

TSETSE FLY IN SOUTHERN RHODESIA, 1918.

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(PLATES II-IV, MAPS I-III.)

The history of tsetse-fly in Southern Rhodesia up to the present year (1918) continues on the whole to be one of expansion, although on the other hand one small, but important, belt appears to have become extinct. In addition, a fly area in the Moçambique Company's territory has extended up to our eastern border, with the result that serious losses of cattle from trypanosomiasis have occurred on the farms in that region. Detailed reports on the advance or retrogression of *Glossina morsitans* in other parts of Africa appear to be lacking, and it is felt that in view of the position of this territory in relation to tsetse-fly a review of the situation to the present day may not be without general interest.

The "fly areas" in Southern Rhodesia may be referred to as follows:— (1) Sebungwe Belt, occupying the greater portion of the western half of the Sebungwe district; (2) Umniati Belt, lying astride the Umniati river, partly in the Hartley and partly in the Sebungwe districts; (3) Northern Belt, occupying the greater part of the country between the escarpment and the Zambesi River in the northern portion of the Lomagundi district, and extending eastward into the Darwin district; (4) Jetjenini Belt, in the neighbourhood of Jetjenini Mountain, Lomagundi district; (5) Suri-suri Belt, in the vicinity of the Suri-suri river, between Hartley and Gatooma, in the Hartley district; (6) Melsetter Border Belt, lying almost entirely in Portuguese East Africa, but affecting certain farms on the eastern border of the Melsetter district.

(1) *Sebungwe Belt.* Owing to its extent and the fact that sleeping sickness is endemic in a certain portion of it, this is at present the most important fly-area in the territory. The extension of the infested country since it shrank to insignificant proportions in 1896-7 until the year 1913 has been described in a previous paper.* During the past five years this progress has been continued and the new country involved is shown in Map 1. The present area of this belt is estimated at about 4,500 square miles.

The value of careful notes on the channels along which the fly has spread lies chiefly in the accumulation of information concerning factors which favour the pest. It is unfortunate that circumstances have not permitted of more detailed work in this connection, but such observations as have been made were carried out with this express object in view. The practical point lies in the possibility of rendering threatened areas unsuited to the pest or of interposing a barrier and thus checking the further extension of the belt.

Broadly speaking, the contentions of the early hunters concerning the association *G. morsitans* with big game are fully supported in this area, although this is not invariably the case elsewhere. The increase of the fly and the extension of its boundaries have corresponded with a notable increase of the larger antelopes, and to a less extent of buffalo. The new territory occupied by the fly is all game country. The most rapid extension has taken place through country where game abounds; fly is

*Bull. Ent. Res. v, Sept. 1914, pp. 97-110.

most abundant at points where game congregates during the latter part of the dry season, and the advance appears to have come to a standstill at more than one point where the country beyond is sparsely inhabited by game.

These statements call for some amplification. A glance at Map 1 shows that during the years immediately following the rinderpest epizootic in 1896, the fly was confined to the vicinity of Manzituba Vlei.* From this vlei in a direction roughly S.S.W. lies a practically unbroken stretch to the Shangani River, in which game is now present in almost primitive abundance, and as the map indicates, a notable extension of the fly has taken place along this channel, and is still in progress. In a direction more S.W., however, the edge of the belt has been at a standstill in the neighbourhood of the old Native Commissioner's camp at Kariyangwe since 1907. West of this station the country is notable for its rocky character and the scarcity of antelope, and it appears probable that the area between this point and the Zambesi River never has been fly country.† At the point marked Manjolo on the Nogola River game, especially eland, is moderately abundant.

It is possible that the reason for the lack of fly in this region may be due to unsuitable vegetation or other causes; but there are numerous spots where the vegetation is to all appearances quite suitable, and there is on the other hand reason to believe that, where game is sufficiently abundant, tsetse can exist in great numbers although the vegetation does not seem to afford ideal conditions. The country lying immediately to the north of the headwaters of the Mzola River, for instance, is very open, being in fact known as the Matobolo Flats, the native name "Matobolo" signifying an open plain. Dotted about the plain are a number of small termite mounds, which bear stunted trees of an evergreen habit. In crossing a portion of these flats in 1916 the writer was surprised to find *G. morsitans* abundant, sheltering in the shade of the stunted trees and darting out to attack the passer-by. Game is plentiful, and certainly constitutes the only apparent source of blood to the flies, which in hot weather appear to be extremely confined in their range. It would appear therefore that a very limited extent of shade will serve *G. morsitans*, provided that living blood is sufficiently plentiful in the immediate vicinity. Where the food supply is more uncertain, greater freedom of movement is doubtless a necessity. We cannot therefore attribute the unsuitability to tsetse of certain tracts of country exclusively to small differences in the type of vegetation, which are not apparent to the eye. We must look for some combination of factors in which facilities for more or less regular meals are probably very important.

The extension of the Sebungwe belt to the S.E. and E. calls for little comment, as the country involved is all well stocked with game.

The writer is not familiar with most of the country to the north of the belt. Fly was located on the lower Sengwe River in 1913, and this belt was supposed to be isolated. It is possible, however, that it may in reality have been connected with the main belt in the vicinity of Sinatchungwe's kraal. In any case, reports of

* On the authority of the late Mr. Val Gielgud, formerly Native Commissioner for this district.

† In 1868 James Chapman remarked on the absence of fly on the south bank of the Zambesi between the Gwaai confluence and a point a few miles below the Sebungwe River confluence, a distance of about 30 miles. This strip contains no game except a small variety of duiker.—"Monograph of the Tsetse Flies," E. A. Austen, p. 143.

Government officials and hunters indicate that this is the position at the present day ; but whereas the region of the Sengwe is heavily infested, the narrow neck joining the two belts contains but little fly, and mules, at least, still pass through with apparent impunity. A considerable extension of the belt in the region of the lower Sengwe and on the Zambesi is also reported.

(2) *Umniati Belt.* The history of this area is of peculiar interest. In 1896-7 it appears to have shrunk to very small dimensions, but the exact position at that time is somewhat obscure. Subsequently the belt extended, in common with other fly areas in the territory and, it may be added, in the presence of considerable quantities of big game. Its present area is judged to be about 1,000 square miles. The writer first visited this part of the country in November 1910, when the southern limit of fly on the Umniati was about seven miles further north than it is to-day. At that time game was plentiful on both sides of the river but especially on the west, and included elephant, rhinoceros, eland, kudu, sable, waterbuck, impala and wart-hog, whilst bushbuck was, and remains still, moderately abundant along the river itself. In addition to game, large and numerous troops of baboons frequented the river, and have not decreased in any way to the present day. These animals are, as a matter of fact, more abundant in this region than in any other part of the territory with which the writer is familiar. The adjacent portion of the Hartley district has been open to free shooting, with one break, since 1905, and this has had an adverse effect on the game on the Sebungwe side of the Umniati river. Professional hunters, camping in the "open area," have poached regularly beyond the Umniati and of late years game has become very scarce where it was abundant as late as 1910 and fairly abundant up to 1912. Between 1910 and 1912 the fly extended about seven miles up the Umniati, but since that year it seems to have come to a standstill at this point. The belt now extends westward as far as the base of the Mafungabusi plateau. The writer has never visited the extreme northern limit of this belt, but is quite familiar with that portion which lies south of the latitude of the Umniati-Sakugwe confluence. In this part it may be stated that fly is everywhere scarce away from the vicinity of the Umniati River, but at one point on the western side four or five miles above the junction with the Njongwe (Dumbwi) it is present in great numbers. According to native evidence this is the spot where the fly survived the adverse conditions of 1896-7, and it is certainly the locality where the marked reduction of the game at the present time has had no appreciable effect in reducing the numbers of the pest. The persistent presence of large numbers of baboons is, however, a complicating factor, and the association of the fly with the vicinity of the river is consistent with the theory that these animals may be acting as hosts to the insect. It is not necessary to enter at present into the conflicting evidence as to whether these animals ever allow themselves to be fed upon by tsetse. It is desired merely to record the facts regarding the Umniati fly belt as far as they are known at present. It may be added that baboons do not enter as a serious factor throughout the great bulk of the fly-infested country in the territory.

