ERADICATION OF TSETSE FLIES, GLOSSINA MORSITANS UGANDENSIS VANDERPLANK, IN THE JUR NARROWS OF THE SUDAN

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INTRODUCTION

The lack of development of tropical Africa is, to a major degree, attributed to the effect of tsetse flies. Some glossinologists believe that tsetse flies have the effect of insulating the African tribes from the surrounding civilization. It is evident, however, that tropical Africa contributed very little towards civilization in the historic periods.

Tsetse flies exert their influence by transmitting trypanosomiasis to both man and animals. This disease is known as sleeping sickness in the former and nagana in the latter. Great epidemics of sleeping sickness early in the century killed over 200,000 out of 300,000 population around Lake Victoria, Uganda, thus causing a mortality of two-thirds, in a period of about five years 1901-1905. Another outbreak in the same area, as recently as 1940, caused a devastating depopulation.

Animal trypanosomiasis has had a more drastic effect on the development of tropical Africa in the past and will have, no doubt, in the future. The exclusion of cattle and other domestic animals from an area greater than the United States (4.25 million square miles) and the subsequent lack of first class proteins for human consumption has resulted in malnutrition and predisposition to disease. The many other economical and medical problems thus created are no doubt the immediate outcome of tsetse flies (Fig. 1).

The origin of the word tsetse comes from the Sechuana language of the Bechuana land in South Africa. The word signifies a "fly destructive

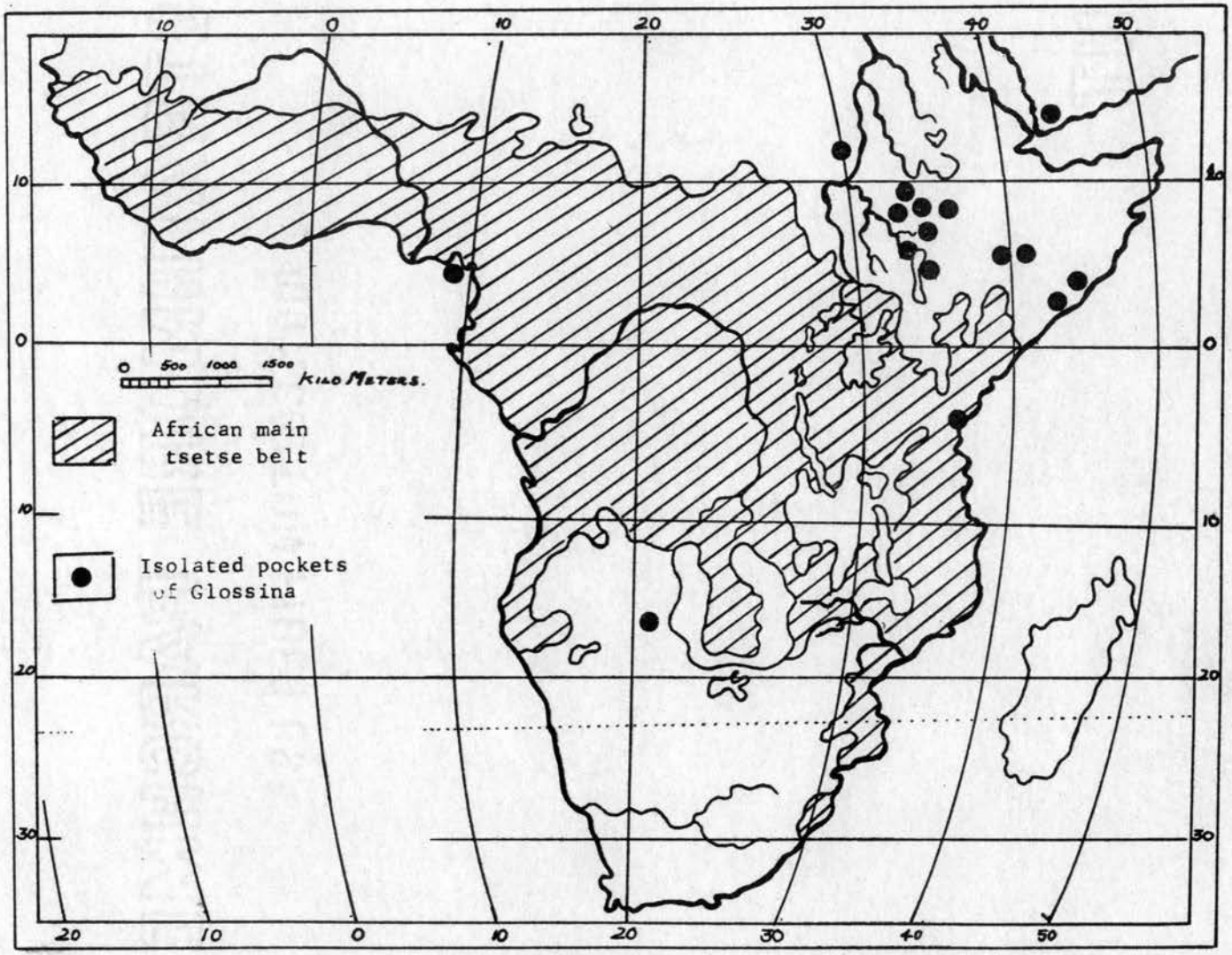

Fig. 1. The distribution of the genus Glossina.

to cattle." Buxton (1955) suggests that tsetse is onomatopoeic, the sound suggesting a sharp buzz.

Tsetse flies are found only in Africa between 14° N and 29° S latitude with the exception of a record of one species, Glossina tachinoides Westwood, from the hills of Southwestern Arabia, Carter (1906). Another four species of fossil tsetse flies have been found in the Miocene shales of Florissant, Colorado, first described by Scudder in 1892. These are believed to be a million years old, and it is generally accepted that one of the great glaciations might have contributed to their disappearance. Geologists, on the other hand, consider this one of the many evidences of an old land junction.

Human trypanosomiasis have been known for over five hundred years. The earliest record came from the ancient kingdom of Mali in the 14th century, Willet (1963). Sleeping sickness was recognized as negro lethargy by the slave traders in the late 17th century and early 18th century. Their rejection of slaves with swollen neck glands signifies their awareness of the dangers of the disease.

All records indicate that trypanosomiasis of domestic animals have been present throughout the whole of the African tsetse belt probably before any historic record began, but the relation of tsetse flies to trypanasomiasis has been known for more than half a century.

One objective of this thesis is to report on the use of insecticides on bait animals and hide screens as a complementary method to game destruction on a wide scale under the special conditions of the Jur Narrows of the Sudan. This type of work, although tried on experimental bases in other East African countries, was not used on a large scale as a method of control.

The other objective is to justify the mass destruction of game which is regarded by many authorities as distasteful, and by some regretable, by comparing it with the conventional methods applied in the other parts of tropical Africa in the control of Glossina morsitans Westwood.

SIGNIFICANCE OF THE JUR NARROWS. The main tsetse belt in the Sudan constitutes the northern limit of the African Tsetse Belt. It is roughly 90,000 square miles and is completely devoid of cattle (Fig. 2). The grassland north of this belt is stocked with cattle. However, there are several isolated pockets or colonies of tsetse flies along the northern fringe of the main African Tsetse Belt particularly in the region between 10^{o} N and 15^{o} N and 30^{o} and 40^{o} E.

The question which arises normally is related to the mode of formation of these pockets far beyond the extremities of the original northern level of the main tsetse belt extending for 300 miles in some instances. The answer is well brought out in the Sudan, i.e., Jur Narrows, and Nuba Mountains.

Though many views are put forward to explain the formation of these pockets, it is generally accepted that the factors which brought about the creation of these independent pockets are purely natural, assisted finally by artificial agencies. According to Buxton (1955) there has been a succession of wet and dry geological periods over parts of Africa and the last wet period resulted in advances of vegetation and game followed with a simultaneous movement of tsetse flies. This was succeeded by the present dry period, which has lasted for thousands of years, consequently the vegetation and game retreated leaving behind isolated colonies of tsetse flies in areas where conditions remained favorable,

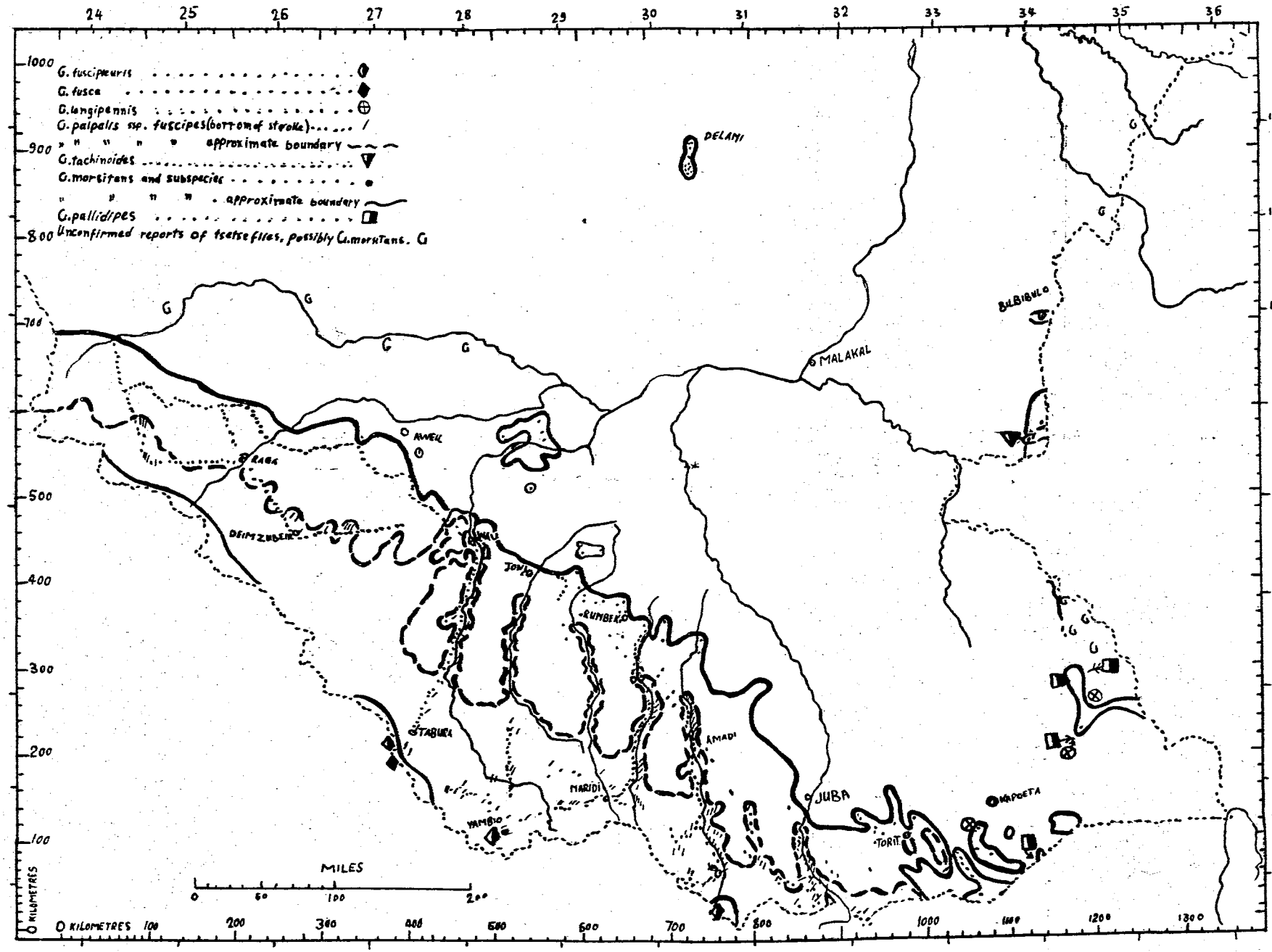

Fig. 2. The known maximum distribution of tsetse in the Sudan

i.e. enough vegetational cover and game. This is particularly true with the Savannah Tsetse, Glossina morsitans Westwood; the only species encountered in the Jur Narrows. Buxton (1955) concludes that even though this explanation is acceptable it is difficult to understand the absence of isolated pockets of Glossina morsitans submorsitans Newstead or Glossina tachinoides to the north of the main area of distribution in West Africa.

Reid (1954) believes that tsetse flies were apparently scarce at one time and confined to the southern reaches of Equatoria Province but isolated patches existed in the Nuba Mountains and Kigille and were there for years. The rest of the Southern Sudan was almost free of tsetse flies. He assumes that with the Darvish raids and the subsequent thinning of population and cattle, the tsetse bush thickened and tsetse were able to advance and when once established they were able to retain their foot-hold.

He assumes that the flies advanced as far as climate and vegetation would allow. He is certain that there were similar advances from the French Equatorial Africa boundary and that these possibly account for the existence of the fly in the Jur Narrows of the Bahr el Ghazal Province.

Despite the existence of trypanosomiasis in the Southern Provinces of the Sudan no control measures or scientific search for tsetse flies were initiated from a veterinary point of view up to 1949. The incidence of trypanosomiasis increased rapidly in 1946-1947, and casualties in cattle reached alarming proportions. Mass treatment with the then, new phenanthridinium compound, dimidium bromide (3,8-Diamino-5-methyl-6 phenyl-phenanthidinium bromide) and antrycide prosalt (4-amino-6-(2-

amino-6-methyl-4-pyrimidylamino) quinaldine-1,1[1]-dimetho salts) was undertaken and a quarter of a million head of cattle were inoculated. The incidence of the disease was low for about a year following this mass treatment but by 1949 trypanosomiasis was reported to be widespread again in both Upper Nile Province and a Bahr el Ghazal Province.

An entomologist was recruited early in 1950 to carry out surveys in the main tsetse belt and to investigate the possibility of introducing cattle into selected parts of the area. This decision was cancelled in 1951 and the entomologist was to carry out an extensive survey in the areas where trypanosomiasis had again become widespread. The survey was to be started in the western extremity of the cattle grazing area of Bahr el Ghazal and continue eastward across the Upper Nile Province; an area of approximately 150,000 square miles.

Preliminary surveys and investigations revealed that the primary focus of infection was the isolated pockets of the Jur Narrows which were separated from the main tsetse belt to the north by an area, some 100 miles in width, which was devoid of suitable vegetational cover for existence of tsetse flies. It was further evident that the Jur Narrows was a famous corridor through which over 330,000 head of cattle pass annually, early in the dry season and at the onset of the wet season, on their way to and from the rich grazing areas around these pockets. During their migration, cattle are forced to come in contact with tsetse bush, and in some instances actually go through tsetse infested bush to avoid the flooded low grounds. Consequently they are exposed to tsetse fly bites, become infected and carry the infection back home to their wet season camps. In these areas infection is further disseminated through the medium of other biting flies such as Stomoxys and tabanids.

