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Miscellaneum

Preliminary Notes on a *Simulium* Survey in the Onchocerciasis Infested Ulanga District, Tanzania

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1. Introduction

The Ulanga District (Morogoro Region) lying between 8–10° south and 35–38° east covers about 40,000 km² (16,000 sqm). The central part of this district, the Mahenge mountains, are mainly between 600–1200 m (2000–4000 ft) above sea level. In north-west, north, and north-east of the Mahenge mountains lies, in a big bow of about 240 km (150 mls), the wide Kilombero valley in an altitude between 200 and 400 m (600–1200 ft). It is formed by the Kilombero river or Ulanga and some big tributaries, so the Mnyera, Ruhudji and Pitu coming from Njombe highland, the Mpanga and the Kihanzi from the Iringa mountains and the Furua from the Mahenge mountains, and collects numerous small and medium sized tributaries from the north-western slopes of the Mahenge mountains as well as from the south-eastern border of the Iringa mountains, which attain heights of 2500 m (8000 ft) and more. In south-east, originating from the Mbarika mountains in the south, the Luhombero collects the numerous small rivers from the eastern slopes of the Mahenge mountains and meets with the Kilombero in the uninhabited Selous Game Reserve. Further in the south-east the Luwegu, coming from Songea District (Ruvuma Region) is another big tributary of the Ulanga. In the east at least the Ulanga meets with the Great Ruaha river and the united rivers pass as Rufiji through the Rufiji District to the coast.

Though the rainfalls, reaching 100–150 cm (40–60 inches) a year, concentrate mainly from March till May, most of the rivers are flowing throughout the year. In the mountains over about 600 m the rivers are stony and breeding of *Simuliidae* occurs nearly everywhere. In the deeper valleys, the hills and the lowlands most of the rivers are sandy and breeding is confined to few rocky passages.

Today the Ulanga District is inhabited by approximately 150,000 Africans, mainly farmers. Most of the villages lie on either sides of the Kilombero valley and on the eastern slopes of the Mahenge mountains, often near to ideal breeding places. The Kilombero plain itself and the southern part of the district are scarcely, the inner region of the Mahenge mountains not at all inhabited. Many of the villages are approachable by car during a few months of the late dry season only.

Onchocerciasis in the Ulanga District was first mentioned by YOUNG, FARR & MCKENDRICK in 1946. Between 1942 and 1946 GABATHULER & GABATHULER (1947) observed 686 cases of onchocerciasis in this district. Most of the cases originated from the southern side of the Kilombero, only few from the northern side.

Stimulated by the results of new onchocerciasis surveys in this district which have been carried out by a team of the Swiss Tropical Institute, Basel, from the Rural Aid Centre, Ifakara (GEIGY, COLAS & FERNEX, 1965), I have

been put in charge of a *Simulium* survey from April to August 1965. I take this opportunity to express my thanks to Prof. Dr. R. Geigy, Director of both Institutions mentioned above, for his help, and his interest in this work and that he enabled me to visit the British Museum for Natural History in London. I extend my thanks also to Mr. R. W. Crosskey, Dr. D. J. Lewis and Dr. P. Freeman from the British Museum, who introduced me to the taxonomy of African *Simuliidae* and examined my collections of larvae and pupae. I am grateful also to the Fathers and Brothers of the Swiss Capuchin Mission for having provided accommodation in the various Mission stations of the Ulanga District. Without their hospitality this survey would not have been possible.

2. Methods and Procedure

In order to get an idea of the number of species and their geographical distribution, pupae and larvae were collected in as many rivers as possible, fixed in 85% alcohol and afterwards identified with the keys of FREEMAN & DE MEILLON (1953) and CROSSKEY (1960). To observe seasonal fluctuations of the potential vectors of onchocerciasis in view of a pilot control project, a small number of selected rivers were searched fortnightly for larvae and pupae at various places. Some of these rivers are in the region around Sali Mission, where a high infection rate with onchocerciasis is found amongst the population. Other regularly checked rivers are at the south-eastern slopes of the Iringa mountains between Kiberege and the Great Ruaha river. The different breeding places were checked periodically for about 15 minutes, in order to be able to compare the numbers of collected larvae and pupae. It has been observed that a certain proportion of larvae of all species detach themselves and are driven down the rivers. Therefore sticks and rubber strips were fixed in the water at convenient places in order to collect the floating larvae and to estimate by this way the proportions of the different species.