It is to be noted that the fly has shown no tendency to spread from this belt in a south-easterly direction towards the railway line, although the country is apparently suitable. The game has been kept down very effectively by hunters in this area for a number of years past.

(3) *Northern Belt.* The writer has not visited this area since 1912 and is unacquainted with the conditions prevailing there at present. The region is untouched by civilisation, and since the year of the rinderpest epizootic the fly has, according to numerous reliable reports, increased and spread very greatly. The latest reports from the Native Commissioners indicate the present extent of tsetse as shown in the map. The infested country is estimated to include about 2,500-3,000 square miles at the present day.

(4) *Jetjenini Belt.* The infested country in this region remains untouched by civilisation as far as the forest is concerned, but owing to its accessibility it is a favourite shooting area amongst hunters, and game is less plentiful than it has been in the past. Tsetse occurs, but not in great numbers, and of late years has shown little or no tendency to spread. In 1914 an outbreak of trypanosomiasis amongst some cattle which had been running for eight or nine months on the Chumsenga River, which was supposed to be outside the fly belt, gave the impression that a southward movement was in progress. This may indeed have been the case at the time, although the evidence that this river had only recently become infested was inconclusive, and fly was certainly present when the cattle were taken there, as proved by the report of a trooper of the B.S.A. Police the previous year. It may be mentioned that game, especially kudu, sable and wart-hog, was found to be moderately abundant in the neighbourhood in September 1914. It is also significant that the northern limit of native-owned cattle in this region has apparently remained the same for a number of years past, namely, about the headwaters of the Ridziwe River and along the Mvume. Capt. Thornton, of the B.S.A. Police, found tsetse at Doma Hill in 1909 and this still marks the southern limit of fly in this direction. The stationary nature of the belt is all the more significant in the light of the fact that in pre-rinderpest days the fly used to extend considerably further south. The southern limit of fly in this district in 1896 according to Mr. R. T. Coryndon, C.M.G., now Governor of Uganda, is marked on the map. It may be added that there is a fairly wide extent of primitive country between the present limits of the fly and the limits given by Coryndon, although a portion of the intervening area has been settled. The unsettled area doubtless contains a moderate amount of game at certain seasons, though the writer has seen very little in the course of some three journeys; but the region is too near to settlement for large game to be really plentiful. The Jetjenini fly belt is about 450 square miles in extent.

(5) *Suri-suri Belt.* From all appearances tsetse has now died out in this area. The history of the fly in this belt up to the year 1913 has already been published, but in order to make the sequence of events clear it is necessary to recapitulate. Tsetse in the Hartley district shared in the great shrinkage of 1896-7 and indeed has not reappeared in many parts which were formerly infested, notably in that portion lying east of the railway. The late Mr. Scott, of the Native Department, formerly resident in the Hartley district, supplied information to the Director of Land Settlement, dated 12th June 1909, of which the following is a condensed version. "In 1895 there used to be a fly belt between a point four miles from Old Hartley and the headwaters of the Ngombe or Mombe river. In September 1897 I never saw or heard of fly during a trip from Fort Martin, to the Beatrice Mine, to the Mgezi at the Manizi range, down between that river and the Msweswi to the Singondo junction

with the Umniati, and then to Hartley. Natives stated that fly had disappeared on game being destroyed by rinderpest. Subsequently to that year I criss-crossed the whole district, except the piece of country bounded on the east by the railway, north by the Hastings road and south by the Msweswe, and never found fly at any time. In 1898-9 I heard of it at the water-holes and headwaters of the Shagari river. In 1901 I heard of its being in the country between the Beri and Umfuli rivers, near their junction, but messengers sent out did not bring any in nor did they find any. In the latter part of that year or early in 1902 I caught tsetse on the railway line on the headwaters of the Suri-suri River. In August 1902, J. McAdams brought in a number that he had caught (some six or eight miles, I think) west of the Golden Valley Road on the Suri-suri River." (Note.—The last statement should probably read "west of the Suri-suri River on the Golden Valley Road," as the latter runs approximately east and west.)

It is evident therefore that from 1898 onwards tsetse began to make its presence felt again in the Hartley district, and that by 1902 it was present in considerable numbers in the neighbourhood of the Suri-suri and Shagari Rivers. There is ample evidence to the effect that during the years following the fly was abundant in certain parts of this area and continued so until the year 1908.

The course of events in the Hartley district constitutes such a valuable record in connection with the question of the relation of tsetse-fly to the larger mammals that at the risk of being accused of labouring the various points the writer is impelled to place as much of the available evidence as possible on record. From a strictly scientific point of view it is rather unfortunate that the old fly area in this locality has been deforested, as there is a tendency at present to ignore the events, obvious at the time, which preceded the deforestation. The points it is desired firmly to establish are (1) that there was a notable reduction of fly in the basin of the Suri-suri, Umswezwe and Shagari Rivers between the years 1908 and 1913; (2) that there was a coincident reduction of large game; (3) that a considerable area surrounding the upper portions of the three rivers mentioned still remained virgin forest as late as 1913, when the wood contractors commenced to work this area in connection with the supply of timber and firewood to the Cam and Motor mine.

The year 1908 seems to have been marked by an unusually large number of cases of trypanosomiasis around the Suri-suri fly area, and the losses continued during the early part of 1909. This may have been due to a culmination in the numbers of tsetse, to the increased hunger of the flies due to the reduction of game up to that year, or to increased agricultural and industrial activity in the neighbourhood. A number of farms on the railway line near the headwaters of the Suri-suri were taken up in that year, and considerable losses were experienced in this region. In addition the Veterinary Department records losses at the Dreadnought and neighbouring mines north of Gatooma, at Hippovale farm on the Umfuli River, on the Eiffel Flats east of Gatooma, and numerous cases amongst transport oxen working from Gatooma and Hartley.

Direct evidence as to the abundance of the flies themselves is also not lacking. Mr. W. E. Masters, of the Dreadnought Mine, in a letter to the writer states that in a well-known vlei slightly to the east of the Dreadnought Mine on the Hartley-Golden Valley road, fly about this time was present in hundreds on every warm day. Mr.

Lt. E. W. Bevan, Veterinary Bacteriologist, records that in this year a local resident caught fly for him "by the matchboxful" at the foot of a range of hills running N.E. from Gatooma, parallel to and not far from the railway line. Dr. Alex. Mackenzie's experience on the Mowiri River in this year and other evidence in regard to the abundance of fly near the Suri-suri have already been recorded. There appears therefore no room for doubt that tsetse was really abundant in certain portions of this area in 1908.

When the writer commenced investigations in this region in the latter part of 1909 he naturally sought to profit by the experience of local residents in regard to the spots where fly was to be found in most abundance. Early in August Dr. Mackenzie very kindly accompanied him to the Mowiri River, where fly had caused him so much inconvenience the previous year, and the writer revisited the area almost monthly in the latter part of 1909 and in 1910. The highest number of flies seen in any one day was nine, notwithstanding the fact that the whole object of the visit was to search for them. On several days none at all were encountered. Early in 1910 a visit was made to the vlei near the Dreadnought Mine and no tsetse were seen in the course of two days. The range of hills near Gatooma was also visited about the same time, with completely negative results so far as finding tsetse was concerned, and as a matter of fact farms along the north-west side of the railway line, including the hills mentioned, began to be taken up from 1909, and cattle were introduced, as they would not have been had the fly been much in evidence at that time. Some of these cattle contracted trypanosomiasis, but the losses were not sufficient to cause the abandonment of the farms, and cattle have been present continuously ever since. It should, however, be mentioned that Mr. Lt. E. W. Bevan, employed an injection as a cure for trypanosomiasis in cattle with considerable success at this time.