At least a million head of cattle were involved and hence nagana was spread all over the country, infecting cattle which had never been in direct contact with tsetse.

REVIEW OF LITERATURE

The voluminous literature on the biology, distribution, and control of the tsetse flies indicates that very few insects have been so thoroughly studied by a group of highly specialized workers as tsetse flies in recent years. The literature dates back to the incrimination of tsetse flies as the vectors of nagana and sleeping sickness by Bruce and others in 1894, Scott (1939).

DIFFICULTIES IN CONTROL. The fact that there are 22 species, each, having its different requirements, habits, habitats, and predelection, constitutes a problem of its own. A species like Glossina morsitans can infest several different types of country each with its own problems. The diversity of the habitats of the different species ranging from the tropical rain forest (Glossina fusca Walker) to the very dry thorny (Glossina morsitans) makes tsetse control complicated and problematic.

Any successful control measure should be based on a sound knowledge and understanding of the fly itself, its biology, distribution, senses, and seasonal variations in habits, and habitat. It also entails a thorough knowledge of tsetse ecology and geology and their effect on the flies and their pupae.

There has been a diversity of control methods which is partially attributed to the different problems and the natural conditions in relation with each species, but it is due, a great deal, to the lack of communication among workers in different parts of Tropical Africa where tsetse control was in progress. This lack of communication has

been overcome, not only among East African workers, but all over Tropical Africa, in recent years through the establishment of the Commission for Technical Co-operation in Africa (CCTA) and the Scientific Council for Africa South of the Sahara (CSA). These provided a permanent center for the exchange, coordination, and dissemination of technical information and to further the application of science to the solution of African problems.

The approach to the tsetse problem has been characterized by attacking the insect with the primary objective of its eradication and no correlation was made between control of tsetse and epidemiology of sleeping sickness. Controlling the disease by cutting down the man-fly contact, as in the case of malaria, was not considered. However, in recent years the concept of tsetse control has changed considerably. British workers in West and East Africa practiced mass diagnosis and treatment, and recently, French and Belgian workers have practiced prophylaxis in control of epidemics, Willet (1963).

The future for this type of control is very promising particularly with the new trypanocidal drugs and with the extensive laboratory research going on for their improvement in both the United States and the United Kingdom. This new approach, it is hoped, would put an end to the severe epidemics of sleeping sickness and the losses of millions of cattle in the near future, Willet (1963).

HISTORICAL REVIEW OF SLEEPING SICKNESS AND NAGANA. The first reliable report of tsetse in the Sudan was recorded in 1861 by Petherick, Lewis (1949). Petherick contrasted the Jur tribe who live on the edge of the main tsetse belt with the Dinkas in the grass plains and reported

the difference in habits of the two tribes was due to an insect. He also reported that the Dinkas at Akot were quite aware of tsetse and tsetse bush.

Baker (1962), during his visit to Obbo, Equatoria Province, encountered many biting flies some of which are believed to have been tsetse. Austen (1878), referred to in Lewis (1949), reported destruction of oxen by tsetse fly in Rumbek, Bahr el Ghazal Province.

The 19th century, however, ended without many specific records of tsetse flies from the Sudan. The severe epidemic of sleeping sickness in the adjacent territories of Uganda and Belgian Congo early in this century created apprehension in the Sudan. An extensive search for Glossina palpalis Newstead was made and much was discovered about its distribution and that of Glossina morsitans, Lewis (1949). Lewis further reported restricted movement of people along the frontier following the epidemic of 1904, the extensive surveys conducted to detect cases, and that the disease was controlled by 1916. Similar measures were taken in the Raga area. He reported peoples moved from their scattered homes in the forest along water courses where Glossina palpalis dominated in Souress Yubu area and concentrated along water-shed roads. Streams were cleared of small trees and overhanging vegetation.

The policy which involved movement of people away from streams to the watersheds had to be abandoned as it created a shortage of suitable land for cultivation. It was decided to move people back to the rivers and streams and practice block scheme settlement coupled with hand catching of tsetse flies, Davey (1948).

Balfour (1906) reported the appointment of a Sleeping Sickness Commission to check the danger of the spreading epidemic from Uganda and

Belgian Congo. Members of the Sleeping Sickness Commission made very valuable observations on the habits and distribution of both Glossina morsitans and Glossina palpalis. A sleeping sickness officer was appointed on their recommendation.

King (1912) and Ruttledge (1928), published notes and maps on tsetse distribution and habitats in Nimule-Shambe reach and the distribution of Glossina morsitans in Koalib Hills of the Nuba Mountains, respectively. Parts of these early surveys were included in the famous work of Newstead and Potts of 1924, Lewis (1940).

Abundance of tsetse flies in the Bahr el Ghazal Province was reported by Enssor (1908). He attributed the heavy mortality of transport animals on the Wau-Mvolo and Khogali-Wau Road to tsetse flies supported by a dense population of game. Anderson (1911) correlated the spread of Glossina morsitans with caravans and herds of game which were seen almost everywhere along the frequently used roads but were somewhat localized otherwise.

The first complete work on the distribution of tsetse flies in the Sudan was published by Lewis (1949) in his monumental monograph, "The tsetse fly problem in the Anglo-Egyptial Sudan". He reviewed the tsetse distribution with special emphasis on sleeping sickness and its vector Glossina palpalis, and the measures to be undertaken against Glossina morsitans the vector of trypanosomiasis in cattle. According to Lewis, the main tsetse belt of the Sudan is occupied by 7 species of the 22 species so far recorded in the main African Tsetse Belt. These included Glossina morsitans and its subspecies, with Glossina palpalis following

streams and rivers, Glossina fuscipleuris Newstead and Glossina fusca along the Nile-Congo divide, Glossina longipennis Corti. in arid country east of the Nile, Glossina tachinoides in the east, and Glossina pallidipes Austen in the southeast.

HAND CATCHING AND TRAPS. Catching tsetse by hand as a method of control seemed to be effective only in the control of waterside tsetse like Glossina palpalis which had a more restricted habitat. The first effective control was conducted by Symes and Vane (1937) according to Buxton (1955). They tried to eradicate Glossina palpalis by use of hand nets and traps along the Kuja River by isolating five blocks within 12½ miles along the river by clearings ranging in depth from 500 to 1000 yards. They concluded that hand catching in isolated blocks appeared to be economical and satisfactory for this species. Their findings further showed that collecting of pupae in such scattered breeding sites had no effect on the tsetse population and clearings up to 1050 yards were not effective barriers.

Glasgow and Duffy (1947) attempted to eradicate Glossina palpalis from two stretches separated by a 5000 yard clearance along the river, one was used as control. The results obtained showed complete disappearance of flies after six months catching. They concluded that the method was cheaper than bush clearance and could be successfully used in combating sleeping sickness epidemics.

Ruttlege (1928) reported an attempt made to eradicate Glossina morsitans by hand catching in Koalib Hills, Nuba Mountains, Sudan. In 3 months, 10 fly boys armed with nets caught 775 flies and a considerable reduction in the fly population was noticed. Ruttledge indicated that no eradication was to be expected despite the scarcity of Glossina morsitans

under the Nuba Mountain conditions where game was nonexistant. Under these conditions, flies were maintained by the native cattle and pigs.

Several workers developed different kinds of traps, as control measures for different species of tsetse, which incorporated sticky materials in them. They were three dimensional and consisted of a box the size of an antelope, cow, or goat. Some, however, were vertical. The first standard trap was devised by Harris (1938). His trap was 6 feet long, 3 feet wide and 3 feet deep. It was covered with 10-ounce double hessian cloth, 72 inches wide, to give the necessary light attraction. An opening 6 inches wide extended along the whole length of the center of the body with a similar opening transversely across the platform which was surmounted by an inverted "V" shaped non-return entrance. The trap was suspended by wire between two trees.

Goat-size traps were first developed by Morris (1949). They were fitted with legs to be sunk in sand to facilitate mobility. His findings indicated that "animal traps' were more attractive to Glossina palpalis and Glossina tachiniodes which feed mainly on sheep, goats, and duikers in the Gold Coast.

Swynnerton and Chorley (1933) described traps in the form of upright dummies resembling the figure of man.

The superiority of DDT-treated traps was first reported by Morris (1950). He further analyzed the variables which were to be considered in use of traps and concluded that color of the object was the most decisive factor.

Jack (1939), working with Glossina morsitans, found that traps with dark blue or black cloth were more attractive than those of hessian or khaki. Harris (1932) conceded, however, that attraction was influenced

by skill in placing the traps at strategic points for effective light and shade. The significance of visibility of traps and selection of site was also indicated by Morris and Morris (1949).

Traps placed near man or large animals caught more tsetse as observed by Macaulay (1942), and Henrard (1942), referred to in Buxton (1955). Swynnerton (1933) experimented with two sets of traps; one with a calf and the other without. More Glossina palpalis were recovered from the former.

Deflying houses and smoke houses, particular types of traps built along roads through which vehicles, bicyclists, and pedestrians would pass proved beneficial as a protective measure to trap tsetse carried by them when going out of fly infested area into clean area. It cut down the risk of spread of tsetse and was widely used un Uganda, and Nyasaland, Buxton (1948).

Swynnerton (1933) described an electric trap of high voltage at back of a lorry and was charged from the battery of vehicle. The stepped-up voltage killed the insects settling on the traps. Similar devices were used on house flies.

Although the primary objective of traps developed by Harris was the control of Glossina palpalis, they never worked satisfactorily even in small foci. In spite of the large number of traps used, only a marked reduction of the fly population was attained, but never control, Buxton (1948). He suggests further development of traps for survey and research purposes and indicated they were not satisfactory when used as a control method.

INSECTICIDES. No insecticides were used prior to the advent of DDT (Dichloro-diphenyl trichloroethane) in tsetse control. However, control

by insecticides has been an area of fruitful research. Buxton (1955) indicated that although much research was conducted in the late 40's little success has been achieved for several years. He suggested that the biology of the tsetse flies was the limiting factor for the following reasons: the pupae are equal to the adults in number; the pupae are underground for more than 60 days; the first larva is deposited within two weeks after the female emerges and sprays must be applied fortnightly to kill adults or residual applications to kill immature forms.

Application of DDT on traps was first tried by Morris (1950). He impregnated the surface of traps with a solution of DDT in kerosene and his findings indicated that impregnated traps caught larger numbers in spite of DDT's irritating effect on the settling tsetse. He assumed the irritation was counterbalanced by the lethal effect of DDT which decreased the possibility of flies escaping from traps.

The primary studies of Vanderplank (1947a) on the value of applying DDT on domestic animals to kill tsetse flies revealed that application of DDT emulsion (10 gm crude DDT/animal) was promising but results were not as significant as those of hide screens. Insecticides would not stay as long as in traps. He concluded, after making several assumptions that he could treat cattle with insecticides, allow them to graze in sufficient numbers in a fly belt and thus exterminate tsetse. He showed that cattle would compete with game if put in concentrations of 75 head per square mile, most of the game would be driven out. His results obtained from treated and untreated screens with Glossina palpalis and Glossina swynnertoni were statistically significant.

Whiteside (1949) experimented along similar lines but on a larger scale when he used 240 oxen in an isolated tsetse bush. This five square-

mile area was infested with the same species (Glossina pallidipes). He achieved 95% reduction in the fly population which returned to normal three months after removal of the animals. He concluded that this may be due to the feeding habits of Glossina pallidipes and suggested the feasibility of the method in control of Glossina morsitans. Buxton (1955) considered this method elaborate and expensive but thought it to be of value if used in combination with other methods. Various workers reported on application of residual insecticides on resting haunts of Glossina morsitans after its success in control of Glossina palpalis. Hocking (1959) applied dieldrin emulsion to lower sides of branches of the resting haunt (Acacia hebecladoides) in a small area (17 square miles). His findings indicated that 90% of insecticide disappeared from the surface of the park in 4 months and the remaining 10% would probably be lethal. He reported a reduction of 98% in population but no control at a cost of 8 shillings per acre.

Similar work was reported by Uganda Tsetse Control Department (1959) where discriminative spraying was not effective and indiscriminative spraying produced only 97% reduction. Their findings indicated that spraying could be used, if improved, as a reclamation measure or at least for creation of a barrier to Glossina morsitans.

AERIAL APPLICATION OF INSECTICIDES. Different preparations of DDT and BHC (2(1,2,3,4,5,6-Hexachlorocyclohexane))were sprayed by hand on bush and trees on the islands, in Lake Victoria, Uganda Symes, et al. (1948). These results showed that single applications produced remarkable reduction in numbers of tsetse but did not eradicate Glossina palpalis. Loss of insecticide by absorption and washing by rain was indicated. They pointed out the necessity of precise knowledge of

resting places of females and importance of evolving a preparation of insecticide which would not be absorbed by the vegetation.

The use of insecticidal sprays or "smokes" from aircraft was first carried out in Zululand, Union of South Africa, in 1945-1946 to control tsetse in a 40 square-mile game reserve, Toit and Klug (1949). They sprayed the area three times with Anson aircraft. The spray fluid contained 5% technical DDT in furnace oil, 90 parts; kerosene, 10 parts; put down at the rate of 0.5 gallon per acre. They sprayed at an interval of three weeks and reported a 94% control finally which continued for seven months. These authors concluded that although no effective control was accomplished, yet the method was worth trying in areas not too extensive and where aircraft could be utilized. Their results indicated that airborne droplets were responsible for the kill rather than contamination of the surface thus necessitating a low flight which was not practical in some types of country.

As adequate control was not achieved, the South African Government resorted to applying DDT as a "smoke" or aerosol. Buxton reported that eight applications at the rate of 0.32 lbs. per acre were conducted, and 99.3% control was obtained. This report stated a high per cent control in spite of the bush being in full leaf and the disadvantage that application could only be done when air was still. Further application of "smoke" at irregular intervals produced 100% control which was checked by introduction of cattle in the reserve.

Dissemination of insecticides from the air in East Africa was studied by several workers after the successful trial in South Africa Hocking (1953). Following successful, small-scale trials, Foster et al. (1959) attempted to eradicate Glossina morsitans, Glossina pallidipes by aerial spray at a lower cost. They used Auster aircraft fitted with a Britten-

Norman rotatory cage spraying unit to give 5% (W/V) solution of Gamma BHC at a dosage of 0.08 gallon per acre and seven applications at 28-day intervals gave 90% reduction for the first two applications but final reduction was only 50%. Their findings attributed failure of better control to low female kills. They concluded that improvement of technique would probably lead to satisfactory control at a lower and economically satisfactory cost.

