THE COURSE OF REINVASION BY *SIMULIUM DAMNOSUM S.L.* INTO THE EASTERN AREAS OF THE ONCHOCERCIASIS CONTROL PROGRAMME DURING THE RAINY SEASON 1983 AND INVESTIGATIONS ON THE VECTORIAL EFFICIENCY AND DISPERSAL OF DIFFERENT FLY-POPULATIONS IN TOGO AND BENIN

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1. INTRODUCTION

Starting May 1977, the northern areas of Togo and Benin are part of the Onchocerciasis Control Programme of the World Health Organization (OCP) and all potential breeding sites of the Simulium damnosum s.l. vector flies there are treated at weekly intervals by insecticides (WALSH et al. 1979). However, large numbers of biting flies were recorded every year during the rainy season (May - October) inside the controlled areas, particularly along the rivers Mô and Kara in Togo and along the Sota, Alibori and Mêkrou in northern Benin. Most of these "reinvasion" flies were presumably coming windborn from yet untreated breeding sites south outside the OCP boundary (GARMS et al. 1979, 1980, 1981, 1982, RENZ 1983, CHEKE & GARMS 1983).

Experimental treatments of the suspected source areas of these reinvading flies in Togo were carried out during the rainy season in 1980 and 1981 (CHEKE & GARMS 1983), but no breeding sites outside the programme area were treated in 1982 and 1983, with the exception of some localized experimental applications of new insecticides by the insecticide screening team from Lomê in the rivers Mono and Aniê, which, however, are not likely to have influenced the over-all size of fly-populations and of reinvasion in 1983. It is therefore possible to compare the variation in the amount of reinvasion for five years without control outside the programme area and to examine, whether the trend of decreasing biting rates, which was observed over the past years at most of the fly-catching sites outside the controlled area (RENZ 1983), would be manifest during this year, too.

Four vectors out of the S. damnosum s.l. complex are involved in the transmission of onchocerciasis in Togo and Benin, namely S. squamosum from numerous breeding sites in the mountainous regions of south-western Togo, which constitute the major part of the reinvading flies in the Mô valley and partially along the river Kara, S. damnosum s.s., whose breeding sites are more southerly distributed than those of S. sirbanum and which both are involved in the reinvasion of the eastern areas of Togo and in Benin, and finaly, there are flies of the S. soubrense/S. sanctipauli group, which is considered to be an interbreeding population, morphologically and genetically different from S. soubrense and S. sanctipauli sensu Vajimê and Dunbar (MEREDITH et al. 1983).

These vectors can be distinguished on the basis of specific inversions on their larval salivary gland chromosomes (VAJIME & DUNBAR 1975), but adult flies can only be classed, as belonging to one of the categories S. damnosum s.s./S. sirbanum, S. squamosum and S. soubrense/S. sanctipauli by using morphological methods (GARMS et al. 1982).

The occurrence of these different vectors in space and time, and their respective contribution to reinvasion and transmission of onchocerciasis in different bioclimatic zones of Togo and Benin were to be investigated in the light of the following questions :

- Which species are coming to bite on man and what is the amount of transmission by each vector ?
- Where are the potential source areas of reinvading flies ?
- What are the differences in the vectorial efficiency of the different vectors in different bioclimatic zones ?

Particular attention should be paid to the northern limits of the areas of distribution during dry- and rainy season and to the vectorial efficiency of the S. soubrense/S. sanctipauli flies. These vectors are assumed to transmit the 'rain-forest form' of onchocerciasis, which is found associated with a low degree of pathogenity to the eye, even at places where the transmission is very high (ATP over 10,ooo, OMS 1982). In the Ivory Coast, S. soubrense/S. sanctipauli larvae became resistant to the commonly used insecticides (temephos and chlorphoxim, GUILLET et al. 1980) and it is therefore crucial to know, whether these flies - or one of their subspecies- could repopulate, if resistant, the former breeding sites of S. damnosum s.s./S. sirbanum in treated areas of the savanna.

The dispersal of flies away from the river and, in particular, the flight range of old, parous and infective flies delimits the extension of the areas, where the human population is exposed to disease transmission. This is particularly true for the reinvasion flies which come to bite on man only near to fast-flowing rivers, but not when migrating over-land (RENZ, 1983). Studies on the dispersal of fly-populations were therefore designed to provide information on the differential flight-range of nulliparous and parous flies and to compare the behaviour of different species in various bioclimatic zones of Togo.

These experiments were carried out at Mô â Mô, where there were almost exclusively reinvading S. squamosum flies, at Djodji with mainly S. soubrense/S. sanctipauli flies together with a few S. squamosum flies, and at Alamassou, where all three vectors were present.

In order to compare the epidemiological significance of different vectors, the term "vectorial capacity" is often, but inacurately used. It has been defined by GARRET-JONES (1964) for an anopheline vector population of malaria as "being an expression of the number of infections the population of a given vector would distribute per case per day at a given place and time". An adaptation of this concept to the epidemiology of onchocerciasis and estimate values for the parameters of the vectorial capacity of different vectors of onchocerciasis will be presented in a seperate paper.

In the following, the term 'vectorial efficiency' will be used, according to the definition, given by WHO (1963): 'Ability of a (mosquito) species, in comparison with another species in a similar climatic environment, to transmit (malaria) in nature'.

At Têtêtou, the majority of nulliparous flies, caught during the rainy season in 1983, were parasitized by mermithids. This was in contrast to the last year, when only few flies were infected. The influence of these parasites on the morphology of the flies and the different infection rates of different vectors were therefore investigated.

2. MATERIAL AND METHODS

2.1. Study area and fly-catching sites (cf. Fig. 1)

The course of the reinvasion was monitored at the same daily fly-catching sites as during the previous studies: At Mô â Mô (r. Mô), Landa Pozanda (r. Kara) in Togo and at Gbassê (r. Bouli) in Benin. Daily fly-catches started at these sites in May and continued until the end of September. Additional information came from the routine OCP-fly-catching sites which were visited at weekly intervals.