The main aim of the survey was naturally to identify the vectors of onchocerciasis and to study their biting behaviour. For this purpose a fly round was organized with three fly-boys and 7 catching points in the Mbezi valley near Sali Mission, which allowed to compare fly densities and biting activities with the results of larval and pupal collections. A number of additional excursions to other parts of the district made it possible to map the distribution of the manbiting *Simulium* population.

A current meter was obtained in July and measurements were carried out in July and August in rivers which had proven to be good breeding places during the previous months. As seasonal changes in breeding densities seemed to be connected with the level of the water in a river, such measurements should be continued over a full year.

3. Results

List of Species

From April till August 1965 larvae und pupae of 18 species of the genus *Simulium* have been collected in the Ulanga District. Some of these species are represented by several different forms or at least morphological modifications with regard to pupal as well as to larval characteristics. Since the collections are not completed with adults, bred from pupae, the taxonomical value of these modifications shall not be discussed in this list.

The arrangement of species below follows the species arrangement given by FREEMAN & DE MEILLON, 1953.

*Group I*¹

S. alcocki Pomeroy, 1922

Two forms or modifications were found. One with 8 the other with 10 respiratory filaments. The gill formulae are 2, 4, 2 and 2, 3, 3, 2.

S. merops de Meillon, 1950

S. impukane de Meillon, 1936

This species is also represented by two modifications with regard to the pupal respiratory organ. The gill formulae are 2, 5, 3 and 2, 3, 2, 3.

S. mcmahoni de Meillon, 1940

Group II

S. cervicornutum Pomeroy, 1920, type form

S. unicornutum Pomeroy, 1920, type form and form *rotundum* Gibbins, 1936

Group III

S. aureosimile Pomeroy, 1920—*S. nigritarsis* Coquillet, 1902

Due to lack of adult specimens it cannot be decided whether the collected larvae and pupae belong to the one or the other species. In this area *S. aureosimile* is to be expected rather than *S. nigritarsis*. Mixed with specimens of the type form, however, a single pupa was found with a respiratory organ like that of *S. nigritarsis* form *duboisi* Fain, 1950.

Group IV

S. hirsutum Pomeroy, 1922, type form

S. adersi Pomeroy, 1922

Simulium sp. of the *S. neavei*-complex

On both sides of the Kilombero river larvae and pupae of the *S. neavei*-complex were found and some of them sent to Dr. D. J. Lewis, London, who kindly examined them. Whereas the specimens collected on the northern side seem to be *S. nyasalandicum*, on the southern side some specimens look like *S. woodi* from Amani (LEWIS, 1960), and one pupal skin like *S. nyasalandicum*. Anthropophilic females were caught on the south side of the Mahenge mountains only.

Group V no species found.

Group VI

S. dentulosum Roubaud, 1915, type form

S. debegene de Meillon, 1934, type form

S. loutetense Grenier & Ovazza, 1951, type form

Group VII

S. medusaeforme Pomeroy, 1920, type form and form *hargreavesi* Gibbins, 1934

Of both forms several modifications in body size as well as in length and angles of the furcations of the pupal respiratory organ exist.

S. vorax Pomeroy, 1922

This species is represented by two modifications with regard to body size as well as to structure size and pigmentation of the filaments of the pupal

¹ Since work in the Ulanga District has been taken up again in February 1966 also specimens of *S. schoutedeni* Wanson, 1947, have been found.

respiratory organ. The larvae show also slight differences with regard to the head pattern and pigmentation.