BUSH CLEARANCE. The relation between tsetse and vegetation was established a long time ago and bush clearance was the most popular and important method of attack since all species of tsetse need some sort of cover to survive. Buxton (1948) speculated that the Africans probably had their own traditional method of protecting their cattle and had plenty of grazing in the old times before they came under the influence of Europeans. He thought they probably avoided fly belts as well as areas invaded seasonally by Glossina morsitans besides attacking thickets and increasing grass at the expense of the bush. He believed that late burning was practiced at the end of the dry season whereby dead grass and thickets were burned. With the advent of colonization, he believed, the tribes lost much of their organization and the fight against bush relaxed. The result was an advance of tsetse in many places. He cites the great increase and thickening of bush due to the enforcement of early burning by the governments in East Africa as evidence of the problems created by the Europeans.

Swynnerton (1936) indicated that all species of tsetse need more than one vegetational type during the seasonal and daily distribution; the frequency of change in distribution being greatest during the dry season. These vegetational types, he showed, constituted their feeding

ground, rest haunt, mating ground, and breeding ground; while different species vary in their requirements. He discussed the feasibility of organized concentrated human settlement close to tsetse bush which would gradually advance and finally exterminate tsetse flies.

Buxton (1955) considered clearing of bush to be replaced by grass as an abnormal process wherein a climax forest would replace grassy vegetation unless it was well maintained until all bushes and trees died out and man and cattle were introduced in sufficient numbers to hold the ground. His conclusion justified the attack on bush as an essential measure against tsetse under most circumstances.

Morris (1949) emphasized that although bush clearance was employed widely as a common measure against tsetse, there is much more to be learned about tsetse in relation to vegetation.

Swynnerton (1934) observed an increase of the density of bush by excluding annual fires as a means of control of Glossina morsitans but he drew attention to the possibility that the increased bush density may create conditions suitable for other species. The effect of thickening of bush on soil temperature was studied by Fairbairn and Culiwick (1950). They pointed out that in the unburnt area the soil temperature was lower and that this was unfavorable to the insect.

Morris (1946) regarded certain trees and shrubs as indications of the presence of Glossina palpalis and Glossina tachinoides and discussed the possibility of eradicating tsetse by destroying these "essential belt trees".

Bush clearance was classified as aggressive or eradicative and defensive or protective, the former aimed at complete eradication of tsetse and

the latter as a protective measure to people who come in contact with tsetse fly with the final objective of complete exclusion in the long run, Buxton (1955).

The most extensive work with bush clearance as a method of tsetse control was undertaken in Nigeria as early as 1909, Moiser (1912). The same method was practiced in Uganda some years before this date. Nash (1936, 1939, 1940) studied the effect of selective clearing and discriminative clearing on tsetse pupae and adults at different times of the year. His findings led to the adoption of discriminative clearing as a popular measure of control against Glossina morsitans submorsitans and Glossina tachinoides in Nigeria. Various degrees of bush clearance combined with other methods were used against waterside tsetse in the Gold Coast, Morris (1946, 1949). Morris suggested the necessity of making larger waterside clearnings to prevent insects from crossing. He found that short clearings acted as feeding grounds for both species and would serve no purpose in cutting down man-fly contact. His findings established that Glossina palpalis crossed clearings more in moist climate than during the hot or cold weather.

Examples of successful control by discriminative clearance are quoted by Buxton (1948). He stated that by felling only 6% of trees in Tanganyika and parts of Uganda Glossina swynnertoni was controlled. While clearing only 1% of the trees produced reduction of Glossina morsitans in Rhodesia. He stressed the fact that the planning of these was the direct outcome of extensive ecological work and better understanding of the biology and requirements of tsetse. He concluded by urging further study of the waterside and roadside clearings.

Swynnerton (1925) was the first to point out that man should be used to hold the land and stop the advance of tsetse or should advance into the fly belt by clearing the bush and cultivating the land. He adopted this proceedure in parts of Tanganyika. Similarly Lambarn (1938), referred to in Buxton (1948), reclaimed 150 square miles from Glossina morsitans by clearing and cultivating maize and tobacco.

Buxton (1955) suggested human settlement with preliminary clearing combined with other subsidary methods in various parts of tropical Africa for control of Glossina morsitans and Glossina swynnertoni as a successful, permanent method of control.

GAME DESTRUCTION. Control of tsetse by destruction of game has long been established although objected to by many authorities. Dependence of Glossina morsitans on game was reported by many workers. Jack (1914) reported evidence from European colonizers who observed the disappearance of Glossina morsitans after the great rinderpest epidemic. According to Thodian (1926), quoted in Buxton (1955), Glossina morsitans disappeared from a mining area near Katanga, Belgian Congo, as a result of the increase in human population and subsequent decrease in game around the growing town.

Lewis (1949) called attention to the former abundance of Glossina morsitans along uninhabited places and their scarcity along roads in the Sudan. He quoted the view of the Azande tribe; that their persistent hunting reduced Glossina morsitans populations.

Macfie (1912) showed that destruction of game eliminated tsetse, particularly Glossina morsitans. The insect, he reported, used to be abundant and troublesome along roads infrequently used. With increased traffic and distrubance of game the animals retreated and tsetse became

scarce or completely absent without any control measure.

LLoyd, et al. (1927) reported that Glossina morsitans submorsitans was affected unfavorably to a greater extent than Glossina tachinoides by exclusion of game.

Game destruction was successfully used in clearing Glossina morsitans from ten thousand square miles of bush in Southern Rhodesia, Buxton (1955). He concluded that it was universally agreed that game destruction was a successful method of control against game tsetse. He advocated that it could be combined with other measures but he advocated careful consideration of zoological and entomological facts before adopting game destruction.

STERILIZATION. Simpson (1958) presented the theoretical examination of controlling tsetse populations by use of artificially sterilized males, after making certain assumptions. He concluded that it was impractical to attempt the control of high density tsetse population by irradiation since a large number of males was required. But he thought it would probably be of value at low density especially when followed immediately after use of insecticides.

Previous experimental work on a similar idea was reported by Vanderplank (1947b). He sterilized females by mating with males of a closely related species, but trials in the field failed.

MATERIALS AND METHODS

Following the outbreaks of trypanosomiasis in cattle in the southern provinces of the Sudan 1946-1950, the Livestock and Veterinary Policy Committee decided to begin surveys of areas where the disease was most prevalent with the object of reclaiming some of them. Early in 1952, the Tsetse Survey and Reclamation team was formed by the Department of Animal Production and a tsetse expert was seconded for three years, from the Uganda Government.

Three Uganda senior tsetse surveyors, experienced in tsetse control work, were recruited and a school for training fly boys and surveyors was set up at Toriet, Equatoria Province. The surveyors and fly boys were given intensive training for six months on how to recognize tsetse flies, find breeding places, distinguish between sexes, to assess their age, and estimate different hunger stages.

The preliminary investigations and the reports furnished by the Dinkas incriminated the Jur Narrows as the main foci of infection. It was decided to start surveys in the area where trypanosomiasis was causing serious losses. Survey units were established and each unit was to consist of an entomologist, field officer, store keeper, senior surveyor, a number of surveyors and fly catchers, and in addition, many laborers and porters. The units were distributed throughout the area to be surveyed.

An aerial reconnaissance was conducted to define the infested area

more accurately. This showed that the area consisted of one big island and three small islands and not of only three islands as previously thought. The word "islands" refers to a patch of residual forest forming a characteristic true tsetse habitat, which may or may not be on water-side and is not surrounded by water but usually by cultivation, while residual forest refers to the only surviving remnants of the original forest of the country as used by Nash (1937). The Jur Narrows Islands, however, differ in that the forests are surrounded by water on two or three sides in the case of Galwal-Guar, Nyang and Rorgumakol and on four sides in the case of Nyinacuil which forms a typical island during the rainy season when the Jur River and its tributaries are flooded; but the term is used in the former sense here. Rurgumakol, the biggest island (320 square miles), covered the eastern side of the River Jur, while Galwal-Guar (140 square miles) Nyang (60 square miles) and Nyinacuil (80 square miles) stretched along the western side of the river. The islands were separated from each other by a bushless water-logged barrier varying from three to six miles in width. The islands comprised an area of approximately 600 square miles (Fig. 3).

By early 1952, tsetse surveys in the area defined above were in full swing. In the first instance the area north of Wau, including the Jur Narrows area, was surveyed. The surveys revealed the following:

1) The Jur Narrows contained four tsetse islands separated from the main African Tsetse Belt by 100 miles which was free from vegetational cover under which condition the tsetse could not survive, hence once these islands were cleared they would remain free.

2) The only species recovered from the islands was Glossina morsitans which had adapted itself to the Jur Narrows conditions.

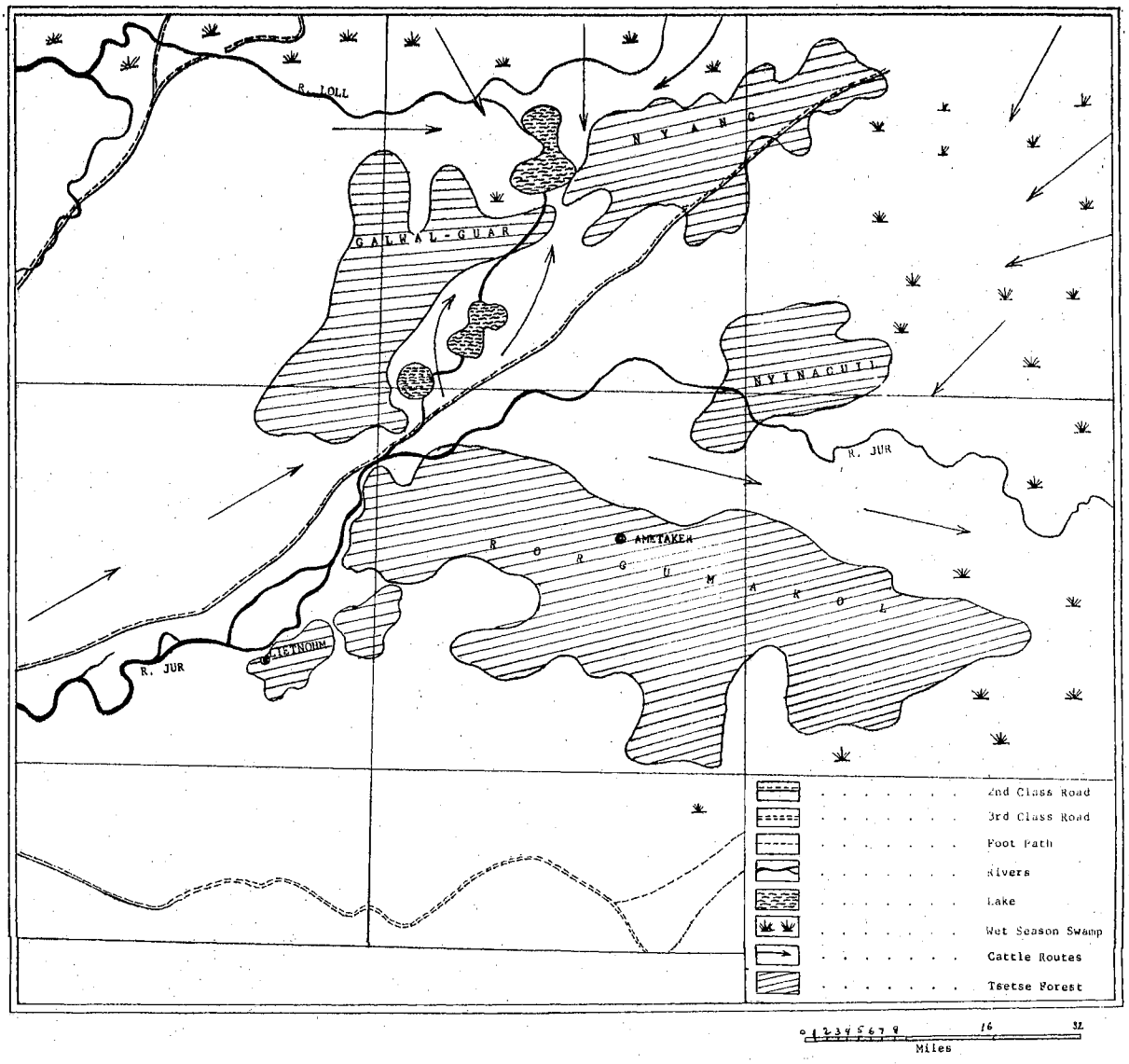

Fig. 3. The Jur Narrows Islands and their relation to each other.

3) The area was stocked with game particularly buffaloes and baboons.

4) Dinkas of the area were land hungry and were anxious to clear parts of the forest and settle, but as they could not take their cattle with them very few were coming in.

It was thought after the surveys that the islands could be reclaimed by a combination of the following methods:

1) Eviction of buffaloes and baboons.

2) Organized human settlement in the area of dry season concentrations of tsetse.

3) Discriminative clearing of vegetation from areas which were unsuitable for settlement.

A Province Tsetse Advisory Committee was constituted of representatives of departments concerned to consider the recommendations mentioned above for reclaiming the area and to submit proposals showing how the work could best be carried out. Finally the committee, after considering the results of closer surveys of the area, decided that game eviction followed by settlement at leisure, after eradication of tsetse flies, was the only practical and economical method of control under the Jur Narrows conditions. This was to be coupled by use of insecticides on bait animals and suspended hide screens.

Description of the Area

VEGETATION. Since the Jur Narrows lie on the northern fringe of the broad-leafed woodland, and on the southern edges of the acacia forest region, which includes the vast seasonally inundated swamps, the vegetation is typically mixed deciduous savannan woodland. It is dominated by

deciduous trees, mostly losing their leaves for varying periods of time in the dry season, with an understory of grass, on the higher ground. The vegetation is mainly composed of Termenalia spp., Acacia spp., Combretum spp., Tamarindus indica Linn., Ziziphus spp., and Balanites aegyptiaca (Linn.), forming thickets of various degrees in this zone (Fig. 4).

The lower ground and the edges were in the main covered by Mitragyna inermis (Willd.). The evergreen mitragyna zone is followed by large stretches of seasonally inundated land known locally as "Toich". The annual inundation inhibits tree growth but forms the vast meadows of almost pure grass in the dry season where the Dinka graze their cattle. In the "Toich", however, occasional prominent termite hills are scattered throughout the region with or without small trees. The "Toich" grasses are mainly Vetiveria spp. and Sporobolus spp. with Hyparrhenia spp. on higher grounds.