All breeding sites inside the OCP area were treated at weekly intervals by aircraft, starting in mid-May in Togo (Landa Pozanda) and by the 29th of June in Northern Benin (Gbassê). Abate[R] insecticide was used for these treatments.

Outside the OCP area, the dynamics of the fly-populations were examined, in Togo, at Landa Mono (r. Mono) and Fazao (r. Anie) by three days of catches per week and at Djodji (r. Gban Hou) and Têtêtou (r. Mono) by two days per week. In Benin, flies were caught at three days per week at Bêtêrou (r. Ouêmê) and at two days at Kaboua (r. Okpara).

The flies were caught according to OCP routine and were brought alive to the laboratory for subsequent identification and dissection. From each fly-catching site, the catch of one day per week was dissected by the sector staff in Atakpamê, Kara and Parakou, up to a maximum number of 60 flies per catch, for the routine of the OCP. Another day's catch was send to the laboratory in Kara for species-identification and subsequent dissection.

Fig.1

(modified from GARMS et al., 1980)

2.2. Identification and dissection of the flies

All flies caught during one day per week at Landa Pozanda, Mô à Mô, Landa Mono, Fazao, Djodji and Têtêtou in Togo and from Gbassê, Bêtêrou and Kaboua in Benin were separated into nulliparous and parous flies, up to a maximum number of 110 flies per day and site. Nulliparous and parous flies were preserved in 70 % alcohol until further examination and dissection. The species-identification of alcohol-preserved flies was done using the same morphological criteria as in 1982 (RENZ 1983, and Table 1). The results of the examinations were recorded on modified OCP data sheets ('fiches 2A', Fig. 2). After the identification, the flies were placed into the wells of a microtitre plate and were stained as follows (NELSON 1958, GARMS et al. 1982):

- 30 min destilled water
- 1-3 days Mayer's Hämalaun
- 1-3 days tap water (1 0/oo fungicide Nipagine was added)
- 1-3 hours 25 % acetic acid

Then the flies were dissected on a slide in one drop of a mixture of 50 % glycerol and 5o % acetic acid (25%). Infections of the flies were recorded on the modified data sheet. All dissected parous flies were reexamined for filarial infections under a WILD compound microscope at the end of the day.

2.3. Selection of the sites for the studies on the dispersal

The studies on the dispersal of the fly-populations away from the river were carried out at Djodji (6./7. and 15./16. 8. 83), Mô à Mô (13./14. 8. 83) and at Alamassou (16./17. 9. 83). Five to seven fly-catching sites were selected, in the vicinity of each village, according to the following criteria: one site at the usual OCP-fly-catching point, which had been situated at the place with the presumed highest biting rate. A second site was chosen at a distance of about 100 m from the river, and another at a distance of about 300 m, along the road or the path leading from the village to the river. One catching site was located inside the village under a tree. Yet other sites were placed at rainy season tributaries or at a waterhole near to the village. Figures 8 to 10, which give the

OCP/VCU

CAPTURES ET DISSECTIONS S. DAMNOSUM

FICHE 2 A (1-2) PAGE (3-4) DE

SECTEUR : .... S/SECTEUR : .... COURS D'EAU : ....

POINT DE CAPTURE : .... (5-10) AN : 19 (11-12) MOIS : (13-14) JOUR : (15-16)

NBR HEURES DE CAPTURE : (17-18) PARTIE DU JOUR : (19-20) NBR S.D. CAPTUREES : (21-24) DISSEQUEUR : .... DATE DISSECTION : ....

NO. SEQ.	HORAIRE DE CAPTURE	ESPECE		AGE	NOMBRE DE LARVES 1er STADE	2ème STADE	3ème STADE TETE	3ème STADE TH. & ABD.	AUTRES PARASITES MERMITHIDES	AUTRES FILAIRES	FONGIDES	REPAS DE SANG		OBSERVATIONS	MICROTIT. PLATE		WING-TUFTS		THORAX	ANTENNA	RATIO	ANTENNA COMPRESSION	PALE SEG.		POSTCRAN. HAIRS		SPECIES IDENTIFIC.
25-26	27-28		30-31	32	33-34	35-36	37-38	39-40	41-42	43-44	45																
01		1																									
02		1																									
03		1																									
04		1																									
05		1																									
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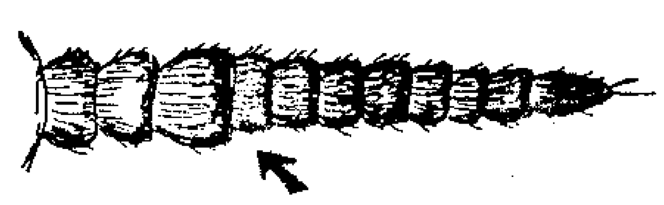
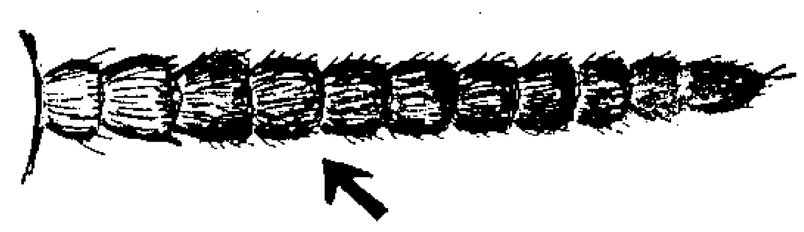
TOTAUX	DISSEQUEES	PARES	INFECTEES	AVEC LARVES 3ème ST. TETE	AVEC LARVES 3ème STADE	NBR LARVES 3ème ST. DANS LA TETE	OBSERVATIONS

WHO 5385.1 OCP (8/79)