S. taylori Gibbins, 1938 (?)

Pupae collected in large numbers in different small swift rivers in the Mahenge mountains show a respiratory organ built on the same principle, but smaller as in *S. vorax* and with only two main trunks in the outer set of filament as known from *S. taylori*. The main trunks, however, are thicker than in typical *S. taylori* and the size of the branch representing the third branch of *S. vorax* is varying widely. The anterior basal lobe has a secondary filament just before the tip and the posterior one ends in a secondary filament. The attachment points of the inner secondary filaments show also slight variation. The organ is illustrated in Fig. 1. The abdomen of the larvae shows no spines and the post genal cleft is not like that of *S. vorax* (Fig. 1).

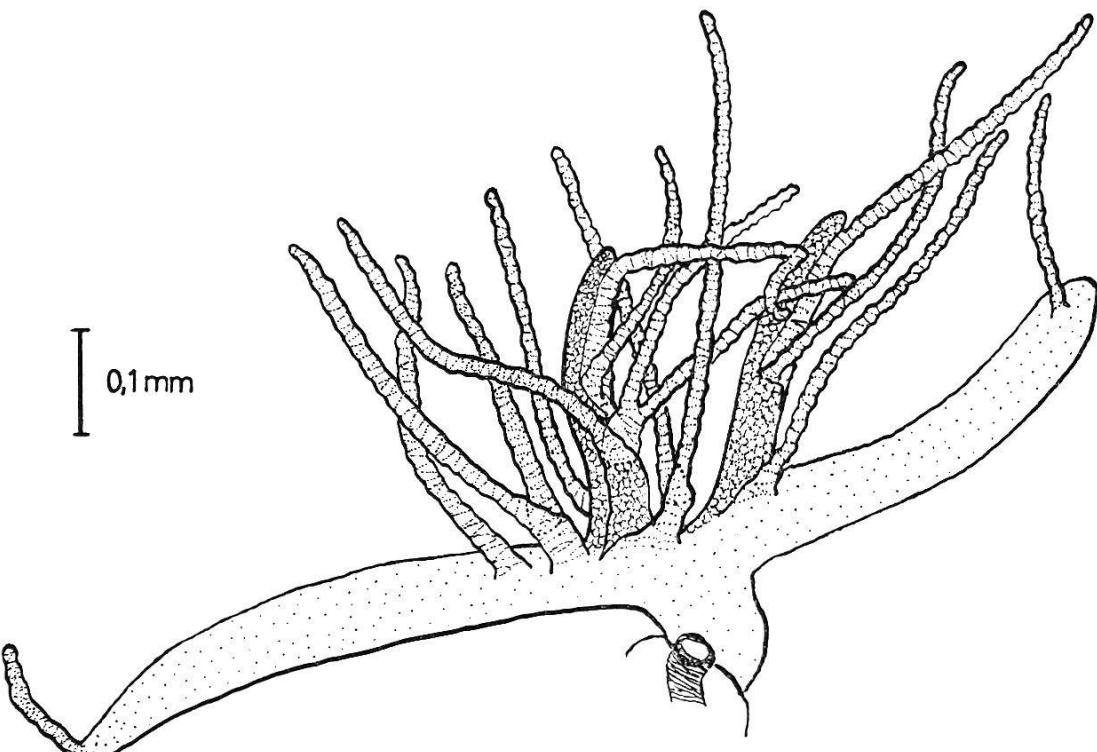


Fig. 1 a. *S. taylori* Gibbins (?). Pupal respiratory organ and postgenal cleft of larva.