The sequence of vegetation zonation was typical of Galwal-Guar, Nyang, and to some extent for Nyinacuil, but was not so distinct in Rorgumakol except in the southern end of Togren and the northern portion of Alobeck. In Rorgumakol open terminalia forests, ebony, Diospyros mespiliformis Hochst. and acacia trees traversed by shallow water courses, devoid of trees, running for many miles with occasional thickets were the main features.

In Nyinacuil the vegetational cover consisted of a very dense forest on the higher grounds gradually thinning out at the periphery to an open Mitragyna inermis zone, sometimes preceded by an open Acacia sieberiana Schweinf zone and finally terminating in the open "Toich". The body of the evergreen thickets consisted of a mixture of Mitragyna inermis,

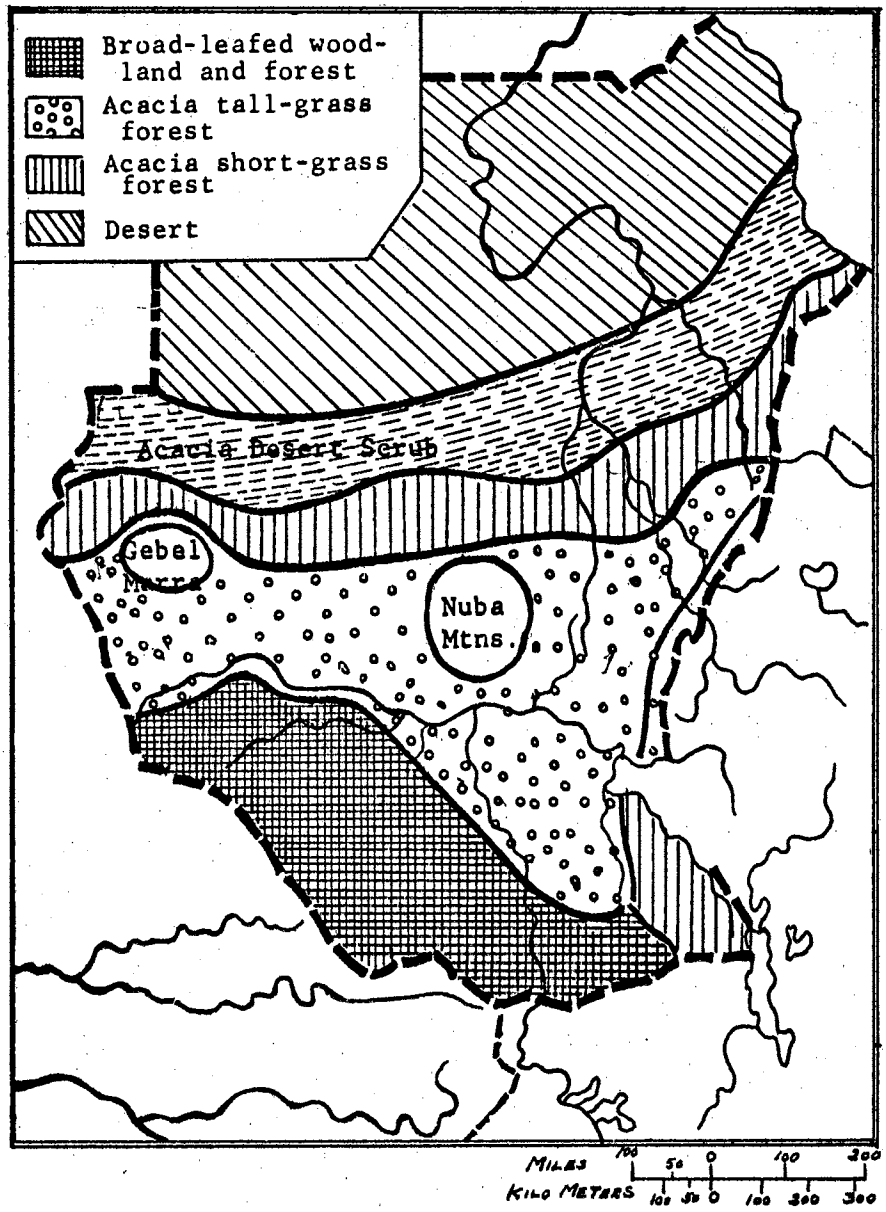

Fig. 4. Vegetation map of the Sudan

Acacia sieberiana, Tamarindus indica very much entangled with creepers and undergrowth of thorny vegetation without grass. The peculiarity of the vegetation was probably due to the sandy clay soil and the high soil moisture content derived from the many streams and water courses traversing the forest and the mitragyna zone. These streams form a network throughout the 20- x 4-mile forest and are flooded from July to October and drain into the River Jur. During late August and early September as the river overflows its banks an opposite flow of water results in considerable flooding of the area. This is followed by a reverse process when the water level in the river falls in late October. Boats and canoes are used along these streams during the floods as a means of transportation, while during the dry season their banks are used as motor tracks since they are the only bushless route.

CLIMATE. The climate was characterized by a seasonal rainfall extending from May to October, and the remaining months being dry. The rainfall averaged 1145 mm in addition, the "Toich" and lower parts of the forest were flooded by the overflow of the river as mentioned above. The maximum temperature was 43 C, while the absolute minimum was 11 C and the minimum 20 C. During the wet season the mean relative humidity was 73% and averaged 46% in the dry season. These figures were recorded by the Meteorological Department Station as the average for the last 29 years (1931-1960).

FAUNA. The extensive flood plain of open grassland surrounding the higher savannah woodland with its perennial grass cover formed an ideal habitat for a number of species of herbivorous and carnivorous mammals which no doubt formed together a characteristic faunal unit. The density of game population was estimated to be over ten animals per square mile

which was relatively high. The distribution and density of species varied tremendously in each island and in different areas within the island according to type of bush and availability of water and grass, the latter being influenced by season.

The following species were found in the area: Buffalo, Syncerus caffer (Sparrman); roan antelope Hippotragus equinus (Desmarest); giraffe, Giraffa camelopardalis (Linn.); waterbuck, Kobus defassa (Rüppell); tiang, Damaliscus korrigum tiang (Heuglin); kob, Adenota kob (Erxleben); reedbuck, Redunca redunca (Pallas); rhineceros, Ceratotherium simum (Burchell); bushbuck, Tragelaphus scriptus (Pallas): oribi, Ourebia ouribi (Zimm.); duiker, Sylvicapra grimmia (Linn); wart hog, Phacochoerus aethiopicus (Pallas); baboon, Papio doguera (Pucheran); monkey, Cercopithecus aethiopes (Linn.), Erythrocibus patas (Schreber), and possibly others; spotted hyena, Crocuta crocuta (Erxleben); lion, Panthera leo (Linn.); leopard, Panthera pardus (Linn.); hippopotamus, Hippopotamus amphibius Linn.; and nile lechwe, Onatragus megaceros (Fitzinger).

Buffaloes, Syncerus caffer, concentrated in the thickets when the plains became flooded and gradually moved out towards the plains with the advent of dry season as the water dried up, coming back to the woodland occasionally to seek shade. Except for periodical (every other year) migrations from Nyinacuil to Nyang, and Galwal-Guar the buffalo herds remained stationary. The giraffe, Giraffa camelopardalis, was confined to acacia bush and never entered the plains. During the rains, however, when the acacia was waterlogged it retired to the woods on high ground. Waterbucks, Kobus defassa and roan antelopes, Hippotragus equinus, occupied the woods and grazed on the edges of the plain along the water

courses and the waterholes. Tiangs, Damaliscus korrigum tiang, spent the dry season on the plain and showed an affinity for termite mounds and moved into the woods during the rains. The same was true with kobs and both were gregarious. Reedbuck, Redunca redunca and oribis, Ourebia ourebi, shared the open wooded area on the periphery and the bushless grass areas traversing the forest were perennial grasses with their new growth; after the fires and early rainy season, together with the isolated trees attracted them for grazing and shade respectively. The Nile lechwe, Onatragus megaceros, inhabited the swamp exclusively.

Bushbucks, Tragelaphus seriptus, were seldom seen during the day. They utilized thick bush for hiding and grazed at dusk and dawn. Duiker, Sylvicapra grimmia and wart hogs, Phacochoerus aethiopeieus, were frequent in the woodland and were not seen in plains from which they were apparently excluded by habitat preference. Tamarindus indica and Balanites aegyptiaca dominated forests were attractive homes for baboons, Papio doguera, and monkeys, Cercopithecus aethiops, Erythrocebus patus, (and possibly others) for whom water is a limiting factor.

The three herds of rhinoceros, Ceratotherium simum, encountered in Rorgumakol moved in association with giraffes in the rainy season and spent the dry season around the waterholes. Since its life is centered on water the hippopotamus had more restricted grazing on the grassland along the river in the dry season and wandered into adjacent bush along watercourses in the rainy season. Few, however, were recorded in Togren of Rorgumakot and many in Nyinacuil.

Appreciable numbers of carnivores were recorded in all the four islands. Leopards, Panthera pardus, and hyenas, Crocuta crocuta, had permanent homes in thickets while lions, Panthera leo, roamed about

following game within the woodland.

Game Destruction

Thirty local hunters with at least 12 years army service were recruited and given intensive training in target practice and in tracking different wild animals with special emphasis on buffaloes. They were armed with different caliber rifles ranging from .22 to .404 caliber and 12 and 16 gauge shot guns. The best shots were designated for buffalo hunting and armed with .404 caliber rifles. They were sent out in pairs to ensure their safety. The .357 caliber rifles were used for big antelopes, waterbuck, roan antelope, tiang, giraffe, kob and wart hog while the 12 and 16 gauge and .22 caliber were used for baboons, the last was also utilized for target training. Lately the .275 caliber rifles with long range and high velocity have been used for baboons, duikers, bushbucks, and reedbucks.

Hunters were issued note books to record species and sex of game shot and the ammunition used. Ammunition was issued every three days by field officers after checking the record of game shot against the number of empty shells turned in (Fig. 5).

GALWAL-GUAR. Game destruction was first adopted in Galwal-Guar, an area of 40 square miles. The area was divided into blocks, each about four square miles. Shooting was carried out systematically and hunters were posted in strategic positions where the game could be driven towards open country to ensure that the animals could not carry tsetse flies with them too long and give game a chance to desert the area. Shooting was first concentrated on buffaloes and then followed by other game.

Name of Hunter _____

Area _____

Block _____ Month _____

Date	Species	♂	♀	Ammunition Used		Total Am. Used	Remarks
				Target	Miss		

Fig. 5. Data forms for recording game killed by a hunter in a month.

NYANG. Shooting was initiated in Nyang, on the same lines as Galwal-Guar by 1954 but hunters were withdrawn during the rainy season due to the boggy nature of the area. Shooting was resumed in December of the same year. Much human settlement was underway by the time reclamation started in spite of the fact that there were very few settlements in the area when the surveys were made. Game destruction continued throughout 1955, 1956, and part of 1957.

RORGUMAKOL. Hunters were posted along the western border of the island on the eastern bank of River Jur in April 1955 to stop mass migration to Galwal-Guar by thinning them out. This was followed by full coverage of the island; 300 square miles, by hunters the following year which necessitated recruitment of more hunters. A great effort was exerted to organize shooting towards the open "Toich" facing the unreclaimed Nyinacuil Island to the north.

NYINACUIL. Buffalo hunters were first posted in March 1957 in Nyinacuil; the smallest of the four islands. Being separated by several miles of "Toich", from both Rorgumakol on the east side and Nyang on the west side, with many streams in between, this island was never accessible before late January or early February. The nature of the bush which necessitated opening of motor tracks and even fly routes was another handicap in the progress of reclamation. Over 600 laborers were engaged during the working season for this purpose. The 1957 season was a prepratory one and no effective work was done until 1958 when the entire island was covered with hunters. The island had been stocked with buffaloes, bushbucks and baboons besides the other species.

FLY ROUNDS. The fly round had been regarded as a means for determining of the concentrations and the fluctuation in tsetse population. A

fly round was designated for each block and it was represented by a path drawn in a spiral way to traverse the principle vegetational communities in the area. The path was marked by signs on trees along the route. In some instances, where vegetation was dense, it was necessary to cut a path through the thicket as referred to above. The round was divided into a definite number of sections or sectors. Two fly catchers were stationed at each block to carry out two daily fly rounds in the early morning from 6:00 AM to 10:00 AM and in the evening from 4:00 to 6:00 PM. This coincided with the periods of daily activity of the tsetse flies. The sections were constructed in such a way that the whole block was covered once a week.

The fly boys were armed with fly nets which consisted of a rectangular bag of muslin measuring 15 inches wide, 17 inches deep with khaki top band through which passed a cane long enough to be bent and ends tied together to form a handle. In the route the two fly boys walked together in a line stopping approximately every 100 yards to catch flies. Flies caught were recorded in note books indicating their sex, (male, female, gravid); age (teneral, adult), and section (numbered 1 through 6). Game seen and tracks observed were to be recorded (Fig. 6). Flies captured were brought in for checking and closer analysis by the surveyor who supervised a number of fly boys. Weekly returns were submitted by each surveyor to the senior surveyor who was in charge of the whole area for compilation and submission to the entomologist. Surveyors and senior surveyors were equipped with bicycles to facilitate their mobility for patrolling the fly boys under their supervision.

Stomach smears of Glossina morsitans were collected from flies in stage one of hunger, i.e. blood was visible, by absorbing the stomach

Area _____ Name of Fly Boy _____

Block _____ Section No. _____

Month and Week _____

Day	Time	M*	T	F	T	G	Total	Remarks: (Game seen, tracks seen)
Sat.	Morning							
	Evening							
Sun.	Morning							
	Evening							
Mon.	Morning							
	Evening							
Tues.	Morning							
	Evening							
Wed.	Morning							
	Evening							
Thurs.	Morning							
	Evening							

*M=Male, T=Teneral, F=Female, G=Gravid

Fig. 6. Data form for recording tsetse caught on fly rounds.

contents in filter paper. The smears were sent to the United Kingdom where preciptin tests against sera of the commonest hosts in Galwal-Guar were done. The object of this was to establish whether Glossina morsitans had any host preference under the Jur Narrows conditions.

BAIT ANIMALS. Cattle, sheep, and goats were used as baits after spraying with DDT or BHC. Some 50 head of cattle with their young were purchased by the Tsetse Survey and Reclamation Team in December 1953 when the first trial with bait animals was done. Then some 300 head were offered on loan by the Gogrial Rural Council and a few were offered by the chiefs of the area as a contribution (Table 1). Sheep and goats were purchased by the team at a nominal price from the natives through their chiefs.

Table 1. List of bait animals showing their origin.