Reference to the annual reports of the Chief Veterinary Surgeon for the years 1909 to 1912 is very instructive, although the record is to some extent complicated by the fact that Gatooma is the base for certain mines in or near the Umniati fly belt and for hunters taking advantage of the free shooting, who have been in the habit of camping annually on the Umniati river, frequently in the fly. However, references to trypanosomiasis in the Hartley district for the four years mentioned are as follows:— 1909: "In Hartley district the mortality during the year was very considerable. Accurate figures are not available, as many animals showing symptoms of illness were at once disposed of." Incidentally, the increased mortality was attributed to the increased number of cattle employed for the mines and on farms in the district. 1910: "The mortality from this disease has, *especially in the Hartley district*,* shown a marked decrease. Whether such decrease is due to the effects of the suspension of the game laws or not, I am not prepared to discuss here, but an effort will be made to obtain further information from members of the staff and residents in the affected districts." 1911: "Only a few cases of this disease occurred, in the districts of Hartley, Lomagundi and Mafungabusi, which contain various areas in which tsetse-fly exists." 1912: "In Hartley district fly are still to be found in small numbers in the farming and mining areas, but only a few deaths of cattle were reported."

Although, owing to special circumstances, which will be dealt with shortly, the month of December 1913 marked the commencement of a sharp increase in the

*Author's italics.

number of cases in the Hartley district, the impression up to that time is summed up in the following passage from the report of the Director of Agriculture for that year :—

“ The free shooting of game allowed in the neighbourhood of Hartley, with the object of eliminating tsetse-fly from that populous area, appears to have achieved its object in a very large measure, as the fly is by no means as abundant as formerly ; and though domestic stock are more widely distributed, very little is heard of their being fly struck. The suppression of trypanosomiasis amongst cattle, consequent on the reduction of fly by driving away the game, cannot be proved to demonstration, but certainly, as in the destruction of dogs to eliminate rabies, everything points to this result having been obtained.”

It will be seen therefore that not only the writer's personal observations but the whole veterinary record for the district prove the great reduction of fly that took place in the area between the years 1908 and 1913.

The fact of a great reduction of game having taken place during the same period scarcely needs proof, seeing that free shooting was allowed in a comparatively populous district. The writer noted a steady diminution in both game actually seen and fresh spoor from August 1909 onwards, and the increasing difficulty of obtaining a “ bag ” was a common complaint as time went on, the scarcity of wart-hog, which was at one time abundant, being especially noted. The marvel is that any game survived the constant persecution ; but so attractive was the area at certain seasons of the year that big buck were to be met with at times even after the deforestation commenced and are probably not altogether absent at the present day. Professional hunters shot largely in this area up to about 1909, as the remains of their camps, littered with bones and refuse, in that year indicated. They apparently did not find it worth while in the years following, but residents, at Hartley especially, made hunting excursions to the Suri-suri an agreeable week-end recreation as long as there was a reasonable chance of getting a shot. The reduction of game is actually a more difficult matter to prove, apart from personal observations, than the reduction of fly, but the Hartley residents who were in the habit of using this area as a happy hunting ground are not likely to call the statement into question.

The fact that a large area remained untouched by civilisation, with the exception of the reduction of game, at the time cutting on the wood contract commenced, is easily established. The writer has in his possession a copy of a large scale map drawn up by the contractors showing the area blocked out for wood cutting, the areas reserved for other mines and the remaining untouched forest in the neighbourhood. There was a continuous area of virgin forest not far short of a hundred and fifty square miles, embracing the bulk of the old fly belt, at the time the wood cutting concession was granted, dating from the 1st January 1913 (see Map III).

As it is impossible that the presence of European settlement could have any direct effect on tsetse-fly four or five miles away in the shady depths of its native forest, there are only two alternative explanations of the Hartley phenomenon. Either the reduction of the game was the direct cause of the reduction of fly or we must appeal again to natural causes and coincidence.

In connection with the Cam and Motor wood contract, a light railway was run down into the fly area in 1913 and in October of that year a considerable number

of working oxen were introduced. A number of these oxen contracted trypanosomiasis. The Veterinary Bacteriologist in his report for 1914 states :—" It is estimated that nearly 25 per cent of these transport animals became infected, but it is impossible to state definitely how many were suffering from trypanosomiasis alone, and how many were the victims of starvation during the drought of the past season."

In view of the heavy losses from trypanosomiasis that have occurred of recent years amongst cattle living outside the known fly areas, these figures are far from suggesting any great abundance of testse in the Suri-suri at the period involved.

The apparent effect of the clearing of the forest, possibly combined with the introduction of an abundant food supply in the shape of oxen amongst the lingering tsetse, was interesting. The forest was cut from the main railway line back towards the Mowiri River, skirting the edges of the alienated farms adjoining the railway, and what little fly remained would presumably follow the receding forests. Away from the edges of vleis and water-courses, however, the forest becomes leafless after the end of July and is not frequented by tsetse at this time, hence the fly may be judged to have moved back along the Mowiri to the Hartley-Shagari road. This road runs through the farm Ameva close to Hartley and on this farm for the first time there was an outbreak of trypanosomiasis in 1914. At the same time two cattle on Hippovale were suspected of being struck, but blood-smears did not confirm this. The traffic between Shagari and Hartley would account for the fly being carried in the direction of the latter, and it may be judged that the first effect of the clearing of the forest was to scatter the remnants of the fly. A few fly were still to be found in 1914 to the S.W. of the cleared area, associated with the Nswunzwe river, but in June of that year the writer encountered only a single specimen, when looking for fly in this locality. The scattered remnants of the fly apparently died out in a comparatively short time, and no cases of trypanosomiasis associated with the Suri-suri area have been recorded during the past two years or more.

(6) *Melsetter Border Belt.* Since 1914 cattle on certain farms close to the Portuguese border in the Melsetter district have become infected with trypanosomiasis during the summer months. This has been due to the extension of a belt of fly in Portuguese Territory towards and up to the Rhodesian border. In this case it is not *G. morsitans* that is implicated, but *Glossina brevipalpis*, Newst., and *G. pallidipes*, Austen. These two species are intermingled in the strip of country lying across the border from the affected farms. In this region the border practically follows the division between the high and low veld, although Spungabera, the seat of government for the Mossurize district of the Moçambique territory, is situated on the high veld. Most of the farms on the Rhodesian side are of an open character and certainly not suited to become permanent fly haunts. The low veld on the Portuguese side of the border is heavily afforested, and the forest extends into Rhodesian territory up the river valleys, several of which are very deep, the water-level being sometimes 2,500 feet below the surrounding country. In other places the forest extends up the side of the escarpment across the border; whilst one or two farms bear open forest, distinct from the sub-tropical growth found in the river valleys. Experience indicates that cattle on the Rhodesian side are only subject to infection during the wet season, and it is judged that the flies extend their range at this season, as is the case with *G. morsitans*. Practically all cases are traceable to stock having been in contact

with the forest during the wet season. They appear to graze on its outskirts with impunity in the winter. No specimens of tsetse have as yet been taken within the Rhodesian border in this region, and the flies in 1917 were present only in small numbers in the neighbourhood of the border on the Moçambique side. On the other hand the losses in cattle have been severe in some cases, as many as eighty-six head during the past season. There is thus reason to think that in Melsetter, as elsewhere, some agency other than tsetse may serve to transmit the infection from an infected beast to others herded in its vicinity.

The situation in the Melsetter district is probably unique in its way, constituting an instance where a very considerable degree of settlement and development lies immediately adjacent to practically primitive conditions across a boundary which is both political and natural.

Breeding Haunts of *Glossina morsitans*.