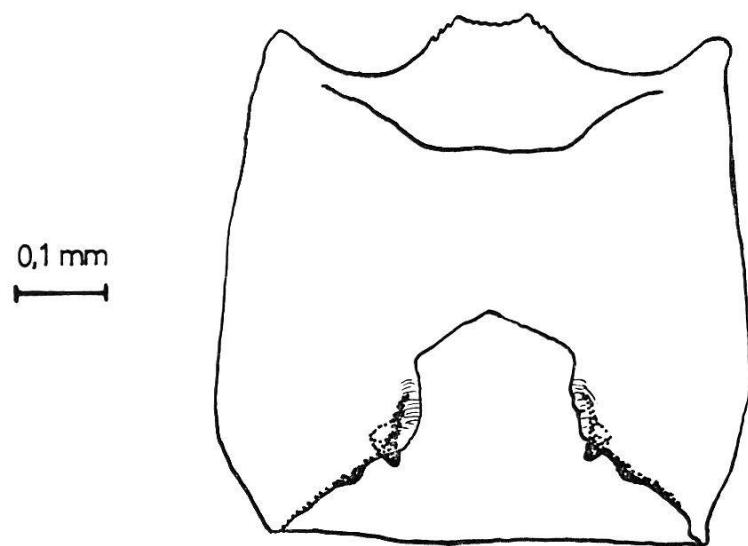


Fig. 1 b. *S. taylori* Gibbins (?). Head capsule.

Simulium sp. of *S. bovis*-complex

Larvae and pupae of the *S. bovis*-complex were found in several rivers on the south side of the Kilombero; some of them have been submitted to Dr. D. J. Lewis who kindly examined them. After dissection and preparation of the genitalia two black pupae appeared to be *S. arnoldi* Gibbins, 1937. Other larvae and pupae found in the Great Ruaha river near Kidatu (north side of the Kilombero) also belong clearly to the *S. bovis*-complex. The branching pattern of the pupal respiratory organ is of the same type as in true *S. bovis*, but the arrangement of the filaments is more clear and the secondary filaments arising from the outer main trunks are bigger than those of the inner sets. The organ is illustrated in Fig. 2.

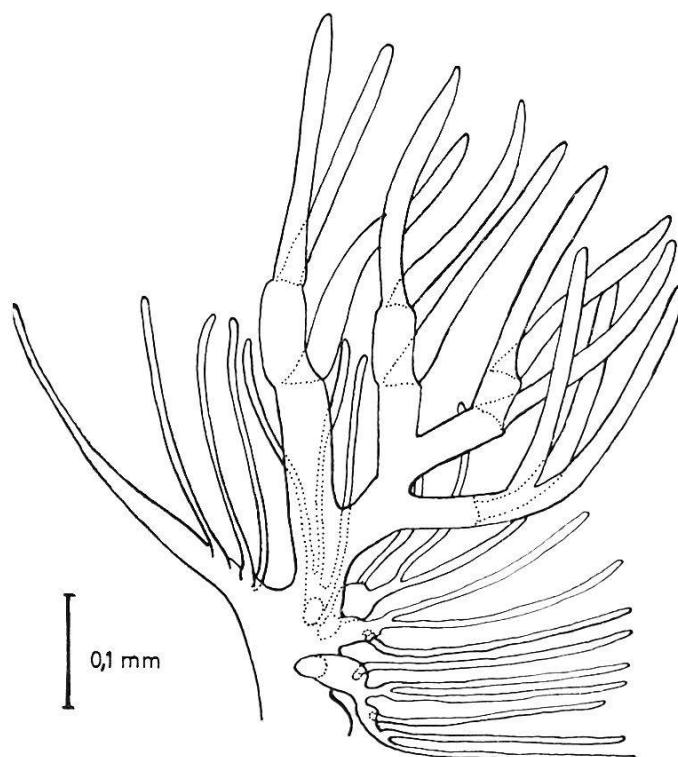


Fig. 2. Pupal respiratory organ of *S. bovis* (Great Ruaha river, Ulanga).