Origin	Cattle		Sheep		Goats	
	Adults	Calves	Adults	Lambs	Adults	Kids
Gogrial Rural Council	296	75				
Chiefs	76					
Tsetse Reclamation Team	129	28	432	86	130	14
Total	501	103	432	86	130	14

The animals were protected with antrycide prosalt against tsetse fly bites before they were driven into the area (10% of the flies were found to be infective). Bimonthly injections were given to maintain the concentration of the drug in the animals body. Generally the cattle were maintained in good health throughout the campaign except in two occasions when a breakdown in prophylaxis was detected probably due to

the higher challenge of tsetse the animals were exposed to trypanosomes in Nyinaciul when bait cattle were used before a marked reduction in tsetse population was attained.

Losses among goats from haemorrhagic septicaemia were high in spite of annual vaccination and their common ailment was pneumonia particularly during the rainy season when the goats were confined to buildings and mortality in kids was surprisingly high. Sheep on the whole were in excellent condition and bred very rapidly.

The animals were sprayed with 0.5% DDT (50% W.P.) or 0.06% gamma BHC (D.P. 6.5% gamma isomer) once a week in the dry season and twice a week during the early rainy season. No spraying was done when it was continuously raining in August and September. Each insecticide was used for two consecutive weeks then alternated with the other. The animals were taken into the fly round in groups of 10 to 25 head. The species of animals used for each area was decided by the type of vegetation.

Cattle were kept in enclosures terminating into a chute constructed of poles where the animals were driven in single file and ends closed. Two sprayers, one on each side, were used. Sheep and goats were held by hand while spraying.

The spraying was applied by hand-operated bucket pumps. The suspension was stirred continuously during spraying. Particular attention was given to the legs and the undersides of the animals for these areas are the most attractive feeding sites for tsetse. Spraying was started at 4:00 in the morning and by 5:00 a.m. the animals were ready to go thru the fly rounds, and later were taken at 3:00 p.m. for the evening round. To avoid breakdown of prophylaxis, animals were rested for one day after every

three-days work and taken outside tsetse bush for grazing. Flies settling on bait animals after spraying were captured immediately and at intervals of 2, 6, and 14 days to determine the residual effect of the insecticide on the animals. A test tube was used in capturing instead of a fly net. Flies were captured after they settled and actually started feeding. Use of a test tube limited contamination as compared to a fly net.

GIRAFFE HIDE SCREENS. Giraffe hide screens were erected at certain strategic points which were carefully chosen to attract the maximum number of tsetse flies. The points included mainly the feeding grounds, breeding grounds and game routes. Fewer hides were placed along paths and vehicle tracks. Cattle dung and urine were placed underneath the hide in a container and renewed weekly. The container was shaded with thatch to cut down unnecessary evaporation. The hide was erected on two uprights (a tree mostly served as one) and one horizontal bar, which resembled an animal when the folded skin rested on the horizontal bar.

The screens were sprayed with 5% DDT and 0.6% BHC at two-week intervals to give 2 grams of pure DDT per square meter. Periodical tests were carried out to detect the killing effect of the treated screens. Flies settling on the screens were captured 6 hours, 2, 4, 8, and 14 days after treatment. The same procedure used in capturing flies from bait cattle was used.

HUMAN SETTLEMENT. Settlement at leisure by Dinkas was encouraged by inducements for the people and by developing the social services. Dry weather roads were constructed within the area and two second-class roads connecting the area with the Rural Council and District Headquarters were completed. Several dispensaries, two medical and one

veterinary, were already functioning when the area was reclaimed. The existing two sub-grade schools were raised to full elementary level. A rural water development scheme was approved and 34 wells were dug where there was water shortage. A sack of sorghum and a sack of ground nuts were issued free of charge for every new settler, as well as mango seedlings. Three fruit gardens were established in the area.

RESULTS

GALWAL-GUAR. Records of game shot, seen or tracked was the method used for providing a comparative index to density and movement of game in all the four islands. Shooting of buffalo followed by other game started in January 1953, in Galwal-Guar, resulted in a remarkable decrease in density of game population within two years. There was a noticable migration of buffalo and tiang as a result of disturbance by hunters. There was a general reduction of approximately 30% of the population during the first year, while by the middle of the second year buffalo, tiang, waterbuck, and roan antelopes were greatly reduced in number and ultimately became rare. The small game such as duikers, reed bucks, bushbucks, baboons, kobs, monkeys, oribis, and wart hogs, were reduced but never exterminated.

The data obtained from the precipitin test, though incomplete, furnished an answer for the food preference of Glossina morsitans under undisturbed conditions of the Jur Narrows. It indicated that Glossina morsitans fed to a greater extent on buffalo, tiang, and wart hog, and to a lesser extent on bushbuck, oribi, kob, and baboon in the order given.

Following reduction of game population a substantial drop in the number of tsetse catches was recorded from every block. The average number of catches per fly boy per month which was 3380 in 1952, before any control measures were applied, dropped to 1430 by May 1953. With persistant shooting during 1954 a drastic drop in catches was observed

and later the complete elimination of buffalo and the other big game brought another sharp drop in the number of tsetse flies and a higher percentage control was achieved. The overall number of catches for the whole area was 7, 7, 4, 2, and 2 tsetse flies for the months of January, February, March, April, and May 1954, respectively.

In late May 1954, the remaining tsetse flies were eliminated with the introduction of bait animals and erection of hide screens in the foci where flies persisted. The percentage control reached 100% by April 1955. The area was declared free of tsetse a year later and people with their cattle were allowed to come into the area and settle.

NYANG. Settlement was much advanced in this island, most of the higher ground with suitable soil was cleared and settled and a lot of new clearings were going on when measures were taken for reclamation of the island in 1954. Only patches of forest with poor or waterlogged soil were left and these had scattered stretches of forest with large numbers of game and high concentrations of tsetse. Few animals were killed during the first year because hunters had to be withdrawn during the rainy season due to the boggy conditions of the area. The shooting of animals increased in 1955 and part of 1956 and was followed by a rapid decrease in numbers of tsetse but a few flies continued to appear every now and then. These were maintained by packs of baboons which were a characteristic feature of Nyang. These animals were greatly reduced in number by organized attacks which took place at dawn while the baboons were still bedded down in trees. The use of large groups of bait animals eliminated the persistent few tsetse flies, and control was achieved by January 1956.

The area remained free of tsetse flies for the rest of 1956. In

July 1957, the Tsetse Survey and Reclamation Team detected a re-infestation of the part facing Burial of Nyinaciul Island where small-scale buffalo hunting commenced a few months earlier. Prompt reclamation measures involving opening up of thicket, shooting of bushbucks and baboons, and use of bait goats cleared the area and no further re-infestation was observed. Except for this one incidence of re-infestation, this area entailed the least effort as compared with the other three islands. The rapid elimination of tsetse flies was due to the advanced settlement of the land already referred to.

RORGUMAKOL. The precautions taken to create a game-free zone along the western side of the Rorgumakol Island proved to be very effective. This was done to safeguard against the possible re-infestation of the already cleared island of Galwal-Guar. The magnitude of work involved in this area was comparatively higher than for the previously reclaimed two islands. Additional hunters, recruited in 1957, covered the areas lightly hunted and dealt effectively and decisively with game in these areas. The shortage of hunters had an adverse effect on reclamation and probably delayed it for six months. However, shooting continued steadily for three years and the game population diminished. Appreciable numbers of animals were killed and the remainder of bushbucks, duikers, reed bucks, and baboons constituted the main hosts for the persistent flies. Difficulty in eliminating these animals prolonged the period of reclamation.

Baboons, well known for their cunning and keen vision, became aware of the effective range of the guns and kept out of range. Rapid reduction was achieved, however, by the introduction of .275 caliber long-range, high-velocity rifles.

The Togren area, at the southern end of the island, was considered to be one of the main tsetse concentrations. Barrier shooting started in 1955 and tsetse-fly catches were started in February 1956. Since the catches per fly boy per month were 717 in February, two additional hunters to the existing force were posted primarily to reduce the baboon population. This increase emphasis on game reduction reduced the catches per fly boy to 355 flies in March, 303 in April, 136 in May and 6 flies in June. Hunters had to be kept in this area for game kept coming back from the still infested adjacent areas. The area has remained free of tsetse flies since July 1956. During the three-year period (April 1955 to April 1958) 14,574 head of animals were killed on this island. Table 2 shows the record of game killed of each species in each island each year.

A general reduction of tsetse population over all the Rorgumakol was achieved by July 1957. The following blocks of the Lietnohm area were practically fly free: Panacach, Togren, Apiath, and Buragok, while in Malwal, of the same area, 28 flies were recorded in March, 8 in April, but no flies were found in any of the areas during May and June. However, at Juet in the western end of the area as many as 89 flies per fly boy per month were collected in the same period as compared to only 8 flies at Anyar.

There was no appreciable reduction in fly catches in Ametaker area as compared to Lietnohm area. The catches in Ametaker block were 362 in March and dropped to 57 in June, and from 617 to 108 at Adil, 81 to 18 at Aljak, 1,034 to 141 at Jok Nyang, 183 to 26 at Anyar, and from 625 to 115 at Ameth.

Further shooting of game had a noticeable effect on the Glossina

Table 2. Record of game killed of each species in each island each year.

Island	Year	Buffalo	Bushbuck	Roan	Wart Hog	Waterbuck	Tiang	Duiker	Reedbuck	Cob	Oribi	Baboon	Monkeys and Others	Total per Year
Guar	1953	225	43	39	145	229	415	46	45	321	24	548	380	2460
	1954	24	201	42	208	82	235	285	654	1048	140	1476	766	5161
	1955	0	35	8	28	18	19	88	61	92	58	214	177	798
	1956	0	19	1	6	3	0	22	12	46	7	36	14	166
	Grand Total	249	298	90	387	332	669	441	772	1507	229	2274	1337	8585
Nyang	1954	6	2	3	8	12	5	0	0	10	0	21	6	73
	1955	4	50	6	31	14	12	38	15	110	22	311	41	654
	1956	27	11	0	9	19	20	0	3	25	0	4	2	120
	1957/58	2	72	0	2	16	14	5	10	129	31	18	0	299
	Grand Total	39	135	9	50	61	51	43	28	274	53	354	49	1146
Rorbumakol	1955	40	2	1	3	29	28	14	4	109	1	30	21	275
	1956	0	23	9	27	24	48	32	39	138	16	149	42	547
	1957	103	188	75	221	344	633	527	475	966	448	724	384	5088
	1958	3	405	222	180	392	645	1144	1335	840	959	483	140	6847
	1959	3	101	34	21	49	143	258	271	398	284	239	16	1817
	Grand Total	149	719	341	452	838	1497	1975	2124	2451	1708	1625	603	14574
Nyin Acuil *	1956/57	178	41	4	45	128	97	3	38	140	0	42	31	747
	1958	195	725	6	46	356	82	11	68	740	49	90	59	2427
	1959	10	855	0	5	34	12	0	47	443	0	1471	9	2886
	1960	10	544	0	0	18	12	0	111	226	0	774	12	1707
	1961	4	81	0	0	1	12	0	34	86	0	84	2	304
	Grand Total	397	2246	10	96	537	215	14	336	1635	49	2461	113	8071

morsitans community. The female percentage gradually increased, attaining finally 50% and occasionally getting higher in some parts. The supplementing of game with bait animals raised the degree of control to a higher level and eventually the last fly was caught in April, 1958. There was a sudden drop in catches in persistent tsetse fly concentrations during the exceptionally dry season of 1958. After most of the water holes dried up the remaining big game left the area and packs of baboons concentrated close to the few remaining water holes. This concentration enabled the hunters to locate their sleeping places and to eliminate them with little effort.

A slight advance of Glossina morsitans eastwards into a fly-free bush was detected at the extreme eastern end of Rorgumakol. The area had been surveyed and no tsetse flies had been found as the bush was considered to be too open to constitute a proper cover for Glossina morsitans. The advance resulted from shooting in the wrong direction, dispersing game eastwards to the tsetse-free bush. The animals were followed by Glossina morsitans. Once game were in the fly-free area they were not disturbed and had plenty of water and succulent grass. These animals stayed around and maintained the few flies that followed them consequently infesting an area extending for 12 miles. This occurred in spite of the unsuitable bush. The addition of two hunters to the already existing strength along with the change in the shooting procedures in a westward direction prevented further spread east and controlled the few remaining flies satisfactorily.

Another re-infestation was recorded in Buragok area which was cleared of flies late in 1956. One female tsetse fly was captured. This was attributed to illegal cattle movement through the bush not yet

reclaimed then passing through Buragok area from the adjacent "Toich". Control was affected by prevention of cattle movement, shooting of game, erection of hide screens, and stocking the area with bait animals. No further catches were reported, the only female caught was considered to be a stray fly following cattle.

NYINACUIL In April 1956, the six hunters posted in the Nyinacuil area shot 178 buffaloes and 569 head of different species of game. Full scale work commenced in March 1958 when the whole area was covered by hunters and in spite of the adverse conditions of the area and the impenetrability of the bush which furnished an ideal home for buffalo and bushbuck, hunters managed to kill 242 game animals. The majority of these were bushbuck and kobs, followed by waterbuck and then buffaloes (Table 2).

The opening up of the bush for motor tract and fly rounds had a marked effect on the shooting potential. The output of hunters increased tremendously, particularly of those engaged in shooting bushbucks and baboons. The area was resurveyed and it was found that the thickets were the main haunt for Glossina morsitans during the wet season. Game animals concentrated on the higher grounds when the "Toich", mitragyna, and acacia zones were flooded; while the tsetse flies followed game to the latter two zones which constituted their dry season grazing areas.

The end of 1958 witnessed no substantial change in the apparent density of tsetse population and the factors involved in its control seemed to have but little effect in spite of the large numbers of animals killed. The record of catches showed a high per cent of male tsetse flies ranging from 77% to 97%. During the 1959 season most of

the buffalo herds emigrated to Nyang and Galwal-Guar Islands. Records indicate that an increased number of game were shot and that particular attention was given to bushbuck and baboon hunting. The apparent density of flies fell gradually and steadily during the year but complete control was not eminent during that year..

Introduction of bait animals and hide screens on similar lines, as in the previously reclaimed islands, brought about a good percentage reduction of flies ranging from 65 to 19.9 and the low fly status was maintained by the end of the year in most sections of the island. During the 1960 dry season (February to June) reclamation was accelerated by augmentation of hunters, and by concentration of all bait animals in the island. This became possible after the Rorgunakol was declared free of tsetse and all of the force stationed there was moved. The last tsetse fly was captured in April 1960 and the area was declared free of tsetse flies a year later.