Very little work has been carried out in this connection, the only area searched for pupae since the writer's previous work on this subject being Sipani Vlei, lying east of the Sengwe River and north-west of Gokwe in the Sebungwe district. This Vlei is intensely infested with fly late in the dry season and bears clumps of evergreen trees on termite mounds, as in the case of Manzituba Vlei, which has already been described.* In one hollow tree alone some forty live pupae were secured and several hundreds of empty pupa-cases, constituting probably a record for any single location. Pupae could be found by searching in almost any sheltered situation at the bases of the evergreen trees near the Vlei and a considerable number were there secured. It may be stated, as bearing on the question of the season during which *G. morsitans* breeds most freely, that the large haul mentioned above was secured in November 1914, and that at the base of the same tree in August 1916 less than ten live pupae were secured, although fly was noted as being "extremely numerous and attentive." This observation is of little importance in itself, but is mentioned here as it happens to be in accordance with the conclusions of Lloyd from careful notes made in Northern Rhodesia.† It is to be remarked also that in the writer's previous work in this connection, in August 1911, only four live pupae were secured amongst a total of ninety-one, the remaining cases being empty. Lamborn also supports Lloyd's observations in this particular,‡ and it would seem that the diminution in the breeding rate and the prolongation of the pupal period during the colder months of the year is more or less established. Lloyd, however, came to a further conclusion, namely that breeding practically ceases during the wet season§ and that the latter part of the dry season, from July to October or November, would therefore comprise practically the whole of the active period of reproduction. This is exactly the season when *G. morsitans* in Southern Rhodesia is concentrated in the permanent shade bordering on vleis, rivers, etc., and it would certainly be of considerable interest if Lloyd's deductions in this respect were correct. The statement, however, needs confirmation, and whilst the writer is unfamiliar with conditions north of the Zambesi, it would appear that the deduction is based upon

* Bull. Ent. Res., ii., p. 357.

† Bull. Ent. Res. v, p. 58.

‡ Bull. Ent. Res., vii., pp. 29-50.

§ Bull. Ent. Res., v., p. 58.

a questionable premise, namely, that the distribution of the fly is the same in both wet and dry seasons. If this is the case in the locality where the observations were made, the results obtained have great value; but it is certainly not the case in Southern Rhodesia, nor, according to Lamborn, in Nyasaland. The vast bulk of the forest in this territory consists of some three species of *Brachystegia*, producing the type of forest known to the Matabele as "gusu," and the well-known mopani. The habit of "gusu" forest varies with the soil and subterranean water-supply. Broadly speaking, the trees concerned appear to become leafless all over the territory at about the same time of year, namely late in July. In many places, as at Salisbury, the new leaves appear again almost immediately, and if this were the case everywhere, it is to be presumed that no marked seasonal change in the distribution of fly in gusu country would take place. In all the fly country known to the writer, however, the forest does not as a rule come into leaf again until the middle of November or later, being apparently dependent to some extent on the commencement of the heavy rains.* As a striking instance of the effect of different soil conditions, in August 1916, the writer crossed the Mafungabusi plateau towards the Umniati River. Water is well held on the plateau, and permanent streams pour down the gorges into which the edge is broken, only to lose themselves during the dry season in the deep sand which extends from 15 to 20 miles between the plateau and the Umniati River. On the plateau the whole forest was in full leaf, whilst between the plateau and the river it was quite leafless. With respect to mopani, this type of forest has never been noticed in foliage between the end of July and the beginning of November and has frequently been noted as leafless after the middle of the latter month.

During the leafless period tsetse congregates in those parts of the fly belt where there are evergreen trees, such as *Ficus*, *Acacia*, *Parinarium mobola*, *Diospyros mashuna*, *Kigilia pinnata*, etc. Such trees occur on the banks of water-courses and the edges of vleis, even though these dry up on the surface during the dry season. Some of them are also found on "ant-heaps" thinly scattered through the forest. In some spots, as on the edges of vleis, where there is abundant underground water the *Brachystegias* come into leaf again in August, even though the vast majority of the same species in the vicinity remain leafless till the advent of the rains.

The concentration of *G. morsitans* from August to November and its general distribution during the wet season and first half of the winter renders observations bearing on the question of its most prolific breeding season very difficult indeed. There is a general opinion that the fly is most abundant in October and November, and this may be the case. It is certainly most in evidence during these two months, but, being much more widely scattered at most other times, it is difficult to draw comparisons. Nevertheless, the establishment of the fact that the hot months preceding the rains are of maximum importance to the welfare of the fly would be of considerable value. It may well be that, apart from the breeding rate, the summer months show the greatest mortality amongst the flies from the attacks of insect enemies and that they generally become reduced in numbers during this period; but as the earliest month with which we can compare the prevalence of fly at any

*An exception occurred during the present year (1918), apparently due to the phenomenally heavy rains of last season, the gusu forest being generally two months ahead of its usual time. The mopani, however, was not affected.

particular spot with its prevalence in November is August, between which month and the past wet season the cold months of May, June and July have intervened, we are in a similar position with regard to judging whether the fly loses ground in the wet season or not, as in estimating the comparative breeding rates. Although the connection may not be apparent, such facts might well shed some light on the question of the dependence of *G. morsitans* on the larger fauna of the forest. The matter will be referred to again under its own heading.

Transmission of *T. pecorum* in the Absence of Tsetse.

In spite of the fact that direct experimental proof is still apparently lacking, evidence indicating that *Trypanosoma pecorum* is commonly spread amongst associated animals in the absence of *Glossina* has accumulated in different parts of Africa during recent years to such an extent that the fact appears now to be widely accepted. (Bull. Ent. Res., viii, pp. 35-41.) In any division of the continent where fly belts occur this danger must necessarily be of considerable importance, and not least in Southern Rhodesia with its comparatively large European population. Not only is there conclusive evidence with regard to this form of transmission in the territory, but fresh instances demonstrating its practical importance occur almost every season. If all cattle owners within measurable distance of the fly areas were aware of the danger of allowing cattle which have been exposed to fly to mingle with healthy cattle, it is apparent that the losses from trypanosomiasis in the territory would be materially reduced. Unfortunately, transport riders and others who are most likely to penetrate fly country with their waggons are not easily reached through the usual mediums of publication.

It may be pointed out that considerable confusion concerning the occurrence of tsetse in various parts, particularly in the Hartley district, has been occasioned by the spread of "fly disease" amongst animals which have never been in a known fly belt, and that in drawing conclusions as to the former extent and abundance of tsetse in this district the possible rôle of other vectors must not be ignored.

Relation between *G. morsitans* and Big Game.

Whilst it is obvious that there are still considerable grounds for a contrary opinion, accumulated evidence in Southern Rhodesia constitutes a case for a vital association between *G. morsitans* and the larger fauna of the forest, which it is impossible to ignore. As already stated, it is possible that baboons play a more important part in some areas than was previously recognised.

The weakness of the contrary theory appears to the writer to lie in the fact that no alternative explanation has been forthcoming of the extremely striking phenomena that support the assumption of a vital association between the two forms of life, at least in South Africa. It is not the writer's intention to detail the arguments in favour of the theory, as these have already been dealt with in a previous paper, but it may be as well to consider such facts as have been made public which weigh on the other side. That there are difficulties in accommodating all the known facts is freely admitted, but these, surely, sink into insignificance in comparison with the difficulties of explaining a vast amount of evidence on any other basis. It is possibly true that *G. morsitans* is not everywhere dependent upon big game, in the restricted sense, but that the fly is and has been dependent upon the larger mammals throughout the greater portion of its range in South Africa is more than probable.

The main arguments to the contrary are apparently as follows :—

(1) The occurrence of fly in numbers in certain tracts where large game is apparently absent.

(2) The fact that a small proportion of the game survived the rinderpest in 1896, so that the fly could not have been absolutely starved.

(3) The discovery of nucleated corpuscles in the stomachs of captured flies, indicating an avian or reptilian diet.

(4) The fact that fluctuations in the distribution of *morsitans* have been noted apart from any wholesale destruction of game.

(1) Observations of this nature on excellent authority have been published relative to Northern Rhodesia, Nyasaland, East Africa and elsewhere, and it would be idle to dispute that such observations carry very considerable weight. On the other hand, in regard to Northern Rhodesia Lloyd, whilst noting that game was not always abundant where tsetse were very much in evidence, nevertheless found excellent cause to conclude that large game is at least highly important to the welfare of the fly.* Again in Nyasaland, whereas certain casual observers have disassociated fly and game, Lamborn, specially engaged in tsetse-fly investigations, came to the opposite conclusion. The well-known statement of Sir F. J. Jackson relative to a dry stretch of country lying between the Msologeni and Tsavo Rivers in British East Africa in 1892 was apparently due to a single and presumably rapid journey in the driest part of the season. It appears that the investigators who are most inclined to associate *morsitans* and the larger mammals are those who have continued their investigations over a considerable period in one territory, and have also paid special attention to the bionomics of the fly. The bulk of the evidence to the contrary has not emanated from entomologists, but from the comparatively superficial and disconnected observations of men of other professions.