IDENTIFICATION OF ADULT FEMALES OF THE S. damnosum KOMPLEX

	S. damnosum/sirbanum	S. sqamosum	S. soubrense/sanctipauli
ANTENNAE - Form :			
- Description :	segments 4 and 5 always compressed, often other segments also	segment 4 (and 5) distinctly compressed	very seldom any compression
- Colour :	first 4 segm. normaly pale	first 2 (3) segments pale	all segments dark
Antennae/Thorax Ratio	2.10 - 2.40 (median 2.2-2.3)	2.04 - 2.20 (median 2.15)	1.80 - 2.04 (median 1.96)
WING TUFTS	almost all pale	most pale, some mixed	some pale, many mixed and dark
- colour class	01 02 03 04 05	01 02 03 04 05	01 02 03 04 05
- % observed	97.7 2.1 0 0.2 0	86.2 6.6 3.2 3.9 0.2	16.0 13.9 17.1 30.1 22.9
POSTCRANIAL HAIRS	typically all pale, lying flat on the head. Few dark	typically many dark or greyish hairs, but often most hairs pale. Sometimes protruding	almost all hairs very black, few pale hairs intermixed
FORE-COXAE HAIRS	all pale	seldom few dark hairs intermixed	usually some very black hairs visible

location of these catching sites , were drawn after aerial photographs from the land registry office in Lomé. However, the region of Alamassou was drawn from a map 1:200.ooo, according to prospection of the area by feet.

2.4. Prospection of Simulium breeding sites by road.

S. damnosum s.l. larvae were collected at breeding sites in Togo but there was not enough time to do so in Benin. Most of the larvae samples, the identifications of which are mentioned in this report, stem from prospections of the OCP sector teams or from the insecticide screening team in Lomé. The larvae were fixed in cold Carnoy and were send to Mr Fiasorgbor (Ouagadougou) for cytotaxonomic identification.

3. RESULTS

3.1. The course of reinvasion in 1983

3.1.1. The meteorological data

The monthly totals of the rainfall (Table 2) were within the normal range of the last years (cf. CHEKE & GARMS 1983, Table 1) in Togo (stations Dapaon, Kara, Sokodê), but were rather low for the beginning of the rainy season in northern Benin (Parakou, Kandi) and were extremely low in the late rainy season in southern Togo (Atakpamê, Notse, Lomê).

Tab. 2

MONTHLY TOTALS OF RAIN-FALL (mm) AT VARIOUS METEOROLOGICAL STATIONS IN TOGO AND BENIN 1983

	Meteorological station mm rainfall per month							
	DAPAON	KARA	SOKODE	ATAKPAME	NOTSE	LOME	PARAKOU	KANDI
MAY	99.9	166.1	133.3	151.8	122.9	303.0	100.1	57.9
JUNE	99.5	168.7	236.2	292.1	136.7	191.6	126.9	131.7
JULY	204.7	250.6	257.8	124.1	21.8	76.1	110.6	135.6
AUGUST	150.2	212.4	846.0	44.2	54.1	1.7	192.1	187.4
SEPTEMBER	130.1			216.9		48.6	82.5	114.6
OCTOBER								

3.1.2. Biting rates at fly-catching sites in Togo (Fig. 3)

At Landa Pozanda, the biting rates were much lower in 1983 than during the previous years. For the total of the rainy season (May to September), the biting rate (1215 flies) was at its lowest level ever recorded and was even lower than during the two rainy seasons of experimental treatments of the suspected source areas of the reinvading flies in 1980 (3270 flies) and 1981 (1629 flies) (Table 5). In 1982, the application cycles of insecticide to the river Kara were interrupted during the months May to August. This explains the very high biting rate in 1982 (9985 flies). Daily biting rates, exceeding 20 flies per man per day were only observed in the second half of the month of August and the highest daily biting rate was observed on the 20th of August (82 flies/man/day). The dynamics of the biting rates were similar to those observed at Mô â Mô and Landa Mono, but in May, more flies were caught at Landa Pozanda than one might have expected from the biting rate observed at these sites.

At Mô â Mô, more flies were caught in 1983 (18,487 flies) than in 1982 (14,503 flies), but this number was still lower than the biting rates in the years 1976 to 1979. The maximum daily biting rate was recorded on 13.8.83 (647 flies/man/day) at Mô â Mô, on the 15.8.83 at Landa Mono (432 flies/man/day) and on the 12.7.83 at Fazao (528 flies/man/day).

3.1.3. Biting rates at fly-catching sites in Benin (Fig 4)

Similarly to the previous years, Gbassê continued to show biting rates exceeding the critical level of 1000 flies per man per year by many times. For the total of the rainy season (May to September), the estimate biting rate was 23,922 flies. The fly-population built-up later in this year than during the preceding years and reached high levels (786 flies/man/day) by the end of June. These flies presumably came from local breeding sites, since the Sota was only treated starting the 29th of June.

Fig. 3 : DAILY BITING DENSITIES DURING THE RAINY SEASONS 1982 AND 1983 IN TOGO

Fig. 4 : DAILY BITING DENSITIES DURING THE RAINY SEASONS 1982 AND 1983 IN BENIN

The rapid decline of the fly-population in July can therefore be considered as the result of the treatment cycles, and the same is indicated by the increase of the parous rate, which was 84 % of all flies dissected in June by the OCP-staff and was 95 % in July. The biting rates at other catching sites of comparable location along rivers flowing north towards the Niger (Alibori, Zougou, Kérémou) did not follow the same pattern and were much lower than those at Gbassê. In particular, the out-break of the fly-population at Gbassê in June/July was not noticed at these sites, and this again would speak for a local source of flies at Gbassê. Some similarity in the pattern of the biting populations can be seen between the catching site Kaboua (r. Okpara) outside the controlled area and the reinvasion sites at the beginning of the rainy season, but not during September, when the increase at Kaboua was not followed by these sites. The high numbers of reinvading flies during August can rather be linked to the pattern of the fly-population at Bêtêrou (upper Ouémé), though the much higher numbers of flies at Zougou (507 on the 15.8.) and Gbassê (651 on the 17.8.) if compared to Bêtêrou (193 on the 24.8.) indicated an additional source of flies.