The data presented are taken from representative areas in Nyinacuil, Katokol, and Jouth blocks, and results are given in Tables 4, 5, and 8 respectively. The figures represent the data for the number of tsetse population, percentage of males, and sex tatio for the period January to June; the most suitable time to assess the demonstrated sections as there are so many variables which affect the population of tsetse flies.

The density of Glossina morsitans in an undistrubed area, which is defined as an area with plenty of game with no control measure applied, is shown by Tables 4, 8, and histogram Fig. 7, and 11. The mean catch per fly boy per month was estimated as ranging from 1000-2670 tsetse flies.

Tables 5 and 6, and histogram Fig. 8 and 9, are representative data

of Amou and Jouth sections respectively and indicate the sex ratio and per cent of males of Glossina morsitans in a disturbed area where control measures were applied and game concentrations greatly reduced.

Table 7 and histogram Fig. 10 detail the per cent of male and variation in absolute number of available flies in Ametaker section with plenty of game and when shooting was going on.

Table 9 and histogram Fig. 12 represent records of catches per one fly boy per month, per cent of male, sex ratio, and per cent control after reduction of game, introduction of bait animals, and erection of hide screens.

The number of settlements in Rorgumakol Island and Nyang Island are given in Table 3. Those of Rorgumakol are given under Lietnohm and Ametaker areas. The table is based on the survey made in 1958. Figures for Nyang Island indicate that most settlements took place before reclamation started.

Table 3. Settlement by location, number of houses, number of people and year, in Rorgumakol and Nyang Islands.

Rorgumakol Island								Nyang Island			
Ametaker Area				Lietrohm Area							
Location	No. of Houses	No. of People	Year	Location	No. of Houses	No. of People	Year	Location	No. of Houses	No. of People	Year
Ametaker	5	25	1958	Malwal	3	8	1957	Ngabakot	10	41	1957-58
Alajak	10	36	57-58	Majok	8	23	1958	Bunanyar	1	1	1958
Adil	45	136	56-58	Maperagep	2	6	1958	Abiyei	9	38	1956-58
Kuben	36	112	56-58	Amarkwin	6	13	1958	Apial	21	83	1952-58
Makuac	12	49	56-58	Thurbiel	1	4	1957	Gumthok	3	16	1954
Marol	12	37	56-58	Athai	3	7	1958	Majangjong	25	97	1953
Guper	20	60	56-58	Marol	3	7	1958	Adol	16	72	1952
Amou	31	79	56-58	Awen	3	7	1958	Thurliet	4	11	1955
Khortumbak	48	155	56-58	Nyankwac	3	11	1958	Ajakdit	13	58	1951-58
Ameth	26	65	56-58	Nyinagwer	5	12	57-58				
Pawak	15	50	56-58	Anitut	2	4	1958				
Paweng	2	23	1957	Bwokogok	1	4	1958				
Ahilyang	1	6	1958								
Joknyang	5	25	56-58								
Yinagwet	10	62	56-58								
Total	278	914			40	106			102	414	

DISCUSSION

Starvation of tsetse by game eviction, followed by bait animals, hide screens, and settlement at leisure were adopted as the most suitable methods for control under the special conditions of the Sudan. These procedures had achieved success at a cost which no other method could rival against the same species in other parts of Tropical Africa. The decision was reached after extensive studies and careful consideration of the extent of the area, urgency of the problem, entomological and zoological facts, and last, but not least, the financial ability of the country.

Glossina morsitans, the only species encountered in the Jur Narrows, apparently had no marked host preference. This was determined by the preciptin test and observations during the game rounds. In the complex fauna of the Jur Narrows where many potential host species occurred, Glossina morsitans depended mainly on big game as a source of food, yet it was evident that they fed on the most available animals and had no well defined host preferences. Consequently the Province Tsetse Advisory Committee decided methods based on marked host preference of tsetse for buffaloes and baboons alone, or in combination with, organized settlement of areas where tsetses concentrated during the dry season and discriminative clearing of areas unsuitable for settlement, would not provide adequate control.

However, even if there were marked host preferences for buffaloes

and baboons, organized settlements could not be used as a secondary method as more adequate surveys revealed that less than 30% of the islands was suitable for settlement and this would entail clearance of over 70% of the tsetse bush which was found prohibitively expensive and even if funds could be raised, labor was insufficient in Dinka land where the residents had no urge to work for money which they could raise by selling a bull if need arose. Considering settlement of the suitable land, it was doubtful whether the Dinkas, who were so closely associated with their cattle, would settle in an area where they could not take their cattle with them, in sufficiently large numbers to produce an effective settlement.

The use of heavy machinery was out of question due to the nature of the soil, the short dry season, and the problem of maintenance in such a remote area. However, recent literature indicates that clearance of as little as 8% of typical tsetse haunt has successfully cleared Glossina morsitans from large tracts of country, Glover and Jackson (1955). Glover (1959), as quoted in Willet (1963), developed a "chain clearing" using two heavy tractors with heavy ship's anchor chains trailing in an arc behind them which could deal with large areas in a short time. Even such improved machinery could not be utilized for the reasons given above.

The efficiency of insecticidal attack was considered but it was doubtful whether the newly developed technique of aerial spraying would work over a large area for it gave unsatisfactory results elsewhere even when used on small area trials. The highest reduction in population was 98% which subsided to 50% three months following last application. Trials in Northern Nigeria with the savannah tsetse, Glossina morsitans sub-morsitans, which is restricted in habitat in the dry season showed some

promise, Blasdale (1960). Insecticide application to vegetation as a measure of control of the restricted riverine Glossina palpalis has so far been very effective. It was definitely out of question to use either aerial or ground spraying to control Glossina morsitans on account of the cost, lack of precise limits of habitat and ability to survive in low concentrations which could be overlooked and later multiply undetected to spread again in a situation where economy and urgency were of utmost necessity.

The area of the Jur Narrows constituted 0.6% of the Bahr el Ghazal Province and although the density of game per square mile was high, yet the available species in the area were evenly distributed throughout the province and no rare species were liable to be exterminated. Small herds of white Rhino, representing the westernmost extention of their range were not killed as they were not in sufficient numbers to maintain foci of tsetse after other game were killed. The other rare species, Nile lechwe, by habitat preference avoided the forest and lived in the swamps and did not constitute a host for Glossina morsitans and consequently was not killed.

The organized hunting from west to east, which was the direction of normal emigration of most species of game, and the policy of reclaiming one island at a time following the same direction gave a chance for 30% of the game to escape destruction. This was a modification of the game elimination method wherby an area serving as a refuge for the animals is left, from which the area can be repopulated. Similar procedures were considered recently in Uganda where game were driven out, or destroyed from a large tract of land and a central area was left as a refuge for animals which was then freed of tsetse flies by insecticidal application

from the ground, Willet (1963).

The use of bait animals, after game had been reduced in numbers, in groups exceeding the number of surviving game in a fly round so that the chance for a fly to get an insecticide free or a contaminated meal from bait animal is 1:3 provided increased control. This made it unnecessary to eliminate all game since the bait animals and hide screens would compete with the few remaining game as an attractive host for Glossina morsitans. The remaining game served as a nucleus to repopulate the area.

The meat of game killed, either fresh or dried, was issued as rations for the units or distributed to the schools and prisons free of charge. The hides were properly dried and sold and the revenue covered the cost of ammunition. Moreover, the game evicted provided facilities for other scientific work as well. The Curator of Khartoum Museum spent several weeks collecting specimens for display. Some American scientists did valuable research work on virus diseases and parasitic infestations of killed game. The Veterinary Research Laboratory investigated the relation of buffaloes in the spread of contagious bovine pleuropneumonia among cattle. In addition, the faculty of Veterinary Science of Khartoum University obtained specimens for anatomy demonstrations, studied and collected histological material of giraffe foetuses and other species. From all points of view the operation provided a good basis for scientific investigations on many diverse subjects.

By the time reclamation was over in Nyinacuil in 1960, the settlers of Galwal-Guar, the first island reclaimed, were complaining of the big herds of buffaloes and packs of baboons that were damaging their crops and the Dinkas were asking the Tsetse Team to intervene. Meanwhile, small numbers of several species of big game were reoccupying Rorgumakol

from the adjacent areas. This clearly indicated the justification of game eviction as a feasible method for the control of Glossina morsitans. When adequate precautions are followed the method possesses the advantage of speed and economy without permanently affecting the natural fauna.

For the assessment of the natural population of Glossina morsitans in the Jur Narrows it was necessary to follow a mathematical model for tackling the initial position and the apparent variation due to effect of introduced control factors. These models generally gave useful information and guides to a rational approach to the problem so that the principle criteria of the control could be evaluated. The picture presented by the initial data in different sections and under different supervisions had a certain identity in percentage of males attracted to the catchers. In an undisturbed area, with plenty of game, and no control measures applied, the apparent density of tsetse population was high and the ratio of adult males to adult females ranged from 6 to 16.5 or a male percentage of 83.5 to 94. As there was not much variation in actual density and observed results in undisturbed areas the sections of Nyinacuil and Katakol, are taken as examples and results are given in Tables 4 and 8 and histogram Figs. 7 and 10, respectively.

Before the commencement of destruction of game the mean of fly catches per fly catcher per month ranged from 1,000 to 2,676 flies. On commencement of game destruction there was a gradual decrease in game population but there was no variation in the availability of flies to the fly catchers and the sex ratio did not seem to undergo much variation in spite of the large numbers of game killed particularly buffaloes, tiangs, and roan antelopes. It seemed that there were sufficient animals left for the needs of the tsetse community, Duke (1919), although game

seemed very scarce, yet it was probably well distributed and the needs of the fly population were well met considering the absence of competition between Glossina morsitans with the number of hosts exceeding a certain number per square mile, Jackson (1933).

The progressive destruction of game was correlated with a marked drop in fly catches. The average monthly catches per fly boy per month showed a peculiar feature in that the drop in each was characterized by a decrease in male percentage and an increase in female percentage. Later the former declined to an average of 50% or even less.

While approximately equal numbers of males and females emerge, the females live longer and the number of females present is greater. Yet the females are less attracted to man in an undisturbed wild community as man is not the females first choice while the male is very active and is attracted to man because it is inquisitive and may follow him. The female is much less active and would not approach man unless it was very hungry and in absence of other hosts. Hence, in presence of reasonable density of game the female would get a meal and take shelter in the bush while the male would be actively looking for females and would be attracted by the fly boys, therefore more available to the catcher. As game decreases beyond the required density the females would spend more time looking for a host, and being hungry, would be attracted to the fly boys, consequently increasing the per cent of females. This observation is presented by Tables 6 and 7, and histogram Figs. 9 and 10, respectively. The reduction in numbers of game by destruction and disturbance, especially of large antelopes was followed by an enormous reduction of the tsetse population with a higher proportion of female, as indicated above.

In Katakol section (Table 8) the percentage control was elevated to 60% when the big game were shot and the remaining shot or tracked game were almost all baboons and/or bushbucks. The evidence as to whether baboons can be regarded as a dependable food of Glossina morsitans is contradictory and in many parts they are considered unattractive to tsetse and incidents are quoted where flies disappeared with the reduction of game in spite of the continuous presence of numerous baboons, Swynnerton (1936). In the Jur Narrows however, observations indicate that persistant foci of tsetse in the later stages of reclamation, when a single fly is encountered every now and then, invariably coincided with haunts of baboons and concentration on baboon hunting brought about effective control. It is believed that Glossina morsitans, in the absence or scarcity of game, will feed "unwillingly" on baboons, Papio doguera, which can maintain few flies, probably not indefinitely. Similar observations were reported from Gambia where baboons are the main source of food for Glossina morsitans submorsitans, Nash (1948) as quoted in Buxton (1955).

The reinfestation of Nyang from Burial, of Nyinacuil and the advance of tsetse eastwards in Rorgumakol was positive proof that when game animals are disturbed by hunting, they tend to disseminate Glossina morsitans, Swynnerton (1921). The barrier of over six miles of open "Toich", which is normally believed to be more than a safe barrier; in case of Nyang, was ineffective. It, therefore, follows that when big herds of buffalo are disturbed by hunting they can carry tsetse for a longer distance than previously thought. The tendency of Glossina morsitans to follow cattle is indicated by reinfestation of the Buragok area, particularly when cattle travel along regular routes. These incidents signify that it is essential to organize and plan the campaign

if game animals are to be destroyed as a measure of controlling tsetse.

Introduction of bait animals in fly rounds and erection of giraffe hide screens in areas where most of the big game were killed and the sex ratio approached one, accelerated decline in absolute numbers of catches and the highest degree of control was obtained as exemplified in Katakol Section, Table 9 and histogram Fig. 10. Bait cattle were herded in groups of 10-25, and sheep and goats in groups of 25-40 to ensure that the numbers of bait animals in a fly round exceeded the speculated surviving game in the fly round.

Introduction of bait animals in an undisturbed area produced a greater number of absolute catches which was explainable as a result of disturbance of game by presence of bait animals and herdsmen which should have left the locality for adjacent areas. This increase was due to availability of tsetse to fly catchers as a result of decrease in game leading the tsetse to spend more time looking for a host. However, there was a relative decrease in the absolute number of tsetse with no increase in the female ratio six weeks later. This decrease was attributable to effect of the insecticided bait animals.

Samples of tsetse flies collected from bait cattle and hide screens at variable intervals after spraying with DDT and BHC showed considerable diversity in survival times of individual flies; females generally lived longer than males and there were individual differences among sexes. The survival time ranged from 20 minutes to 4 hours. There was not much variation in survival time of flies captured immediately after application of insecticide while it generally exceeded 40 minutes from animals sprayed 2 days before. The survival time of flies captured from hide screens was 10 minutes to 1 hour and hide screens seemed to retain more

insecticide than bait animals. The latter lost varying proportions of insecticide by brushing against vegetation and grass besides the losses due to dampness and moisture.

Hide screens with cow dung or urine attracted more flies than the ones without. This was due to attraction by scent. It is established that scent is a secondary sense to sight by which Glossina detects its hosts, Chorley (1948).

Goats were found to be more effective than cattle and sheep in dense thickets due to their browsing habits which makes them more attractive to the flies. Consequently cattle and sheep were used in open bush and goats were concentrated in the thickets. The use of bait animals for checking in the final stages of reclamation was very helpful in detecting the occasional emerging flies which would be more attracted to bait animals than a patrol of fly catchers.

No planned settlement scheme was laid as the policy was to encourage the Dinkas to settle and clear bush at leisure. It was a secondary proposal as a means of consolidating the position after the tsetse has been expelled from the area by the specific method of game destruction and bait animals. This in no way means that there was a possibility of re-infestation from the main belt with a 100-mile barrier in between. However, one of the objectives of the scheme was to make available good land for grazing and cultivation for the Dinkas who suffered from land hunger.