With reference to Lloyd's observations on the influence of the prevalence of game on the ratio of the sexes caught, the following may be of interest :

November 1910, Gorai River, Zambesi Valley, Lomagundi district. Game, except warthog and duiker, practically wanting ; 37 males and 45 female flies caught.

December 1910, Umniati River. Game and baboons plentiful ; 57 males and 20 females caught.

April 1911, Gorai River, Zambesi Valley, Lomagundi. Game moderately plentiful ; 53 males and 3 females.

August 1911, Manzituba, Sebungwe district. Game abundant ; 143 males and 74 females.

October 1911, Umniati River. Game present but not very abundant, baboons abundant ; 85 males and 50 females.

June 1914, Thirty-one flies sent in by hunter, probably taken on Umniati River where game was by this time scarce, although baboons abounded ; 25 males and 6 females.

November 1914, Umniati River. Game scarce but baboons abundant ; 100 males and 28 females.

August 1916, Sipani Vlei, Sebungwe district. Game abundant ; 32 males and 14 females.

*Bull. Ent. Res. v, p. 60. and vii, p. 67-71.

These figures are more or less in accordance with Lloyd's results, and they also suggest that baboons may constitute an efficient substitute for game as a food-supply for tsetse. It should be noted that all the collections, except that near the Gorai river in April 1911, were made during the season when the fly is concentrated, and that the collection referred to is the only one showing extreme disparity in the proportion of the sexes. During the period of concentration there is no scope for the females to separate from the males, whilst during the remainder of the year they have a considerable extent of forest at their disposal. This fact may have some bearing on the result.

(2) The fact that a material percentage of the game survived the rinderpest is an obstacle in the way of accepting the theory that the reduction of the game at this period was the sole cause of the immense reduction of the fly. We are, however, in the same difficulty with regard to the disappearance of fly from many belts in South Africa, following the wholesale destruction of game by hunters, for in neither case was the removal of the animals complete. It is in this connection that further evidence as to the question whether the hot months preceding the rains are of maximum importance to the fly or not is required. Supposing this to be the case, the change in the habits of game consequent on persecution might have a very considerable effect. The most favoured haunts of the fly during the season of concentration are the edges of vleis, and under natural conditions this places them in a position to secure more or less regular meals; for, as is known to all hunters in Africa, the game comes regularly to graze on the green grass in these vleis in the afternoon during the hot dry months and must necessarily pass through the haunts of the fly. Under persecution game develops a habit of visiting the vleis at night and leaving at dawn, so that the fly does not get the same opportunities for feeding. It is conceivable that the great losses amongst the game during the rinderpest may have produced a similar shyness, which, supplementing the undeniably immense reduction in numbers of the animals, might account for a practical cessation of breeding, during what may be the most important period. During the wet season the presence of only a fraction of the usual food-supply scattered throughout the forest would in any case have a very deleterious effect.

Some of the more vigorous opponents of the game and fly theory appear to think it necessary to suppose that every fly was starved at the time of the rinderpest if the lack of food is to account for the fly's disappearance, but this is obviously quite unnecessary. A practical cessation of breeding would produce the same result and this might conceivably be brought about by a greatly reduced and uncertain food-supply. We know little enough concerning the factors that induce the fly to breed, but we do know that regular meals are necessary to the insect in confinement, and it seems almost probable that a state of semi-starvation in nature would either cause the insects to cease breeding, or that pregnant females, with growing larvae draining their vitality, would tend to die off or abort in such circumstances. Unfortunately it is impossible to verify such facts under artificial conditions.

The most striking point in connection with the controversy is, however, that not a single alternative suggestion of any weight has been made. It has been vaguely suggested that climatic conditions may have been accountable or that the fact of

feeding on animals suffering from rinderpest may have actually killed the flies. With respect to the latter, observations might have been made in East Africa during recent years, but it is on the face of it an almost incredible hypothesis. Moreover, if every fly was killed in this way does it not imply a very close association between animals subject to rinderpest and tsetse-fly? With respect to the climate the writer has been at some pains to obtain particulars of rainfall and temperature in Southern Rhodesia at the period involved and there is nothing whatever to suggest any remarkable deviation from the normal. The following returns were furnished through the courtesy of the Rev. E. Goetz, S.J., M.A., F.R.A.S., of Bulawayo.

A set of observations is on record from the Zambesi from 1891 to 1897, but some of these were taken at Baroma and some at Zumbo, a complete set for either station being lacking. These two stations are, however, only about fifty miles apart and the climates are more or less similar. It may be mentioned that fly apparently disappeared from this vicinity in the 1896-7 season and has not since reappeared. The records for three seasons ending 1896-7 are given on the opposite page.

If climatic conditions are to account for the widespread dying out of tsetse-fly at this period, one would expect either an intense general drought, an excessively prolonged period of dull weather and rain, an excessively high maximum or an excessively low minimum temperature, but there is no record of any such occurrence. As a matter of fact the seasons of 1889-90 and 1890-1 showed far heavier rainfall, as also did last season, 1917-18. Dull weather was so prolonged last season that the maize crop was largely a failure and no effect is apparent on the tsetse-fly. Seasons of much lower rainfall than 1896-7 had also no effect on the pest, and, as may be seen from the record, the maximum and minimum temperatures recorded did not actually vary as widely as those of the preceding years.

These figures would seem to dispose effectively of the theory concerning exceptional meteorological conditions, and at present we are altogether without any plausible explanation to account for the immense reduction of fly at that period except the slightly antecedent immense reduction of wild ungulates.

(3) The presence of nucleated corpuscles in the stomach of *G. morsitans* has been recorded by several investigators, but there is apparently only one record of any considerable percentage of flies showing this evidence of a non-mammalian diet,* and the circumstances may have been exceptional. There is no doubt that a hungry *morsitans* is quite willing to feed upon any warm-blooded creature, and possibly any vertebrate, that comes within its notice, and in the case of certain large birds, the operation should not be difficult. Amongst those which no doubt contribute an occasional meal to the fly may be included the ostrich, cranes, herons, ground hornbills, vultures and various birds of prey, including eagles, owls, etc., and doubtless several other types. Such birds are obviously far too scarce or come far too rarely within range of the fly, to constitute an efficient substitute for the usual mammalian diet. That the vast majority of birds with their active dispositions and untiring pertinacity in pecking at insects serve to support *morsitans* is extremely unlikely, and there appears to be no evidence at all to suggest such a possibility.

*[Lloyd, Bull. Ent. Res. iii, p. 236.—Of 52 flies containing blood, the nature of the blood cells could be recognised in only 20; of these, 5 contained non-mammalian nucleated cells.—ED.]

Rainfall in inches at Salisbury, Mashonaland.

Year.	July.	August.	Sept'm'r.	October.	Nov'mb'.	Dec'mb'r	January.	February	March.	April.	May.	June.	Total.
1895-96.	—	—	—	0.48	1.95	12.88	8.69	6.92	1.94	0.81	—	—	34.94
1896-97.	—	—	—	0.01	6.32	2.84	5.78	7.07	4.79	1.34	—	—	29.06
1897-98.	0.00	0.00	0.14	1.04	3.77	9.86	4.12	4.28	2.34	1.76	0.27	0.00	27.48
1898-99.	0.00	0.21	0.06	0.77	3.12	4.81	1.74	18.79	6.34	1.97	0.06	0.04	37.91

Rainfall at Hopefountain, Matabeleland.