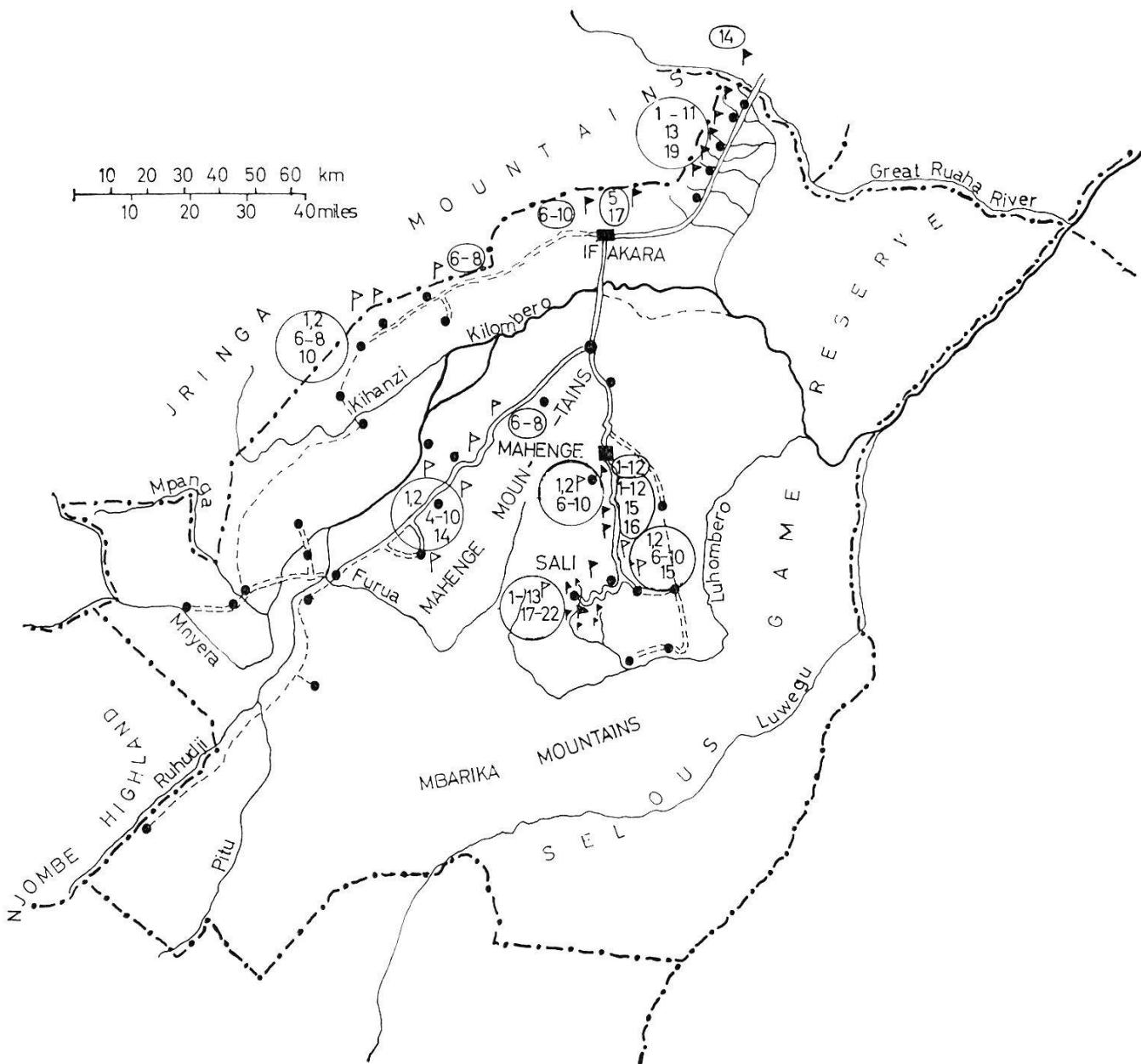
S. damnosum Theobald, 1903

Larvae und pupae of this species are very common and found in different modifications with regard to pupal size, shape of cocoon (short and long necks) as well as to colour of larvae, size of dorsal humps and number of big, flattened abdominal scales.

Distribution and Frequency

At present the observations about distribution and seasonal fluctuations of any species do not give complete information about the influence of ecological conditions on the species. For instance no relations between vegetation, local climatic factors and other characters of a certain breeding site could be found to explain the preference of a species for just this river or this breeding site and its absence on other similar sites.

For the most common and widespread species *S. vorax*, *S. damnosum*, *S. cervicornutum*, *S. hirsutum* and *S. alcocki*, however, some relations between environment and occurrence became obvious during these five months. *S. dam-*



Map 1. Distribution of *Simulium* species in the Ulanga district as far as known today.