The Dinkas being semi-nomadic people with a considerable degree of social organization and loyalty to their chiefs presented no difficulty in being persuaded to come into the forests for settlement. They were hesitant at the beginning and probably were wondering how the Tsetse Team would bring an end to "Mou" (tsetse flies) through catching by fly

net. They could not comprehend the relation of game shooting to eradication of "Mou". The control of tsetse in the first island of Galwal-Guar, was a signal for Dinkas to pour into Nyang and Rorgumakol to reserve the higher, fertile ground. Considering the social and anthropological set-up of the Dinkas, it is evident that they have affinity and great attachment to the land where their ancestors lived. Large stretches of Galwal-Guar and Rorgumakol were under settlement since 100 years ago and the area was cultivated and stocked with cattle before the people were driven out, probably by tsetse flies which had been concentrated in small foci and then spread. Now that the area was under reclamation and since a part was already reclaimed, the people were anxious to come back to the regions where their forefathers lived.

SUMMARY AND CONCLUSIONS

Game destruction combined with insecticided bait animals during the final stages of reclamation worked out successfully in reclaiming four islands of the Jur Narrows of the Sudan from Glossina morsitans ugandensis in slightly more than six years.

Though there is an objection to game destruction as a method of tsetse control, its application was justified under the special conditions of the Jur Narrows where other methods were either too expensive or not applicable for several environmental, social and economic reasons. Some methods, like aerial spraying, besides being expensive, were unreliable as they would not effect a 100% control.

The area comprised only 0.6% of the Bahr el Gazal Province and the number of game killed was negligable while the modifications of the method i.e. shooting in direction of normal migration of several species of game and working in one island at a time, saved 30% of the total game population which established nuclei to repopulate the area. Meanwhile the two rare species in the area were preserved.

Insecticide treated bait cattle, sheep, and goats were introduced into fly rounds after the game population was reduced. The apparent density of Glossina morsitans population decreased and the sex ratio was one. This was practiced for the first time on a large scale as a control method and worked effectively in controlling the few persistent flies without complete elimination of game a condition which was difficult and expensive to achieve. The bait animals competed with the few

game remaining as a host for Glossina morsitans and accelerated reclamation.

The cost of reclamation was estimated at $450 per square mile approximately. This compared favorably with descriminative bush clearance followed by settlement, indiscriminative bush clearance, and aerial spraying which would have cost approximately $1200, $1500, and $3000 respectively according to East and West African standards.

The reclamation of the Jur Narrows Islands rendered the Islands suitable for settlement by the Dinkas and establishment of agricultural practice and a cattle industry in the shortest possible time with minimum expenses. It has also cut down the incidence of trypanosomiasis not only in the Southern provinces but in the other provinces of the Central Sudan.

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APPENDIX

Table 4. Record of catches per fly boy, per month, in Nyinacuil Section; an undisturbed area where game were not reduced in number, 1958.

Month	M	F	Total	Per cent M	Sex Ratio M/F
January	330	20	350	94.2	16.5
February	680	50	730	93.1	13.0
March	840	90	930	90.3	9.3
April	1290	100	1390	92.8	12.9
May	1860	250	2110	88.1	7.4
June	420	70	490	85.7	6.0

Table 5. Records of Catches per fly boy, per month, in Amou Section; a disturbed area where game were reduced in number, 1957.

Month	M	F	Total	Per Cent M	Sex Ratio M/F
January	760	530	1290	59.4	1.4
February	230	170	400	57.5	1.3
March	380	200	580	65.9	1.9
April	110	120	230	47.8	0.9
May	121	128	249	48.5	0.94
June	53	76	129	41.0	0.69

Table 6. Record of catches per fly boy, per month, in Jouth Section; a disturbed area where game were reduced in number, 1957.

Month	M	F	Total	Per Cent M	Sex Ratio M/F
January	420	170	590	71.3	2.4
February	350	190	540	64.8	1.8
March	190	100	290	65.5	1.8
April	56	42	98	57.1	1.3
May	38	57	95	40.0	0.6
June	46	69	115	40.0	0.6

Table 7. Record of catches per fly boy, per month, in Ametaker Section; a disturbed area where game were reduced in number, 1956.

Month	M	F	Total	Per Cent Males
January	-	-	-	-
February	3762	1681	5443	69.1
March	3834	2212	6046	63.4
April	4429	2061	6490	68.2
May	2808	1933	4741	59.2
June	1870	1057	2927	63.5

Table 8. Record of catches per fly boy, per month, in Katakol Section; an undisturbed area where game were not reduced in number, 1958.

Month	M	F	Total	Per Cent Males	Sex Ratio M/F
February	810	120	930	87.0	6.9
March	3260	220	3480	93.6	14.8
April	3780	140	3920	91.3	14.0
May	3240	380	2620	85.1	5.8
June	2270	160	3430	97.4	14.1

Table 9. Record of catches per fly boy, per month, in Katakol Section, where game were reduced in number. Bait animals and hide screens introduced in May, 1959.

Month	M	F	Total	Per Cent M	Sex Ratio M/F	Per Cent Control
February-1959	540	60	600	90.0	9.0	--
March	1090	100	1190	91.6	14.8	65.5
April	730	42	842	86.7	14.0	75.8
May	260	110	370	70.2	5.8	88.1
June	210	50	260	80.7	14.1	95.4
July	144	66	210	68.5	2.2	93.9
August	7	36	42	16.6	0.19	98.7
September	11	19	30	36.6	0.57	99.1
October	1	2	3	33.3	0.5	99.9
November	--	--	--	--	--	--
December	--	--	--	--	--	--
January-1960	4	0	4	0	0	99.8
February	0	0	0	0	0	100.0
March	0	0	0	0	0	100.0
April	0	1	1	0	0	99.9
May	0	0	0	0	0	100.0
June	0	0	0	0	0	100.0
July	0	0	0	0	0	100.0

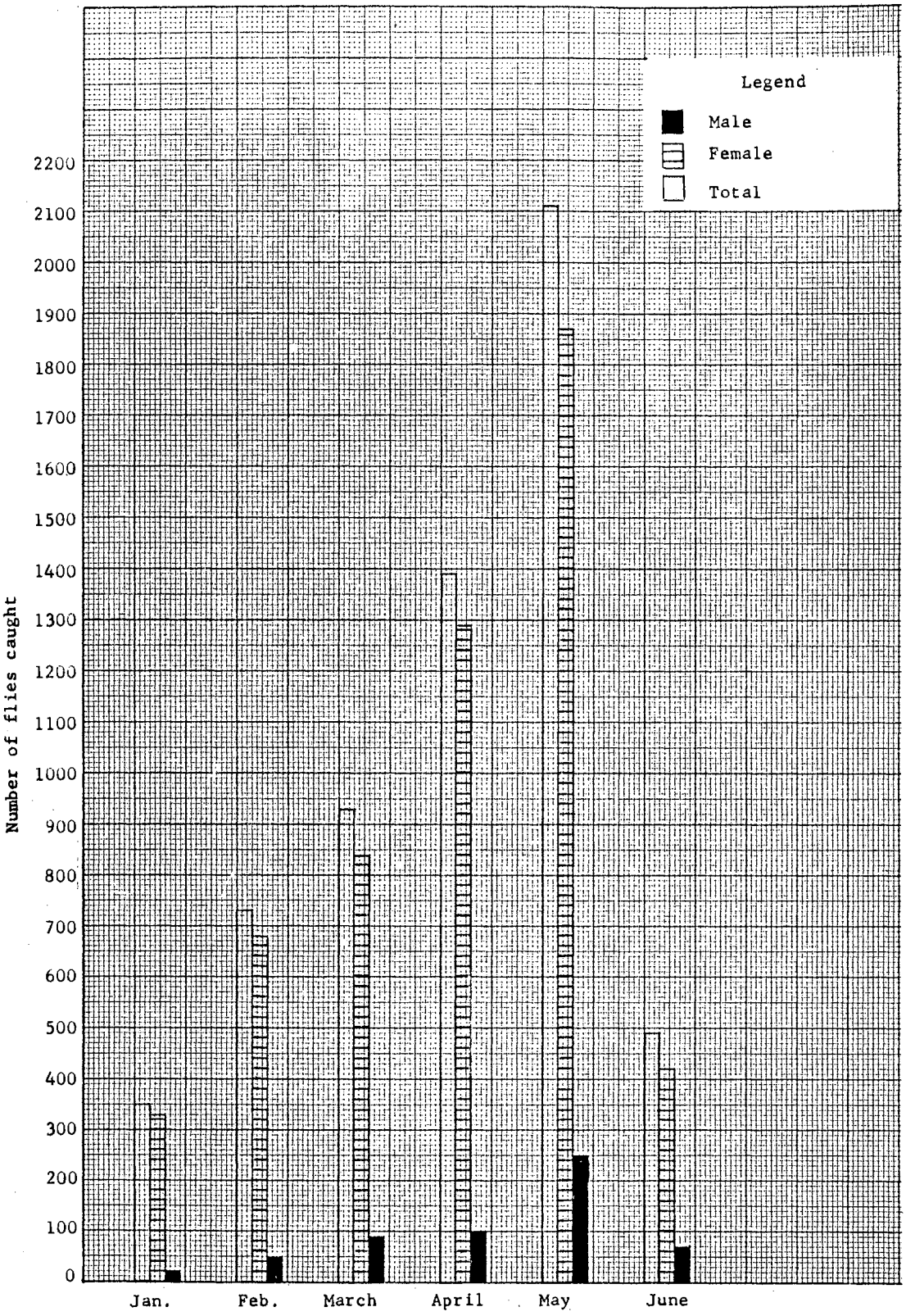

Fig. 7. Number of flies caught at Nyinacuil, January through June, 1958.

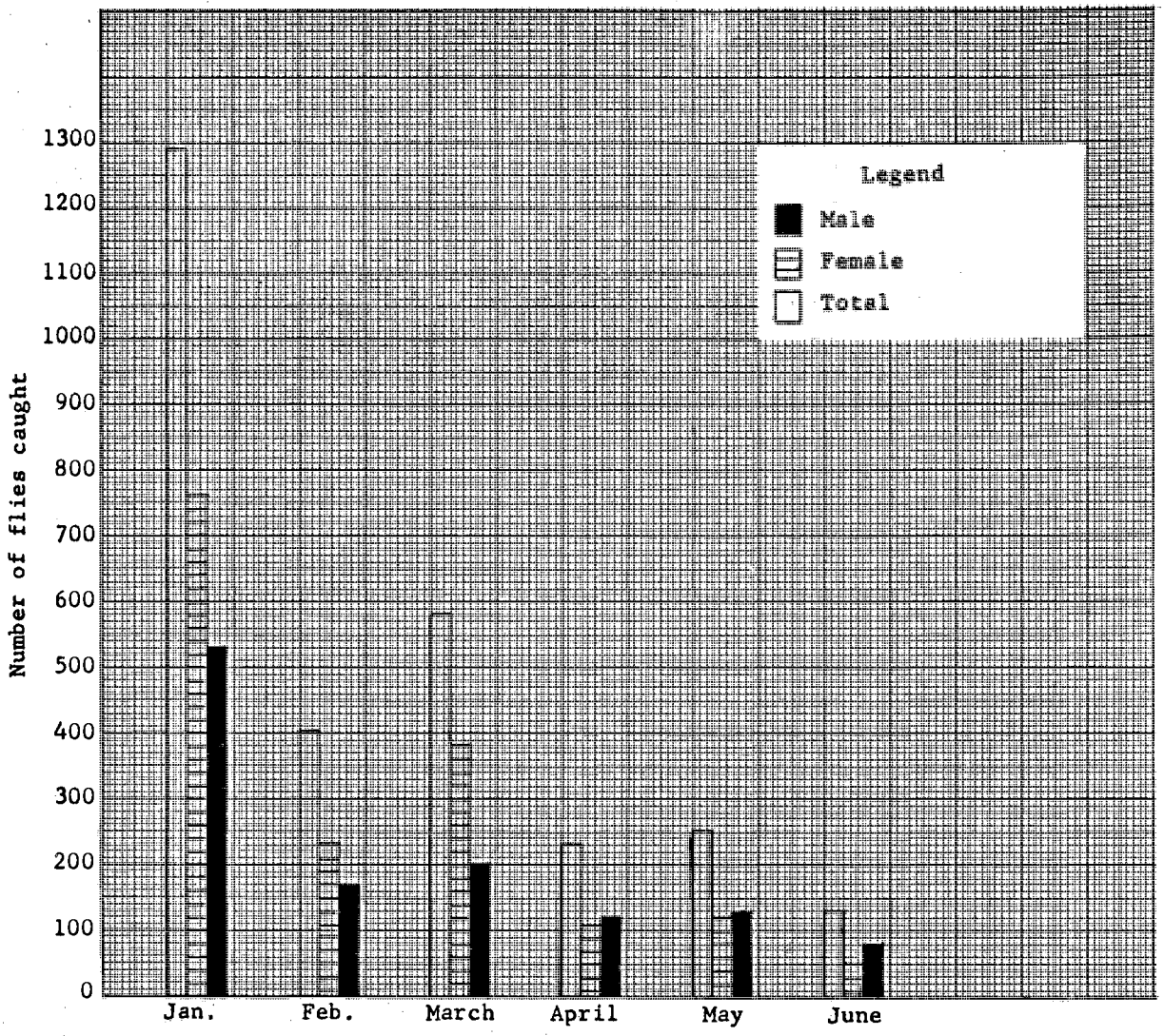

Fig. 8. Number of flies caught at Amou, January through June, 1957.

