.

11. Die Vegetation und andere Bedingungen in Galual und Nyang werden diskutiert, und es wird daraus geschlossen, daß die Glossinen in Nyang nur in den Dickichten überdauern können, da diese lange Zeit ihre Blätter behalten, während in Galual ein jahreszeitlich bedingter Ortswechsel für das Überleben der Tsetsefliegen notwendig ist, indem das Vorhandensein von *M. inermis* für das Überstehen der langen Trockenzeit unentbehrlich zu sein scheint.

12. Beigebrachte Daten über das Mikroklima unter *M. inermis*-Beständen ergeben, daß es dort bedeutend kühler und feuchter ist als in den höheren Lagen, aus denen sich die Zonen 3, 4 und 5 zusammensetzen.

13. Puppen und Puppenhüllen konnten unter *M. inermis* in großer Zahl gesammelt werden. Man gelangt zur Auffassung, daß sich die Brutplätze während der Regenzeit weit über die höheren Lagen ausdehnen. 10% der Puppen erwiesen sich aber wegen Austrocknung als nicht lebensfähig.

14. Parasitismus ist selten und konnte nur bei 1% der lebensfähigen Puppen festgestellt werden. Es schlüpften 3 Exemplare von *Thyridanthrax abruptus*.

15. Frisch vollgesaugte Fliegen pflegen sich an der Basis von *M. inermis* aufzuhalten.

16. In den Freifängen ist der Prozentsatz weiblicher Fliegen hoch. Man vermutet, daß dies mit den hohen Außentemperaturen zusammenhängt, durch welche die Fütterungsintervalle abgekürzt werden.

17. In einem Sonderfall betrug die Länge der Puppenperiode 59 Tage.

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References.

Andrews, F. W. (1950). The Flowering Plants of the Anglo-Egyptian Sudan. Vol. 1.

Austen, E. E. & Hegh, H. (1922). Tsetse Flies, their characteristics, distribution and bionomics . . . London. Imperial Bureau of Entomology.

Bedford, H. W. (1930). The distribution of tsetse flies in the Sudan. — Bull. Ent. Res. *21,* plts. XIV-XVII pp. 413-415.

Brown & Massey. (1926). Flora of the Sudan.

Burtt, E. (1952). The Occurrence in Nature of Tsetse Pupae (*Glossina swynnertoni* Austen). — Acta Tropica *9,* 304-344.

Buxton, P. A. (1948). Trypanosomiasis in Eastern Africa, 1947. — H.M.S.O., pp. 1-44.

— (1950). Notes on Trypanosomiasis and tsetse in the southern parts of the Anglo-Egyptian Sudan. (Multigraph.) — Bureau Perm. Interafr. Tsetse. Tryp. No. 85.

Davey, T. H. (1948). Trypanosomiasis in British West Africa. — H.M.S.O., pp. 1-14.

Evans, J. T. R. (1949, 1950). Bovine Trypanosomiasis in the Sudan. Parts 1, 2 and 3 (Govt. reports).

Geigy, R. & Huber, M. (1952). Untersuchungen über Bau und Funktion der Stigmen bei verschiedenen Glossina-Arten und bei Stomoxys calcitrans. — Acta Tropica, *9,* 233-263.

Glasgow, J. P. & Wilson, F. (1953). A census of the tsetse-fly *G. pallidipes* Austen and of its host animals. — J. Anim. Ecol., *22,* 47-56.

Glover, P. E. (1950). Game destruction in Zululand—the effect on *G. pallidipes.* — Bureau Perm. Interafr. Tsetse. Tryp., 136/0.

Jack, R. W. (1912). Observations on the breeding haunts of *G. morsitans.* — Bull. Ent. Res., *2,* 357.

Jackson, C. H. N. (1949). The Biology of tsetse flies. — Biol. Rev., *24,* 174-199.

— (1950). Carriage of tsetse flies by big game. — Bur. Perm. Interafr. Tsetse. Tryp., 135/0, pp. 2.

Lewis, D. J. (1949 a). *G. tachinoides* in North-East Africa. — Bull. Ent. Res., *39,* 529-530.

— (1949 b). The tsetse fly problem in the Anglo-Egyptian Sudan. — Sudan Notes and Rec., *30,* 179-210.

— (1950). Notes on tsetse flies in the Anglo-Egyptian Sudan. — Ibid., *32,* 96-105.

— (1953). The *Tabanidae* of the Anglo-Egyptian Sudan. — Bull. Ent. Res., *44,* 175-216.