Year.	July.	August.	Sept'm'r.	October.	Nov'mb'.	Dec'mb'r	January.	February	March.	April.	May.	June.	Total.
1894-95	0.00	0.20	0.00	0.92	1.64	2.86	5.63	9.25	4.01	0.23	0.00	0.00	24.74
1895-96.	0.00	0.00	0.00	0.20	4.74	10.61	3.46	3.63	(3.19)	(1.11)	0.00	0.00	(26.93)
1896-97.	0.00	0.00	(1.05)	(1.08)	1.85	4.72	8.74	4.38	5.52	0.00	0.00	0.63	27.97
1897-98.	0.00	0.00	0.00	0.00	4.99	7.82	7.75	0.98	4.69	0.47	6.31	0.04	27.05
1898-99.	0.00	0.00	0.69	0.41	3.29	5.05	4.44	7.07	1.79	2.48	0.41	0.04	25.67

Season 1894-5, Baroma.

	July.	August.	Sept.	October.	Nov.	Dec.	January.	Feb.	March.	April.	May.	June.
Mean Temp. (C.).	21.1	23.9	26.0	31.2	30.4	28.4	27.7	26.2	26.9	26.0		
Abs. Max. (C.).	28.7	32.2	33.0	41.2	39.0	35.2	35.3	33.1	32.4	32.3		
Abs. Min. (C.).	13.5	16.7	18.5	23.7	23.6	21.5	22.5	20.2	21.1	19.1		
Rel. Hum. (Mean).	61	58	50	41	52	62	68	84	75	65		
Rainfall (mm.).	10	2.0	13.0	0	68.9	49.6	86.9	27.10	20.9	16.2		

Season 1895-6, Zumbo.

	July.	August.	Sept.	October.	Nov.	Dec.	January.	Feb.	March.	April.	May.	June.
Mean Temp. (C.).	23.8	23.2	27.3	30.3	31.8	26.6	26.4	26.9	27.8	27.5	23.9	—
Abs. Max. (C.).	32.1	32.2	37.7	41.0	40.4	32.5	34.3	33.9	34.3	34.0	32.2	—
Abs. Min. (C.).	12.6	15.8	17.4	17.4	22.1	22.5	20.4	22.3	23.2	20.4	19.0	—
Rel. Hum. (Mean).	58	45	37	36	43	77	77	74	69	60	69	—
Rainfall (mm.).	0	0	0	0	50	33.04	62.22	21.70	49	0	0	—

Season 1896-7, Baroma.

	July.	August.	Sept.	October.	Nov.	Dec.	January.	Feb.	March.	April.	May.	June.
Mean Temp. (C.).	21.4	24.6	27.9	30.4	31.4	29.9	36.2	33.5	36.9	—	—	—
Abs. Max. (C.).	25.4	28.8	33.3	35.5	37.1	34.7	36.2	33.5	36.9	—	32.7	28.5
Abs. Min. (C.).	16.2	20.3	22.1	23.4	26.0	24.9	22.9	20.5	21.2	—	18.3	14.6
Rel. Hum. (Mean).	64	59	44	45	44	70	77	82	68	—	56	58
Rainfall (mm.).	0	0	8.4	24.2	8.4	14.58	12.55	89	0	—	0	2.6

With regard to the possibilities of an extensive reptilian diet, the larger reptiles are very scarce in most *morsitans* areas, and those that depend upon water are frequently altogether absent. A reptilian diet in many areas would necessarily be confined to small active lizards and chameleons. There is no evidence to suggest that the former would allow themselves to be fed upon to any extent, but chameleons are no doubt an occasional source of sustenance. Where the fly occurs along the banks of a fairly large river, however, there would appear to be no obvious reason why the same food-supply as that which serves *palpalis* should not suffice. *G. morsitans*, however, not only shows no predilection for such situations, but appears largely to avoid them. In the portion of the Umniati area already referred to, fly is certainly to be met with on the banks of the river itself, but is far more abundant in the adjacent forest. Its distribution therefore does not suggest a dependence on water-loving reptiles or amphibia. The pest actually lives in the old game haunts, now greatly depleted, but its habitat is constantly crossed by large troops of baboons moving to and from the river, and the paths of these animals are quite a conspicuous feature in this locality. Whatever diet is serving the fly along this stretch, however, it does not appear to produce the same increase in the pest as an abundance of game, as is shown by the lack of tendency to expansion since the reduction of the latter.

(4) The fact that fluctuations in the distribution of *morsitans* occurred previous to any wholesale reduction of game has really little bearing on the controversy, as nothing comparable with the phenomena which accompanied game reduction either locally or over a vast area is on record. It would be curious if tsetse-fly were not subject, at least in some degree, to similar influences to those which induce enormous fluctuations in the occurrence of many other insects, such as excessive multiplication of parasites and other enemies in a given area. *Glossina*, on account of its slow rate of reproduction, has less ability for recovery than the vast majority of other insects and so must be more liable to die out entirely under persecution.

To sum up, the case for the vital association of *G. morsitans* with the larger mammals appears to the writer to be extremely strong, in South Africa at least, and the evidence brought forward in opposition comparatively insignificant. There appears to be no direct evidence at all that *morsitans* feeds to any great extent on the smaller mammals under natural conditions, and the failure to find trypanosomes in the blood of such mammals by Montgomery and Kinghorn, and the Royal Commission in Nyasaland, constitutes distinct evidence to the contrary. Whatever may be the truth concerning the vital dependence of *morsitans* on the larger mammals in all areas, there is every reason to believe that the pest feeds upon them by preference and thrives best in their presence, and apart from any other consideration this constitutes a powerful argument for the suppression of the larger game animals, which are, in any case, bad neighbours to farmers and stockowners. The writer yields to none in his love of wild life, but when it comes to a choice between developing colonial territory economically or maintaining it as a zoological garden, there can only be one decision.

Explanation of Fly-belts.

Austen on page 4 of his "Handbook of the Tsetse Flies" sums up the question of fly belts as follows:—"We are still somewhat in the dark as to

the factors that determine the limits of these 'belts,' but, although tsetse are undoubtedly dependent upon the blood of vertebrates for their continued existence, all recent evidence goes to show that the most important element is the physical character of the locality, and probably its suitability as a breeding ground." These remarks, of course, refer to tsetse-flies generally, and not *morsitans* in particular, but they leave out of consideration one rather obvious fact, namely, that the limits (of *morsitans* at least) are not necessarily permanent. Uninfested country adjacent to a fly area may be just as, or even more, favourable to the pest than the country it inhabits, the fact being demonstrated beyond question by its becoming heavily infested later. This has been occurring constantly in Southern Rhodesia since the rinderpest, the limit of the Sebungwe belt in certain parts, for instance, year by year traversing country obviously favourable on both sides of the line. The character of the locality, probably intimately combined with the incidence of a suitable food-supply, appears to account for the permanent limits of a belt; but what determines the transitory limits? Why is it that *morsitans* does not spread thinly over the whole of its potential area instead of inhabiting only a part? A fly belt has, in fact, a coherent quality of its own which needs explaining. Except during the season of concentration from July to November or later, the insect is as a rule by no means confined by physical conditions, as is shown by the fact that it more or less deserts its dry season haunts and spreads for some miles through the surrounding forest. As far as the writer has been able to ascertain its dispersing range does not exceed two or three miles, although there would seem to be no obvious reason why it should not be considerably greater. Again, the males are undoubtedly carried in all directions up to ten miles, or possibly more, by the movements of animals and human beings, but as Lamborn has shown in Nyasaland, they have both the instinct and the power to return to the point whence they were carried. The females seem only to seek animals and human beings for the purpose of feeding, and they are probably rarely carried any considerable distance. A strong "homing instinct" has been proved in respect of the males, and is to be inferred, at least over a comparatively short distance, in respect of the females.