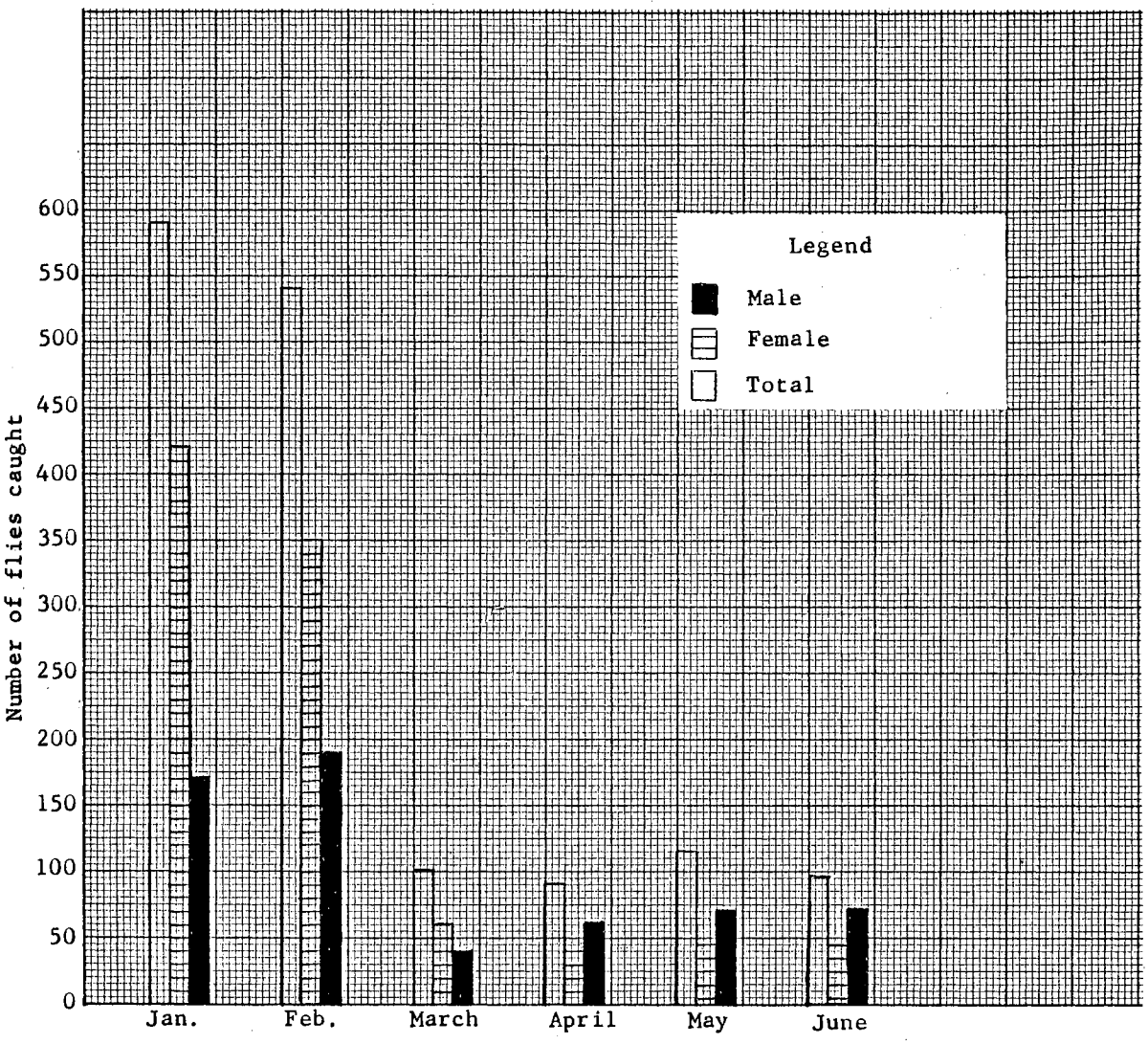

Fig. 9. Number of flies caught at Jouth, January through June, 1957.

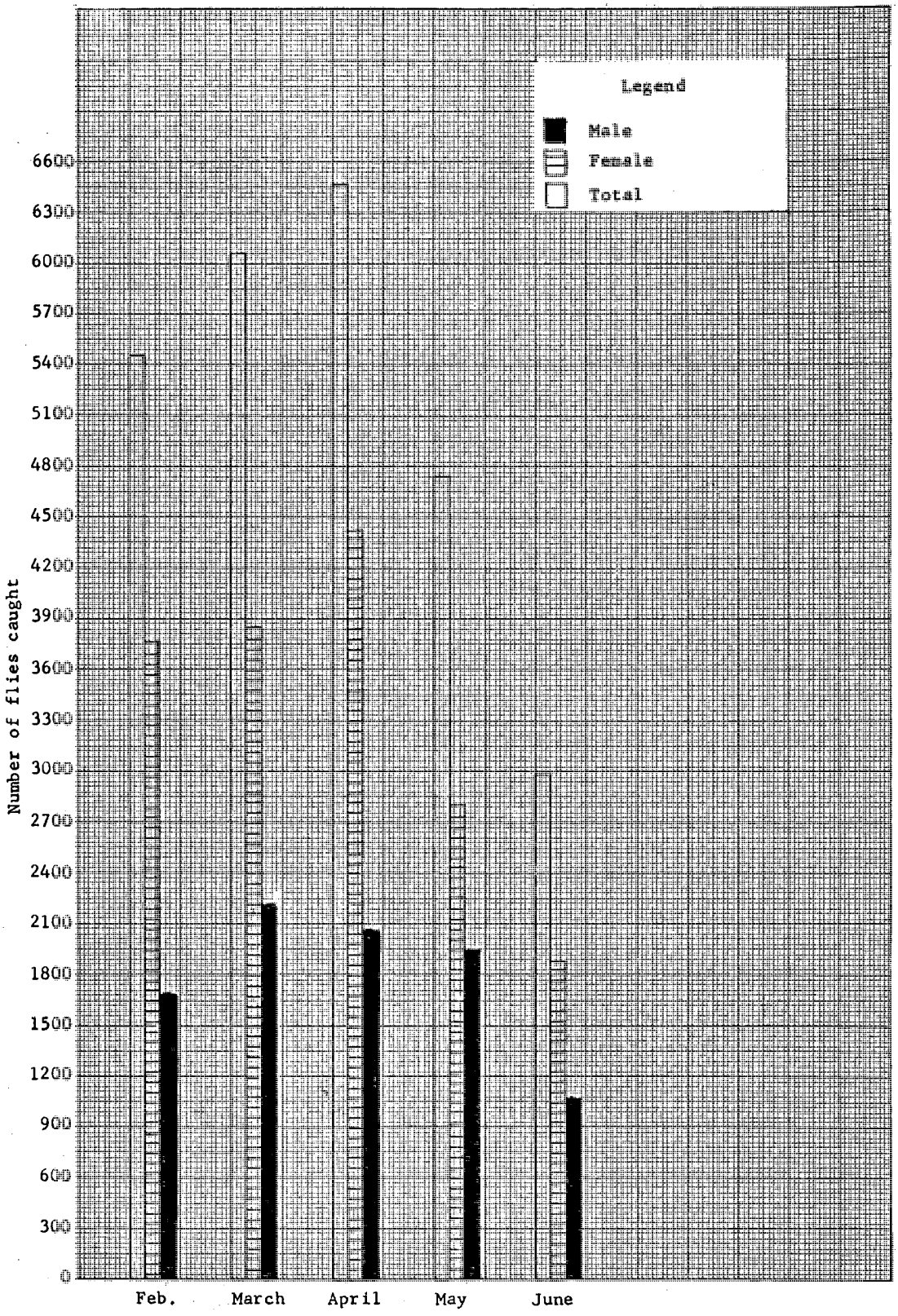

Fig. 10. Number of flies caught at Ametaker, February through June, 1956.

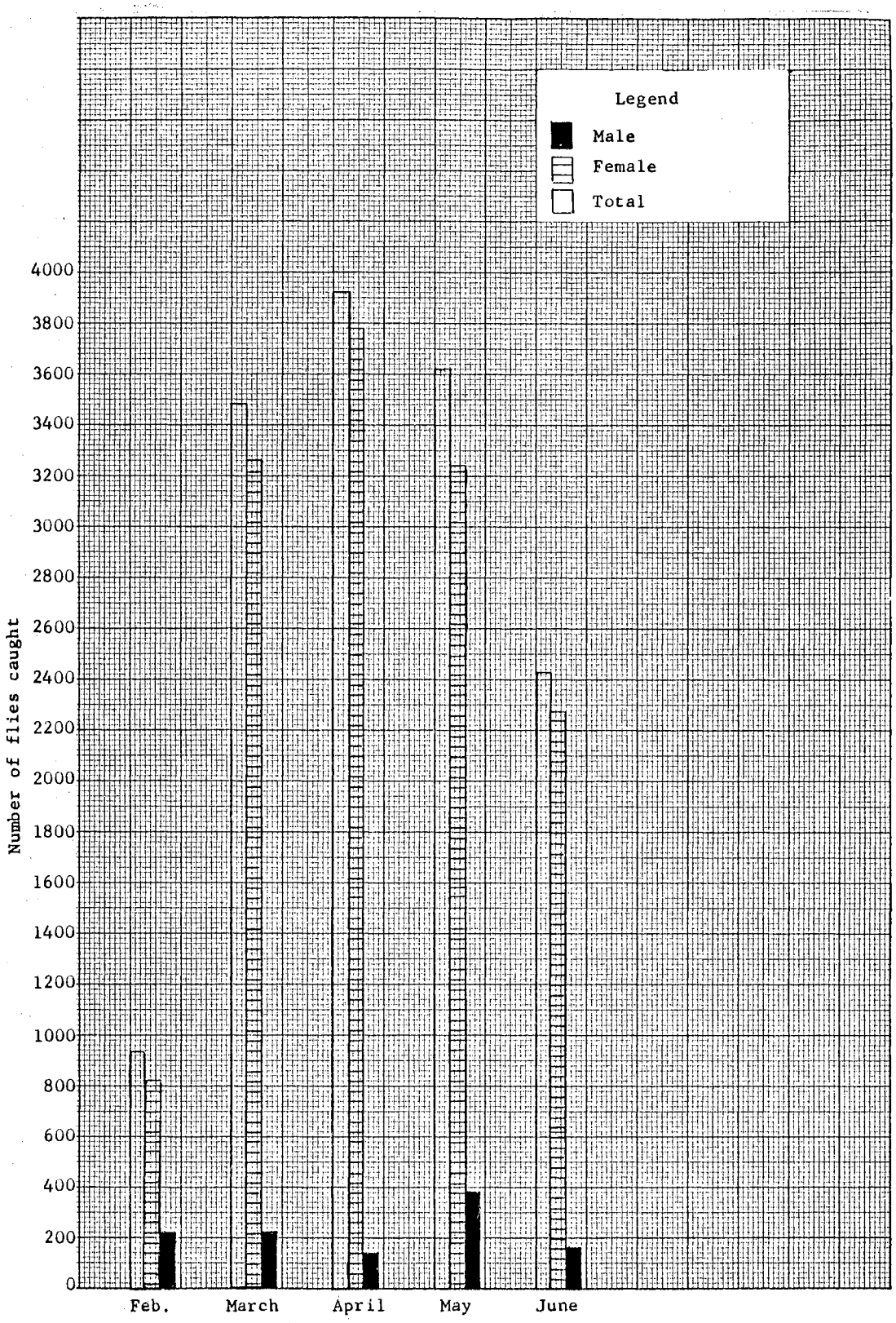

Fig. 11. Number of flies caught at Katakol, February through June, 1958.

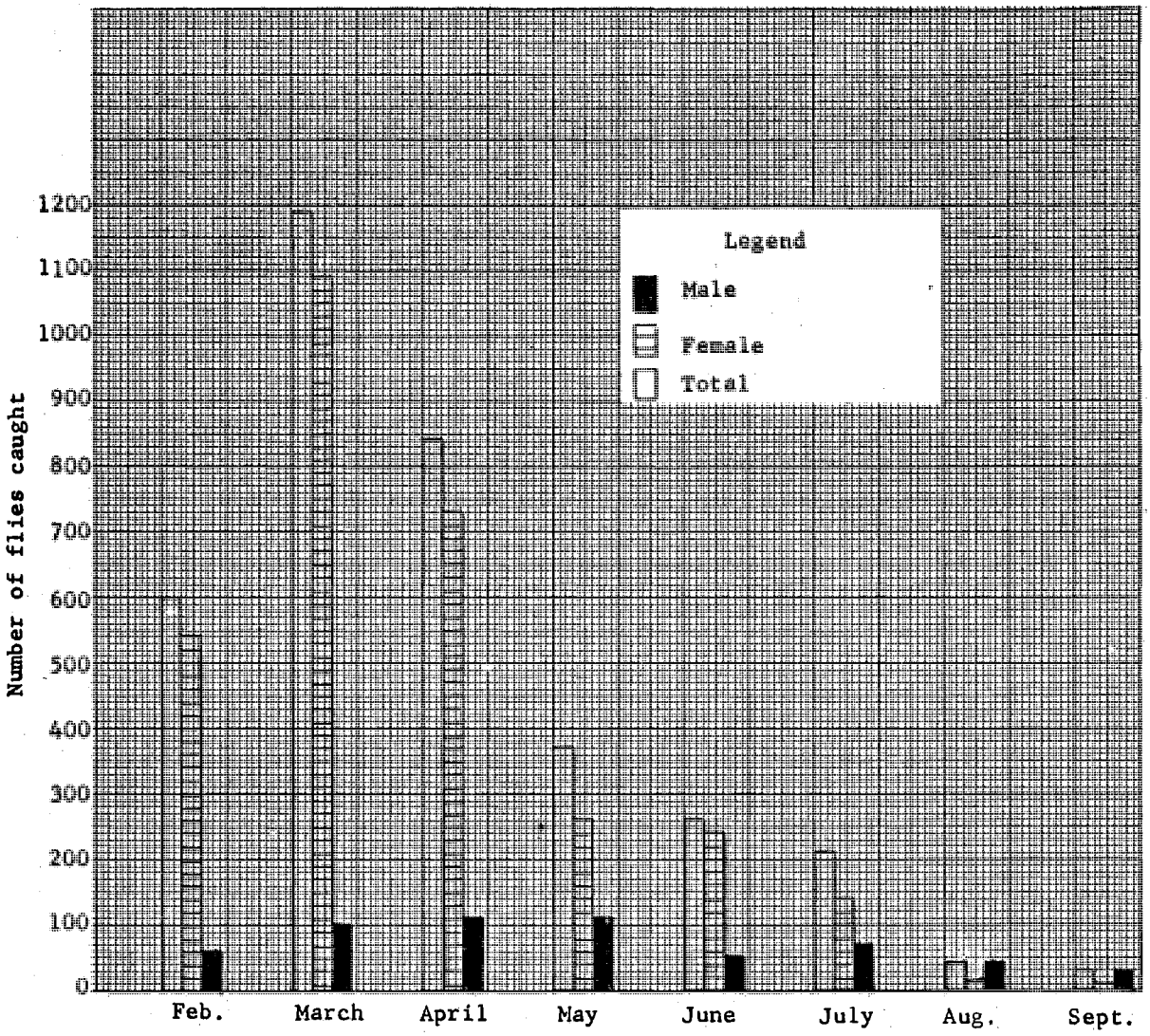

Fig. 12. Number of flies caught at Katakol, February through September, 1959.

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