- Roads passable throughout the year
 - - - Roads and tracks passable only some months in dry season
 ▶ regularly checked breeding sites
 ▷ occasionally checked breeding sites
 ○ (1-6,15) breeding species at this site
1. *S. damnosum* 12. *S. unicornutum* form *rotundum*
 2. *S. vorax* 13. *S. neavei*-complex
 3. *S. taylori* 14. *S. bovis*-complex
 4. *S. medusaeforme* 15. *S. aureosimile* or *nigritarsis*
 5. *S. medusaeforme* form 16. *S. nigritarsis* form *duboisi*
 hargreavesi 17. *S. adersi*
 6. *S. hirsutum* 18. *S. dentulosum*
 7. *S. alcocki* 19. *S. debegene*
 8. *S. impukane* 20. *S. loutetense*
 9. *S. mcmahoni* 21. *S. merops*
 10. *S. cervicornutum* 22. *S. schoutedeni*
 11. *S. unicornutum*

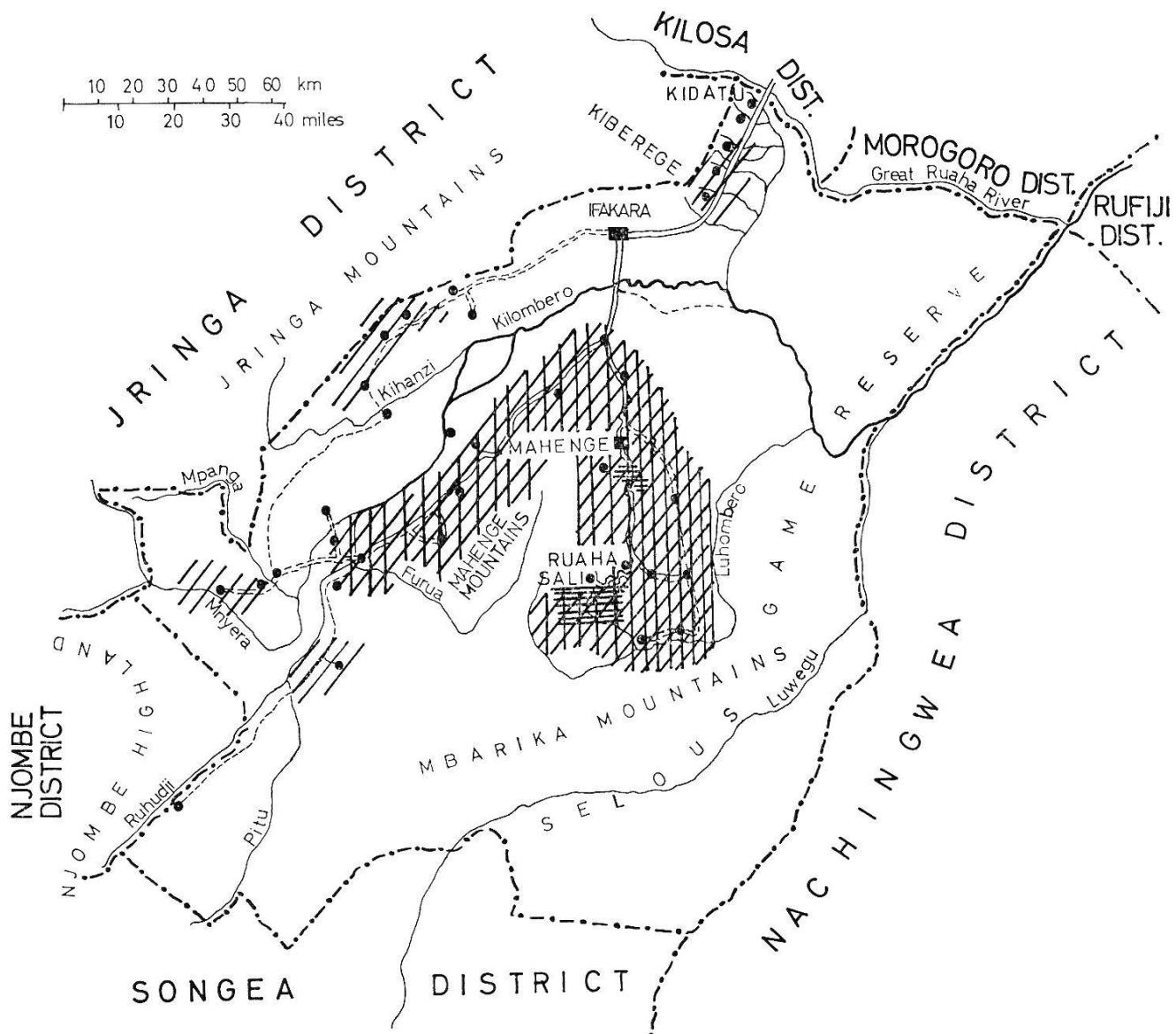
nosum and *S. vorax* need faster running and better aerated water than the three other species. In consequence to this the following observations were possible. At the end of the rainy season, when the level of the rivers lowered, an increase in overall larval densities took place in all stony mountain rivers with a current of about 100 to 500 lit./sec. and in the regularly checked rivers between April and August a succession of high larval densities was observed, beginning with *S. vorax* and continued by *S. damnosum*, *S. cervicornutum*, *S. hirsutum* and *S. alcocki*. Though in the same time the water temperatures fell according to the altitude from 24°C to 17°C and even 16°C at about 1000 m and from 26°C to 20°C at about 300 m they are not supposed to be responsible. It is more likely that this succession stands under the influence of the current speed in consequence of the waterlevel in a given river profile, and that the suitable breeding conditions in the numerous mountain rivers are to a good deal responsible for mass breeding and abundance of these species at a certain time of the year. Breeding of *S. vorax* and *S. damnosum* in the late dry season is probably confined to single breeding sites of bigger rivers, whereas breeding of the three other species in the rainy season happens only in very small perennial and nonperennial rivers. In such rivers *S. damnosum* is found only occasionally during the rainy season.