The instinct of a fly to return to its haunts if it strays or is carried into unfavourable country, and the instinct of the males to return to the common haunt, where the females are to be found, are quite comprehensible; but they do not explain why favourable country adjacent to fly areas is frequently free of the pest. The fact of the matter seems to be that the fly is absolutely unadventurous, if the term be permissible, not ranging very far from its provedly favourable dry season haunts, nor allowing itself to be carried beyond the range of its power to return. It appears to the writer that this is to be explained, not by the lack of any tendency to wander, but by the possession of a *definite instinct to avoid wandering*; as it is to be supposed that in the absence of such a controlling instinct the flies under the stimulus of hunger would tend to range far and wide in search of food, as they well might do without encountering unfavourable conditions during nearly eight months of the year.

Assuming the existence of a strong instinct to avoid undue wandering, an explanation of its development on the basis of benefit to the species must surely be possible. One of the results is a more or less gregarious habit, but it is difficult to perceive what benefit the fly derives from this. Other things being favourable a single fly is

undoubtedly quite capable of looking after itself. The writer formerly inclined to the opinion that owing to the slow rate of breeding a gregarious habit, in enabling the sexes to meet and mate with the maximum certainty and regularity, might be of considerable value; but this theory would seem to be untenable in the light of the fact that there is no evidence to show that separate matings are necessary for each act of reproduction, the probability being that one act of copulation suffices for the female's life-time. The following suggestion is put forward for consideration, namely the value of *parental experience*. If there is one thing proved in connection with tsetse-fly it is its lack of adaptability. Under favourable conditions of forest and food-supply it frequently occurs in great numbers, but it is altogether absent from large tracts of country not affording its very particular requirements as to conditions, and tends to vanish entirely from its habitat if conditions be modified to its disadvantage. Given a wandering habit without a "homing instinct" a considerable proportion of the flies would tend to stray into unfavourable country and perish, and it appears conceivable that this fact may have led to the development of a strong instinct against wandering, *which functions whether the surrounding country be favourable or not*. In the vast majority of cases the fact of a fly being born at any particular spot proves the suitability of the locality to the species, and, as in the case of a certain conservative type of human being, what is good enough for the parents may be judged good enough for the off-spring.

The Manner in which Fly-Belts extend.

This is a matter which has received some attention in this territory for a number of years past. The following rules are in accordance with the evidence accumulated, but must be regarded at present as merely tentative:—

(1) The advance does *not* take the form of disconnected offshoots at a distance from the main belt, but the whole movement is analogous to that of a rising flood, flowing along favourable channels and gradually extending the flooded area; (2) when the line of advance is interrupted in regard to permanent shade, as in crossing a watershed, the movement is confined to the wet season; (3) large numbers of flies are necessary at the previous dry season limit before a moderately wide region affording only summer shade can be crossed; (4) the fly can only spread in the presence of considerable quantities of the larger mammals.

The observations leading to these conclusions have been confined to Southern Rhodesia, but with the exception of the last they appear to be due to the same cause, which is independent of locality, namely, that the flies tend to remain in or return to one particular spot. The recently observed facts in this territory are altogether opposed to the theory that fly moves into and establishes itself in new districts with game, as has been stated by hunters and explorers in the past. Newly infested spots may be disconnected by a few miles from the former limits of the belt during the season of concentration, but the belt is continuous during the season of dispersion.

The fact of fly being only able to advance from one dry season haunt to another in the wet season is easily understood on the basis of the seasonal dispersion of the insect, which enables larvae to be deposited in the intervening forest until the neighbourhood of the next river, or other suitable dry season haunt is reached. When the next season of concentration arrives, the pest presumably concentrates in both

directions, a portion of the flies going back to the previous dry season haunt and a portion to the new, probably whichever is the nearer. The term " wet season " is not used loosely in this connection, notwithstanding the fact that the forest retains its foliage for some months after the cessation of the rains. The wet season lasts until April, and the three months following are, with the occasional exception of August, the coldest in the year, when the breeding rate appears to be at its lowest ebb and the tendency to extension is apparently checked by this fact. It is to be remarked that whereas advance along a well shaded river may be a more or less continuous or regular process, advance across interfluvial areas tends to be irregularly spasmodic. One dry season haunt having been attained, a pause of several years sometimes intervenes before the next step, and observations indicate that the next step, if it be a fairly long one, say five or six miles, is only possible when the fly has become really abundant at its previous halting place. As an instance, the passage from the Mzola to the Kana River in the Sebungwe district, a distance of about six miles, took place in the wet season of 1915-1916, but the fly was present on the Mzola in small numbers in 1912-13. Once the pest obtained a footing on the Kana, it increased rapidly in the presence of large quantities of game and late in 1916 had become fairly abundant, showing that it was no lack of favourable conditions ahead that caused the delay. The necessity for great numbers would appear to be explicable as follows :—At the beginning of the rains the flies scatter at once for a short distance in all directions from their narrow dry season haunts. A certain proportion of the females deposit larvae near the limit of their spreading range towards the new objective. Flies emerging from these also scatter in all directions, a proportion of the females again larvipositing in the required direction. The repetition of this process may result in the neighbourhood of the next river or vlel being reached before the next season of concentration ; but it is clear that, the rate of reproduction being so low, only a small proportion of the numbers that originally scattered would extend so far in a few months, hence the necessity of large numbers to start with.

These remarks may seem somewhat academical, but they have a distinctly practical side. If the writer's deductions are correct, it would appear that the clearing of a comparatively narrow strip of forest might serve to check the advance of the fly, notwithstanding the fact that the males would constantly be carried across to the other side. The cost and maintenance of such a clearing would be prohibitive on a great scale, but by taking advantage of local conditions it might prove practicable to check the advance of a belt in some particular direction. An experiment of this nature was actually commenced at the south-western extremity of the Sebungwe belt in October 1918, but has had temporarily to be abandoned owing to the influenza epidemic.



Fig. 1. Gusu forest in full leaf near Gwaai River,
Southern Rhodesia, October 1918.

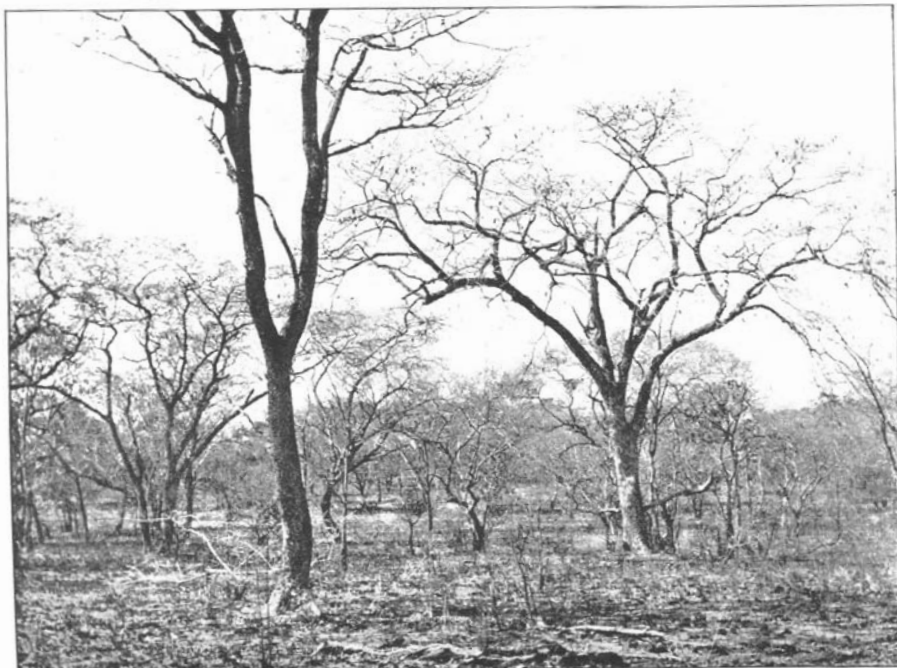


Fig. 2. Leafless Gusu forest near Sipane Vlei,
Southern Rhodesia, August 1916.