3.1.4. Monthly averages of the daily biting rates at some fly-catching sites from May 1979 to September 1983 (Fig. 5)

The seasonal variations of the biting rate at the sites Landa Pozanda, Bêtêrou, Kaboua, Djodji and Têtêtou can be divided into two types : Perennial populations like at Djodji and Têtêtou or seasonal populations like at the other sites. The population at Djodji seems to have recovered from the experimental treatments in June and July 1981 and came back almost to its original level. The extremely dry dry-season 1982/1983 has brought, for the first time since fly-catching started at this site, the biting rate at Têtêtou down to zero during the months of March and April. At the other sites in the savanna, the dry-season gap in the biting rate increased more or less steadily over the past years and was particularly marked during the last dry season.

Fig. 5 : Seasonal variations of the monthly averages of the Daily Biting Rate

3.2. Prospection of breeding rivers and identification of larvae

The results from the identification of larvae samples are summarized in Table 3 . The most important changes in the composition of the larval populations were observed, if compared to the results of previous years, at Djodji and Tététou (see next paragraph). The majority of larvae at Djodji were now 'S. sanctipauli', S. soubrense/sanctipauli and 'S. soubrense', probably forming an interbreeding population, and S. squamosum disappeared more and more in July, August and September. No S. damnosum s.s. and S. sirbanum were found at Djodji in the Gban Hou. At Tététou, the breeding sites in the Mono were repopulated, after the complete disappearence of larvae during the drought, by S. damnosum s.s. only, together with very few S. sirbanum. This is the more surprising as, at the same time, S. sanctipauli and S. soubrense/sanctipauli were identified in samples from the upper Mono at Segboé. Mermithid infections were frequently observed in larvae from Tététou (Fiasorgbor, pers. comm.).

No larvae of S. squamosum were found in the Mono, but were they were frequently found in all tributaries of this river (Anie, Aou, Na, Ogou, Kolowaré), sometime together with S. damnosum s.s., but never in association with S. sirbanum. The latter species was only found at a low proportion amongst S. damnosum s.s. in the Mono in Togo and in the Ouémé and Okpara in Benin.

3.3. Seasonal changes in the species composition of the larval populations at Djodji and Tététou

In order to follow-up the seasonal variations in the species composition of the larval populations at Djodji and Tététou, the results from the cytotaxonomic identifications are summarized, for the past years and for dry- and rainy seasons seperately (Table 4). At Djodji, S. soubrense/sanctipauli was not identified before the dry season 1981/ 1982 and was now present at 13 % of the total population. However, this might be due to the difficulty of seperating these larvae ("Beffa form") from those with standard S. soubrense or S. sanctipauli chromosome arrangements (MEREDITH et al. 1983), but S. soubrense/sanctipauli lar-

Tab. 3: **CYTOTAXONOMIC IDENTIFICATION OF SIMULIUM DAMNOSUM s.l. LARVAE FROM BREEDING SITES IN TOGO AND BENIN DURING THE RAINY SEASON 1983**

(Identifications by Mr. G. Fiasorgbor, larvae collections by the Sector staff, the insecticide laboratory in Lomé, Dr. Cheke and Mr Renz)

Date	Site	(River)	da	si	sq	so	sa	so/sa
	Djodji	(Gban Hou)						
9.3.83					16		5	
24.5.83					2		4	
5.7.83					18		31	
12.7.83					11	2	1	13
19.7.83					17	1	38	11
26.7.83					13		12	5
7.8.83					4		5	
23.8.83					3		28	2
30.8.83					1		16	
6.9.83					4		14	3
	Tététou	(lower Mono)						
26.11.82						7		12
11. 2.83	Adjarala	(Mono)	2			11		26
3. 3.83	"	"	4			11		41
14. 6.83	Bégba Rapids	"	94	2				
7. 7.83	Tététou	"	101	2				
10. 8.83	"	"	21					
11. 8.83	"	"	19					
26. 8.83	"	"	24	1				
28. 8.83	"	"	68					
20.10.83	Adjarala	"	21					
	Landa Mono	(upper Mono)						
2. 9.83			33					
	Ngambéto	"						
25. 8.83			44			1		
21.10.83			58					
22.10.83			24					
	Kpessi	"						
4. 7.83			39					
25. 8.83			22					
27. 8.83			42	2				
	Segbohé							
16. 9.83			68				3	3

Date	Site	(river)	da	si	sq	so	sa	so/sa
	Amou Oblo	(Amou)						
8. 8.83					38			
28. 8.83					30			
6. 9.83					7			
17. 9.83					1			
	Amou Glei	(Amou)						
28. 8.83			18		43			
1. 9.83			6		17			
	Akaba	(Anie)						
16. 8.83			19		9			
	Blitta	(Anie)						
17. 8.83			22		35			
25. 8.83			14		38			
	Yeloum	(Anie)						
24. 8.83			38		7			
	Pagala	(Anie)						
25. 8.83					23			
7. 9.83					33			
	Blitta	(Anie)						
7. 9.83					19			
	Alamassou	(Anie)						
16. 9.83			1					
	Konigbo	(Anie)						
21. 9.83			22					
30. 9.83			30		2			
5.10.83			16					
13.10.83			31					
	Aou Losso	(Aou)						
19. 8.83					51			
25. 8.83					82			
2. 9.83			1		36			
23. 9.83			2		67			
	Kolowaré	(Kolowaré)						
6. 9.83			3		20			
23. 9.83					14			

Date	Site	(river)	da	si	sq	so	sa	so/sa
	Tchalou	(Na)						
27. 8.83					58			
	Goubi	(Ogou)						
23. 9.83			1		2			
	Kati	(Sio)						
8. 8.83			3		11			
28. 8.83			15		60			
	Ezimé	(Oulé)						
8. 8.83					1			
	Brouffou	(Gban Hou)						
6. 9.83					17			
	Ayagba	(Gban Hou)						
6. 9.83					23			
20. 9.83					67			1
11.10.83					17			
	Bétérou	(Ouémé)						
25. 8.83			41	4				
	M'bétékoukou	(")						
9. 8.83			11					
21. 8.83			75				1	1
22. 8.83			49				3	
24. 8.83			119	1			6	3
1. 9.83			21				5	2
	Aguigadji	(Ouémé)						
23. 8.83			40			2	2	
	Bassa	(Okpara)						
25. 8.83			58	6				