Other species like *S. medusaeforme* type form and form *hargreavesi*, *S. unicornutum* type form and form *rotundum*, *S. mcmahoni* and *S. impukane* were also rather common and widespread during these months but only in a few rivers really abundant. A form of *S. bovis* which has not been described yet, was observed in big numbers in the Great Ruaha river only. Other members of the *S. bovis*-complex and *S. adersi* were rare, but are supposed to become common or even abundant in a later season of the year. Other species like *S. aureosimile*, *S. dentulosum*, *S. debegene*, *S. loutetense*, seem to be more particular since they were rather rare and sometimes found in single rivers or single breeding sites only. Crabs as vectors of larvae of the *S. neavei*-complex were trapped in the regularly checked rivers around Sali and between Kiberege and the Great Ruaha river. Whereas larvae of this complex were always rare in the rivers around Sali, an increase in number of larvae per crab could be observed in the Kiberege rivers in August.

The distribution of the species with regard to their breeding rivers is shown in Map 1.

The Vectors of Onchocerciasis

With man as bait, *S. damnosum* and a species of the *S. neavei*-complex were caught, but only on the southern side of the Kilombero river in the Mahenge mountains and none on the northern side in and along the Iringa mountains. Though the density of larvae of *S. damnosum* was equal on both sides, and in the case of the *S. neavei*-complex the number of larvae was even higher on the northern side. No specimen of any other species which is known to bite man was caught anywhere else. Therefore, it seems that the *Simulium* fauna of the Ulanga has anthropophilic components on the southern side of the Kilombero only. As mentioned above, larvae of *S. damnosum* were most abundant during the months May and June. In July the number of *S. damnosum* larvae decreased starting in the mountains and proceeding to the lower sites. At the end of July the larval density was remarkably reduced. Since the fly round was continued also after our visit it is now possible to say that *S. damnosum* is present throughout the year though very small in numbers in the late dry season. Few weeks after heavy rainfalls the number of catches



Map 2. Distribution of onchocerciasis and its vectors in the Ulanga district as far as known today.