Lewis, E. A. (1950). Game, Tsetse, and Trypanosomiasis Control. — Bur. Perm. Interafr. Tsetse. Tryp., 134/0, pp. 7.

Lloyd, Ll., Johnson, W. B. & Rawson, M. C. (1927). Experiments in the control of tsetse-fly. — Bull. Ent. Res., *17,* 423-455.

Morison, C. G. T., Hoyle, A. C. & Hope-Simpson, J. F. (1948). Tropical Soil—Vegetation Catenas and Mosaics. — J. Ecol., *36,* 1-84, 17 pls.

Nash, T. A. M. (1933). The ecology of *G. morsitans,* Westw., and two possible methods for its destruction. — Bull. Ent. Res., *24,* 107-195.

— (1948). Tsetse Flies in British West Africa. — H.M.S.O., pp. 77.

— (1952). Some observations on resting tsetse fly populations and evidence that *G. medicorum* is a carrier of trypanosomiasis. — Bull. Ent. Res., *43,* 33-42.

Nash, T. A. M., & Page, W. A. (1953). The ecology of *G. palpalis* in Northern Nigeria. — Trans. Roy. Ent. Soc., *104,* 71-169, 7 pls., 15 figs.

Potts, W. H. (1950). A review of the game destruction Experiment, Shinyanga, 1945-1950. — Bur. Perm. Interafr. Tsetse. Tryp., 137/0, pp. 6.

Potts, W. H. & Jackson, C. H. N. (1952). The Shinyanga game destruction experiment. — Bull. Ent. Res., *43,* 365-374.

Ruttledge, W. (1929). Tsetse flies *(G. morsitans)* in the Koalib Hills, Nuba Mountains Province. Sudan. — Bull. Ent. Res., *19,* 309-316.

Swynnerton, C. F. M. (1936). The tsetse flies of East Africa. — Trans. Roy. Ent. Soc., *84.*

Tothill, J. D. (1948). Agriculture in the Sudan.

Trypanosomiasis Committee of Southern Rhodesia. (1945). The Scientific Basis of the Control of *G. morsitans* by game destruction. — Bull. 1303, *42,* 124-128.

Addenda.

(1) Since 1953 a full scale game-eviction campaign has been carried out in the islands of Galual and Nyang under the direction of Mr. *T. W. Chorley.* Complete eradication of tsetse appears to have been effected. Hunting is still carried on to some extent in order that any animals entering the islands may be promptly killed; this is to ensure that any flies emerging late will not find food, and will die immediately. It is hoped that full data will be published in due course.

It was noted with interest by the workers in the area that in Nyang, and in Galual to a lesser extent, the tsetse appeared to be living for most of the period January to March 1955 on a diet obtained from baboons.

Recent detailed information from Nyang has shown that the map, Fig. 1 is not strictly accurate. The areas of the islands are often very small; furthermore the islands of Nyang are often completely separated and not connected as shown. The survival of the flies is due to the presence of thick bush.

Since my original visits much settlement has been carried out.

(2) *Analyses of blood meals:*

A total of 50 smears of blood from tsetse containing recognisable blood were sent to Dr. *Bernard Weitz* of the Lister Institute of Preventive Medicine, Elstree, Herts. U.K.

Dr. *Weitz* tested the blood meals using a precipitin test he has developed at the Institute.

Out of 50 blood meals 29 were negative to either Avian or Mammalian antisera. Dr. *Weitz* considers it probable that the blood was too far digested for the serum protein to be antigenic.

The remaining blood smears reacted positively to give the following results: Humans 7, Buffalo 4, Wart-hog 4, Bushbuck 2, Roan 2, Waterbuck 2, Rhino 1. One tsetse had fed on both buffalo and wart-hog. No meals had been taken from monkey or baboon.

These analyses of tsetse blood meals are of much interest; they differ slightly from what was expected in that no meals were taken from hartbeeste or tiang, or baboon. The high proportion of human (33%) is probably due to the fact that the tsetse had probably fed on one of the fly-boys before they were caught.

The accurate analyses of tsetse meals and meals from other biting flies should undoubtedly give a great deal of information which will be of value to both field and laboratory workers. They are simple to obtain, all that is required is that flies with recognisable blood in them be crushed on to filter paper, and the papers are then forwarded to Dr. *Weitz.*

I am extremely grateful to Dr. *Weitz* for making these analyses for me, and for allowing me to publish them as an addition to this paper.