Tab. 4: **VARIATION IN THE SPECIES COMPOSITION OF THE LARVAL POPULATION AT DJODJI AND TETETOU FROM 1979 - 1983**

Cytotaxonomic identification of larvae by cytotaxonomists of the programme (reports 1980 - 1983)

D J O D J I

YEAR	SEASON	NUMBER OF LARVAE EXAMINED	IDENTIFICATION OF LARVAE (%) da	si	sq	so	sa	so/sa
1979	RAINY SEASON	76	0	0	21	0	79	0
	DRY SEASON	0	-	-	-	-	-	-
1980	RAINY SEASON	25	0	0	24	16	60	0
	DRY SEASON	20	25	0	60	0	15	0
1981	RAINY SEASON	90	0	0	20	12	68	0
	DRY SEASON	234	21	0.4	74	1	2	0.4
1982	RAINY SEASON	128	0	0	98	2	0	0
	DRY SEASON	21	0	0	76	24	0	0
1983	RAINY SEASON	259	0	0	28	1	58	13

T E T E T O U

YEAR	SEASON	EXAMINED	da	si	sq	so	sa	so/sa
1980	RAINY SEASON	89	29	0	0	69	0	2
	DRY SEASON	0	-	-	-	-	-	-
1981	RAINY SEASON	37	62	0	3	19	3	14
	DRY SEASON	343	6	0	0.3	26	0.3	68
1982	RAINY SEASON	138	7	0	0	17	0	76
	DRY SEASON	114	5	0	0	25	0	69
1983	RAINY SEASON	353	99	1	0	0	0	0

RAINY SEASON: May to October, DRY SEASON: November to April vae were already identified at Tétêtou, when no such larvae were found in samples from Djodji.

S. damnosum s.s. which was present in all samples of the dry-seasons in previous years, was not found in one (small) sample collected in March 1983.

S. squamosum was always found at Djodji during dry- and rainy seasons, and it became the predominant species after the experimental treatments in 1981. Only in this year, the former population of S. sanctipauli came back to its original size.

At Tétêtou, S. damnosum s.s. had always been present during the rainy season at a proportion of 7-62 % and, during the dry season, at 5-6 %. The rest of the population was mainly S. soubrense, S. soubrense/sanctipauli and (few) S. sanctipauli (interbreeding 'Beffa form'). S. sirbanum and S. squamosum were only found very occasionally. However, during the rainy season 1983, no larvae of S. soubrense, S. soubrense/sanctipauli and S. sanctipauli were observed. Coincidentaly, the biting rates were at the lowest level ever recorded at this site, and mermithid-infections were found frequently in both larvae and adults of S. damnosum s.s..

3.4. Comparison of the biting rates during the rainy- and dry-seasons 1979 to 1983: Trend of decreasing biting rates

The biting rates at most of the catching sites inside as well as outside the programme area in Togo and Benin decreased over the past years. Tables 5 and 6 give, for rainy and dry seasons seperately, the estimate values of the total biting rates. Within the OCP area, the biting rate during the rainy season 1983 was at its lowest level at Landa Pozanda for all years without insecticide applications outside the programme area and it was rather low at Mô â Mô and Gbassê.

The most important reductions were seen at Têtêtou, Kaboua and Bêtêrou outside the OCP boundary, where the biting rate during the rainy season 1983 was only at about 1/4 of its original level in 1979, when regular fly-catching started.

There is still no simple explanation for the decline of the fly-populations in this region, and it can therefore not be predicted, whether this trend will continue in future or not.

The experimental treatments of the source areas of reinvasion in Togo during June to August 1980 and 1981 (CHEKE & GARMS 1983), as well as the effects of the B.t. H14 insecticide trials carried out by Dr. Cheke in south-Togo during October to December 1981 and the activities of the insecticide-screening team in Lomé (field trials since 1982) might have contributed to the phenomenon of decreasing biting rates in Togo, too, although the quantitative influence of these treatments on the total ABR is difficult to assess and might not have been very important at most of the sites, exept during the years 1980 and 1981.

Tab. 5: Total S. damnosum s.l. biting rates during the rainy seasons 1976 - 1983

(May to September only)

	1976	1977	1978	1979	1980	1981	1982	1983
Landa Pozanda***	17.529+	3.379	3.119	4.194	3.270	1.629	9.985++	1.215
Mô à Mô***	22.638+*	28.080	27.823	24.465	17.077	9.775	14.503	18.487
Gbassé***	-	40.669	49.968	30.062	34.997	17.381	10.595	23.922§
Fazao	-	-	-	30.115	14.416+++	4.992+++	10.747	33.725
Landa Mono	-	-	33.752	31.316	25.977+++	3.510+++	16.179	15.174
Bétérou	-	-	19.333	25.662	38.704	16.678	12.691	4.616
Goubi	-	-	(12.938)**	-	-	-	2.972	8.494
Djodji	-	-	-	108.550	81.888	27.455+++	13.703	75.677
Kaboua	-	-	-	88.141	69.426	32.484	16.781	21.275
Têtêtou	-	-	42.246	59.433	73.998	110.949	27.870	13.106

+: no control

++ : no control in August

§: no control during May and June 1983

+++: experimental treatments

* : without May 1976 (approx. 1.500 flies

** : August and September 1978 only !

***: in controlled area

Tab. 6: Total *S. damnosum* s.l. biting rates during the dry seasons 1976 - 1983

(November to April)