- Roads passable throughout the year
- — — Roads and tracks passable only some months in the dry season by cars
- · · · · District boundaries
- ||||| Cases of onchocerciasis established
- ||||| Presence of anthropophilic *S. damnosum* established
- ===== Presence of anthropophilic member of the *S. neavei*-complex established

increased rather quickly at the beginning of May. During May there were two peaks of biting activity between 9 and 12 a.m. and 3 and 6 p.m. In June the morning peak dropped. In July the number of catches decreased at the higher points. Since in May the increase in larvae was following the increase in manbiting adults and the decrease in larvae came first at every breeding place in the mountains, there must be a considerable migration of adults depending on the season.

Adults of *S. damnosum* seem to occur everywhere in the Mahenge mountains including their borders to east and west, whereas the adults of the *S. neavei*-complex were observed in the region around Sali Mission and occa-

sionally around Mahenge only. They were caught, though smaller in number, also regularly at the same daytimes and on several places together with *S. damnosum*. At the end of August a little increase in the number of catches became visible. It is strange that in the same time only very few larvae and pupae, much less than adults, were found in the rivers around Sali, though rivers of all kinds were searched over on rather long distances. In the region between Kiberege and the Great Ruaha river larvae and pupae became more frequent at the same time but no adults were caught.

Some females of both species which had fed on an onchocerciasis infected person showed microfilariae in their midgut and after some time (24–48 h) in the case of *S. damnosum* the entering of microfilariae into the thoracic muscles could be observed. They showed the same distribution of nuclei in their hind region as fresh microfilariae of *Onchocerca volvulus*. After dissection of thoracic muscles, females of both species which were caught at different places were found to be infected with sausage forms. Though no observations of the development from microfilariae to sausage and infective forms in experimentally infected females were made, it is very probable that in the Mahenge mountains both species are vectors of *O. volvulus*. Further investigations to establish the infection rates of the two species will be carried out later on.

Several onchocerciasis surveys carried out by staff members and students of the Medical Training Centre, Ifakara, during the summer course 1965, showed that the infection rate of *O. volvulus* in the human population differs widely from place to place. More than two thirds seem to be infected at the eastern slopes of the Mahenge mountains, Sali, Ruaha, Mahenge, whereas about one third only proved to be infected at the western slopes. It is astonishing that on the northern side of the Kilombero some people were found infected (GABATHULER & GABATHULER, 1947; COLAS, 1965, personal communication) though no vectors could be caught on man during this survey. As there is intense traffic between north and south and as people from the south settled only few years ago in the north, a new survey has to prove, if infections can take place also in another season of the year or if these people became already infected in the south. The distribution of vectors and of onchocerciasis is shown in Map 2 as far as known today.

4. Summary and Conclusions

During a five months visit in the Ulanga District, lasting from April till August 1965, larvae and pupae of 18 species of *Simuliidae* have been found. Nearly half of these species occur in different morphological modifications and some are even represented in different forms. Most of these species are very catholic, therefore common and widespread and in certain times of the year abundant, especially *S. damnosum*. Other species, as for instance those of the *S. neavei*-complex and of the *S. dentulosum* group, are more particular and rather rare in this area.

In 1965 after heavy rainfalls in April, the months May and June were very convenient for mass breeding in the mountains, where the rivers are rocky or stony on long distances. A correlation between succeeding mass breeding of the most common species and the decrease in the current was obvious.

The Kilombero plain separates an entirely zoophilic *S. damnosum* population in the north from one with anthropophilic components in the south. In higher regions (Sali and Mahenge) a not yet full identified member of the *S. neavei*-complex occurs which is also anthropophilic, whereas on the northern side

of the Kilombero another member of this complex is apparently non anthropophilic.

Main vector of onchocerciasis in the southern side is *S. damnosum*. No vector was found on the northern side.

Highest population density of *S. damnosum* was observed during May and June but this species can be caught throughout the whole year.

Since in this region *S. damnosum* has the habit to breed in the numerous small perennial mountain rivers, of which the largest number is not yet mapped, and which are often difficult to approach even by foot, control of onchocerciasis for the whole area combined with extensive vector control stays out of question. A thorough *Simulium* survey, however, with a control campaign restricted to one suitable valley promises new interesting observations about general biology and behaviour of this *S. damnosum* population.

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