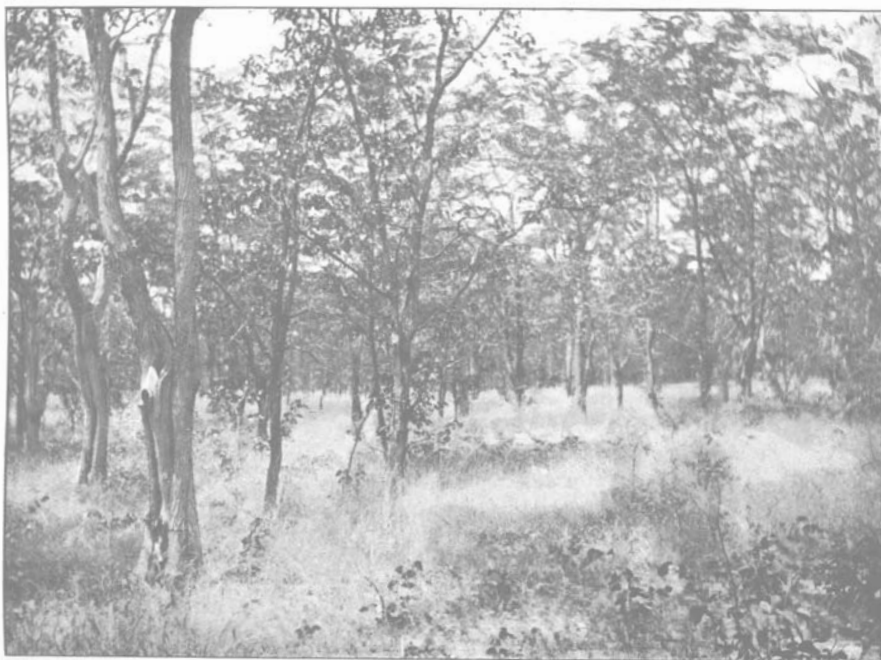


Fig 1. Mopani forest in full leaf in the Zambesi Valley, April 1914.

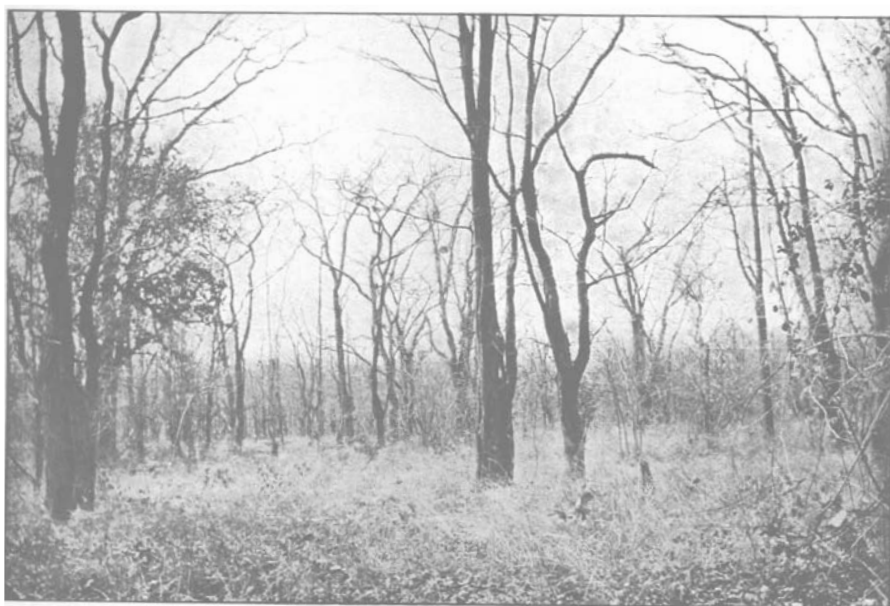


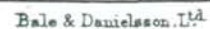
Fig. 2. Mopani forest in leafless condition, Wankie's District, near Gwaai River, October 1918.



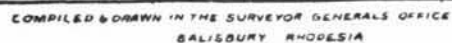
Fig. 1. Large numbers of pupæ of *Glossina morsitans* were found in a hollow in the trunk of this tree; Sipane Vlei, Southern Rhodesia, November 1914.

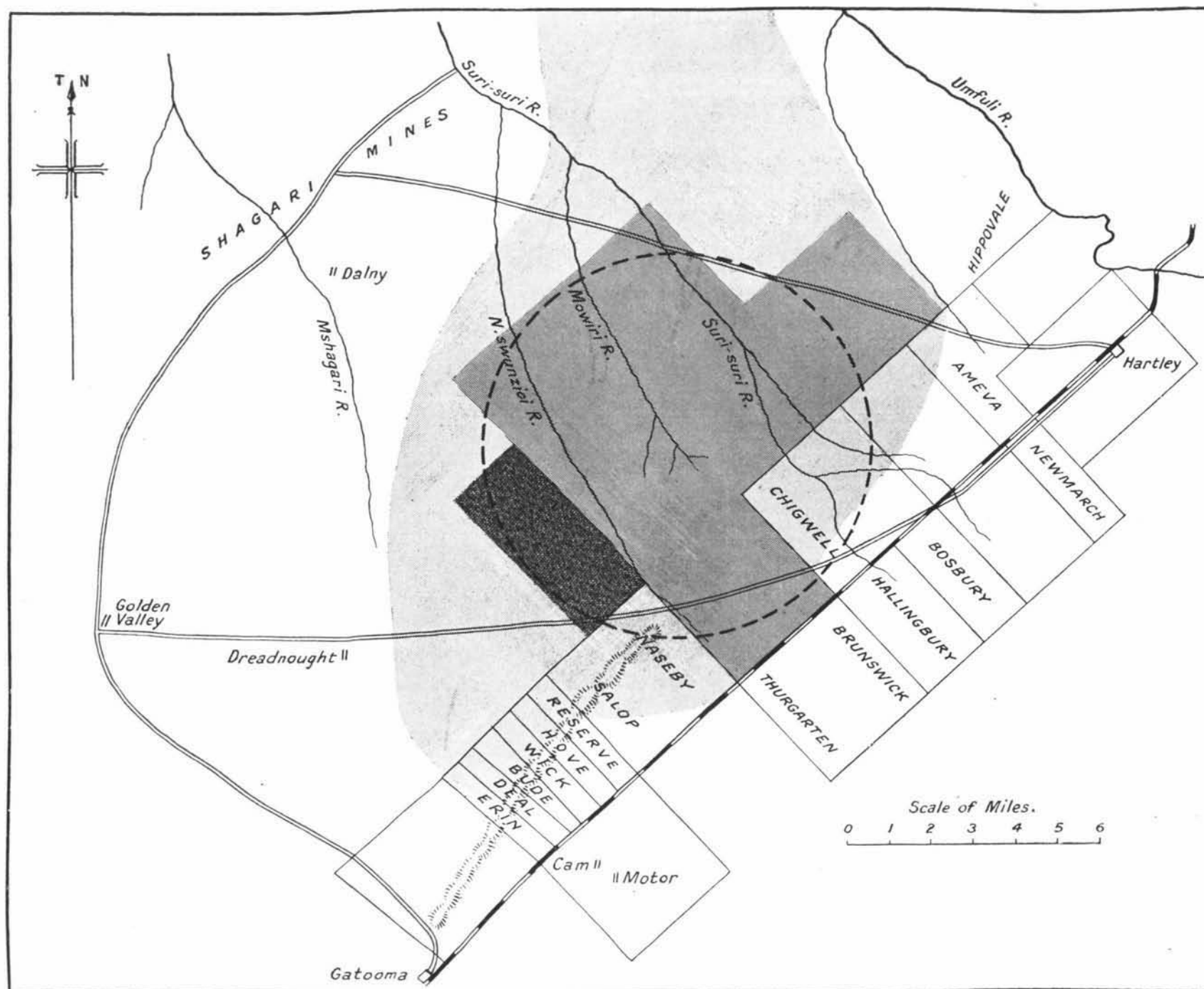


Fig. 2. Enlarged view of the hollow in which the *Glossina morsitans* pupæ were found.



Map showing the increase in recent years of *GLOSSINA MORSITANS* in the Sebungwe District, Southern Rhodesia.





THE SURI-SURI FLY BELT IN THE HARTLEY DISTRICT, SOUTHERN RHODESIA.