	1976-77	1977-78	1978-79	1979-80	1980-81	1981-82 §	1982-83
Landa Pozandā***	10.839+	9.701**	2.191	1.799	1.586	231	580
Mō ā Mō***	9.525+	14.178	3.035	1.698	2.072	854	2.331
Gbassē***	21.943+	35.213	19.249	11.343	4.166	2.938	4.093
Fazao	-	-	397	2.209	789	508	267
Landa Mono	-	-	14.982	6.616	5.305	1.410	2.100
Bētērou	-	4.427	4.450	5.020	3.148	892	2.072
Goubi	-	-	2.030	-	-	-	-
Djodji	-	-	103.374	85.052	121.673	25.873	40.878
Kaboua	-	-	34.837	20.489	16.476	9.856	8.943
Tētētou	-	-	33.288	20.037	38.281	18.000	13.935

+ : no control

** : without February 1978

*** : in controlled area

§: some localized applications of B.t.H 14 insecticide during October to December 1981 in the rivers Anie, Mono, Aou, Bouvelēm, Tērou (CHEKE, pers. comm.)

3.5. Results from the identification and dissection of the flies

3.5.1. The occurrence of different members of the S. damnosum s.l. complex in Togo and Benin

During the studies in 1983, a total number of 1341 flies from various catching sites were examined and were classed into one of the three categories S. damnosum s.s./S. sirbanum, S. squamosum and S. soubrense/ S. sanctipauli. Together with the results from the identification of flies in 1982 (RENZ 1983), these data were used to calculate an estimate proportion of each vector group in the total biting rate, per rainy season and per year, for different catching sites in various regions of Togo and Benin (Table 7 and Fig. 6). The values for the biting rates per year and per rainy season were taken from the OCP microfiches data for those years, when no insecticide applications were done outside the programme area (1978/1979, 1981/1982, 1982/1983). An average biting rate per year is calculated, together with the proportion of the total biting rate during the rainy season. The relative proportion of the three vector groups was taken from the results of the identification of flies in 1982 and 1983 and was weighted by the corresponding biting rate during these years to obtain an average proportion of each vector at every site (Fig. 6).

Most of all flies came to bite during the rainy season (May to September), and only 4 to 40 % of all flies came to bite during the dry season (November to April). S. soubrense/S. sanctipauli flies were dominant at Djodji, Têtêtou and Kaboua, S. squamosum was the predominant species at Mô â Mô and Fazao, and S. damnosum s.s./S. sirbanum at Gbassê. Not enough flies were identified for the population at Landa Mono.

These estimates represent only very crude values, since they were based on a very limited number of flies identified during a few months in two years (July to October 1982 and August to September 1983). More data should be used for these calculations, especially for the remaining months of the year. When more data would be included, a similar calculation could be made for the amount of transmission by the different vectors at the various sites.

Tab. 7

Annual Biting Rates (ABR) and composition of vector populations at some of the OCP catching sites inside aund outside the programme area in Togo and Benin.

Site	Estimate Annual Biting Rate+ (Nov.-Oct.) 1978/79	1981/82§	1982/83++	average ABR	% of ABR in RS+++	species composition (%) during RS++++ 1982 da/si	sq	so/sa	1983 da/si	sq	so/sa
Landa Pozanda	9.082	12.293	1.882	7.752	87	61	35	4	20	80	0
Mô à Mô	32.274	17.630	22.273	24.059	91	-	-	-	3	96	0.2
Gbassé	58.549	23.662	29.821	37.344	77	-	-	-	+++	/	/
Fazao	36.278	12.622	37.052	28.651	96	-	-	-	4	96	0
Landa Mono	52.343	22.208	19.521	31.357	80	-	-	-	/	/	/
Bétérou	40.435	15.877	16.086	24.133	90	44	40	16	82	14	5
Djodji	237.964	43.885	138.245	140.031	60	4	78	18	0	6	94
Kaboua	146.197	34.263	40.478	73.646	76	11	13	76	23	1	76
Tététou	102.920	54.984	27.650	61.851	65	2	2	96	94	6	0

+: no insecticide applications at Simulium breeding sites outside the programme areas

++: no data for the biting rate in October 1983. The ABR is the sum of 10 months + 2×September

+++: RS = rainy season, May to October

++++: the identifications were carried out during August, September and October

da/si : *S. damnosum s.s./S. sirbanum*; sq : *S. squamosum*; so/sa : *S. soubrense/S. sanctipauli*

§: some localized applications of B.t.H 14 insecticide during October to December 1981 in the rivers Anie, Mono, Aou, Bouvelêm, Térou (CHEKE, pers. comm.)

Fig. 6

THE COMPOSITION OF FLY-POPULATIONS DURING THE RAINY-SEASON

PLACE	$\overline{ABR}$	RAINY-SEASON
A: Mô à Mô	24.ooo	(91%)
B: Landa Poz.	7.7oo	(87%)
D: Fazao	28.6oo	(96%)
E: Landa Mono	31.3oo	(80%)
G: Kaboua	73.6oo	(76%)
H: Gbassê	37.3oo	(77%)
M: Djodji	140.ooo	(60%)
N: Têtêtou	61.8oo	(65%)

3.5.2 Comparison of the results from the dissection of fresh or alcohol-fixed and stained flies

A total number of 9,182 flies were separated into nulliparous and parous flies during the studies in 1983, and 1341 of these flies were classed into the three vector groups and were dissected for the detection of filarial infections. All dissections in 1983 were done with alcohol-fixed and haemalaun-stained flies. Since the staining of the flies renders the filarial larvae very distinctly visible in the muscles of the thorax, one might suspect, that this new method provides an higher detection rate of infected flies and infective larvae, if compared to the usual dissection of fresh unstained flies. The results from the dissection of fresh flies in 1982 were therefore compared to the results of 1983 (Table 8), for each vector group seperately.

The infection rate (proportion of parous flies infected) was slightly increased for stained flies of the group S. damnosum s.s./ S. sirbanum and for S. soubrense/S. sanctipauli, but was lower for S. squamosum. No difference was found for the proportion of parous infective flies by using the different methods and the average number of filarial larvae per infected or infective fly was only slightly, but statistically insignificant, increased by the staining. The higher proportion of infected flies in the S. soubrense/S. sanctipauli group in 1983 might be partially explained by an higher proportion of flies from the heavily infected site Djodji in this year (cf. Table 9).

One might therefore conclude from these results, that the dissection of alcohol-fixed and stained flies provides about the same results as the dissection of fresh flies, and that the results obtained by the two different methods can be compared without restrictions. In the following, the results of all dissections will be combined in order to have enough data for the comparison of the vectorial efficiency of the different vectors.

Tab. 8:

COMPARISON OF TWO METHODS FOR THE DISSECTION OF FLIES : IN 1982, INFECTION OF THE FLIES WAS DETECTED BY DISSECTION OF FRESH FLIES, WHILST IN 1983, FLIES WERE FIXED AND STAINED

(Data from the dissection of flies from Djodji, Tététou, Landa Pozanda, Bétérou and Kaboua only)

	examined	parous	infected L_1,L_2,L_3	(% of parous)	larvae per infected fly	infective L_3total	(% of parous)	larvae per infective fly
S I M U L I U M D A M N O S U M s.s / S. S I R B A N U M								
1982	691	250	55	(22.0)	2.1	15	(6.0)	1.4
1983	300	152	38	(25.0)	2.4	8	(5.3)	2.5
S I M U L I U M S Q U A M O S U M								
1982	869	293	47	(16.0)	2.3	15	(5.1)	1.4
1983	84	59	9	(15.3)	2.7	3	(5.1)	1.7
S I M U L I U M S O U B R E N S E / S. S A N C T I P A U L I								
1982	1108	481	119	(24.7)	5.3	19	(4.0)	8.2
1983	400	166	55	(33.1)	6.4	9	(5.4)	3.6

3.5.3. Parous and infection rates of various fly-populations

In total, 4,003 flies (1,043 S. damnosum s.s./S. sirbanum, 1,412 S. squamosum, 1,548 S. soubrense/S. sanctipauli) were identified and dissected during the studies in 1982 and 1983. Parous and infection rates are given, for each vector group separately, for the flies from Landa Pozanda, Djodji, Têtêtou, Bêtêrou, Kaboua, Mô â Mô, Fazao and Alamassou in Table 9 , together with an estimate number of infective larvae per 1000 biting flies (QUILLEVERE 1979).

The parous rate of the flies varied significantly from one site to another, mainly due to a varying proportion of old reinvading flies. This explains the high parous rates observed for S. squamosum at Landa Pozanda and Mô â Mô (76 and 71 %), which is in contrast to the low parous rate of the same vector at Djodji (16 %). The very high parous rate at Alamassou is certainly not representative for the age structure of the fly-populations there, but is rather due to the fact, that only few flies were dissected when the fly-population was on decline.

The proportion of infected and infective parous flies varied largely from one site to another and for the different vectors, although the number of flies examined was not sufficient in most cases to render these differences statisticaly significant. This is particularly true for the proportion of infective parous flies. In general, infection rates were high for S. damnosum s.s./S. sirbanum (20.1 % of parous) and S. soubrense/S. sanctipauli (23.5 %), regardless of the situation of the catching site. Flies from Djodji and from Têtêtou showed the highest infection rates, which were higher than those observed at Bêtêrou and Kaboua, probably due to an increased proportion of blood-meals on microfilarial-positive persons at these sites. The situation at Alamassou gives an exemple for the degree of infection that can be reached in an highly anthropophilic fly-population. Infection rates were lowest for S. squamosum (7.8 % of all parous flies) and very few infected flies of this species were found at Djodji and Mô â Mô. The situation at Mô â Mô will be discussed in detail in the next paragraph. Higher infection rates of this vector

Tab. 9 : PAROUS AND INFECTION RATES OF FLIES: (COMBINED RESULTS FROM DISSECTIONS IN 1982 & 1983)

Dissections during August to October 1982 and July to September 1983

S. DAMNOSUM S.S./S. SIRBANUM

	Parameter	Landa Pozanda	Djodji	Têtêtou	Bétérou	Kaboua	Mô à Mô	Fazao	Alamassou	Σ all sites
Number of flies -										
dissected	a	347	17	149	373	105	14	2	36	1043
parous..............	b	149	0	70	133	50	10	2	23	437
infected (L_1,L_2,L_3)...	d+e-f	41	0	20	24	8	2	0	16	111
with developing stages	d	34	0	13	20	8	1	0	12	88
with infective stages[++]	e	12	0	7	5	0	1	0	8	33
double infections.....	f	5	0	0	1	0	0	0	4	10
Arithmetic mean number of larvae per -										
infected fly (L_1,L_2)..	g	2.00	-	2.07	2.00	3.00	2.00	-	1.75	2.07
infective fly (L_3)....	h	1.58	-	2.57	1.40	-	3.00	-	1.80	1.85
Proportion of flies (%) -										
parous..............	100b/a	42.9	0	47.0	35.7	47.6	71.4	100	63.9	41.9
infected (L_1,L_2)......	100d/b	22.8	-	18.6	15.0	16.0	10.0	-	52.2	20.1
(95% conf. limits)[+]...		(16-31)	-	(11-30)	(10-22)	(8-30)	(0-27)	-	(31-73)	
infective (L_3)........	100e/b	8.1	-	10.0	3.8	0	10.0	-	23.0	7.6
(95% conf. limits)[+]...		(4-14)	-	(5-20)	(1-9)	(0-7)	(0-27)	-	(18-56)	
Transmission potential per 1000 biting flies...........	1000eh/a	55	-	121	19	0	-	-	-	58

S. SQUAMOSUM

	Parameter	Landa Pozanda	Djodji	Têtêtou	Bétérou	Kaboua	Mô à Mô	Fazao	Alamassou	Σ all sites
Number of flies -										
dissected	a	235	362	23	268	65	403	47	9	1412
parous..............	b	178	56	12	80	26	284	47	8	691
infected (L_1,L_2,L_3)...	d+e-f	37	1	3	10	5	11	4	3	74
with developing stages	d	27	1	2	8	3	9	3	1	54
with infective stages[++]	e	12	0	2	2	2	2	1	2	23
double infections.....	f	2	0	1	0	0	0	0	0	3
Arithmetic mean number of larvae per -										
infected fly (L_1,L_2)..	g	1.89	4.00	5.00	1.75	6.33	1.67	1.50	2.00	2.19
infective fly (L_3)....	h	1.55	-	2.00	1.00	1.00	4.00	-	3.00	1.91
Proportion of flies (%) -										
parous..............	100b/a	75.7	15.5	52.2	29.9	40.0	70.5	100	88.9	48.9
infected (L_1,L_2)......	100d/b	15.2	1.8	16.7	10.0	11.5	3.2	6.4	12.5	7.8
(95% conf. limits)[+]...		(10-22)	(0-9)	(4-45)	(5-19)	(3-31)	(2-6)	(2-19)	(1-48)	
infective (L_3)........	100e/b	6.7	0	16.7	2.5	7.7	0.7	2.1	25.0	3.3
(95% conf. limits)[+]...		(4-12)	(0-6)	(4-45)	(0-10)	(0-30)	(0-3)	(0-14)	(2-71)	
Transmission potential per 1000 biting flies...........	1000eh/a	81	0	-	8	31	20	64	-	29

S. SOUBRENSE/SANCTIPAULI

	Parameter	Landa Pozanda	Djodji	Têtêtou	Bétérou	Kaboua	Mô à Mô	Fazao	Alamassou	Σ all sites
Number of flies -										
dissected	a	19	312	528	105	544	1	0	39	1548
parous..............	b	9	103	255	36	244	1	0	32	680
infected (L_1,L_2,L_3)...	d+e-f	4	51	72	2	46	0	0	10	185
with developing stages	d	4	43	61	1	42	0	0	9	160
with infective stages[++]	e	0	11	12	1	4	0	0	1	29
double infections.....	f	0	3	1	0	0	0	0	0	4
Arithmetic mean number of larvae per -										
infected fly (L_1,L_2)..	g	5.25	5.14	4.39	8.00	5.90	-	-	13.4	5.54
infective fly (L_3)....	h	-	5.00	8.75	1.00	6.75	-	-	3.00	6.59
Proportion of flies (%) -										
parous..............	100b/a	47.4	33.0	48.3	34.3	44.9	-	-	82.1	43.9
infected (L_1,L_2)......	100d/b	44.4	41.7	23.9	2.8	17.2	-	-	28.1	23.5
(95% conf. limits)[+]...		(20-72)	(32-52)	(19-30)	(0-13)	(13-23)	-	-	(14-47)	
infective (L_3)........	100e/b	0	10.7	4.7	2.8	1.6	-	-	3.1	4.3
(95% conf. limits)[+]...		-	(6-19)	(3-8)	(0-13)	(1-4)	-	-	(0-15)	
Transmission potential per 1000 biting flies...........	1000eh/a	0	176	199	11	50	-	-	77	123

[+]: 95% confidence limits of the proportion of parous infected and infective flies

[++]: infective larvae, infective flies: all fully developed third stage larvae, irrespective to their location in head or thorax or abdomen of the flies at other sites might be partially explained by the difficulty of separating these flies from S. damnosum s.s./S. sirbanum (at Landa Pozanda) and from S. soubrense/S. sanctipauli (at Kaboua and Tētētou).

The proportion of infective parous flies was highest for S. damnosum s.s./S. sirbanum (over-all 7.6 %), followed by S. soubrense/S. sanctipauli (4.3 %) and was lowest for S. squamosum (3.3 %).

The arithmetic mean number of filarial larvae, indistinguishable from O. volvulus, per infected and infective fly was about similar for S. squamosum and S. damnosum s.s./S. sirbanum (2.07 versus 2.19 developing stages per infected fly and 1.85 versus 1.91 infective larvae per infective fly), but was three times higher for S. soubrense/S. sanctipauli (5.54 developing stages and 6.59 infective larvae).

An indication for the vectorial efficiency of different fly-populations is given by the estimate number of infective larvae per 1000 biting flies. This index is highest for S. soubrense/S. sanctipauli (123 larvae), followed by S. damnosum s.s./S. sirbanum (58 larvae) and is lowest for S. squamosum (29 larvae).

Intraspecific variations of the vectorial efficiency of the same vector in different bioclimatic zones are difficult to detect, due to an unsufficient number of flies dissected at most sites. Nevertheless, it clearly results from the data given in Table 9 , that S. damnosum s.s./S. sirbanum is an equally good vector of onchocerciasis in the savanna and in the southern areas of Togo and Benin and that the average number of filarial larvae per infected or infective fly in the south is similar or even higher than that observed in the savanna. S. squamosum showed the lowest rate of infected and infective flies. This can probably be explained by a reduced susceptability of these flies to infections by O. volvulus (RENZ 1983, BARBIERO 1983). S. soubrense/S. sanctipauli showed the highest vectorial efficiency in the southern areas at Tētētou, Djodji and, at a reduced rate, at Kaboua. However, few infective flies of this group were caught in the northern areas of its distribution, although many flies were found infected.

3.5.4. Variations in the infection rate of parous flies from Mô à Mô 1982 and 1983

The infection rate of parous flies at Mô à Mô was extremely low during our studies in end of July, August and September. On an average, less than 4 % of all parous flies were infected and less than 1 % were infective (Table 9). Almost all flies were identified as S. squamosum, whereas 2 out of 10 flies, identified as S. damnosum s.s./S. sirbanum were found infected. This phenomenon could be interpreted either by a low susceptability of S. squamosum to infections by O. volvulus, or by the fact, that these flies did not have the chance to feed on an infected human population in these sparsely populated areas.

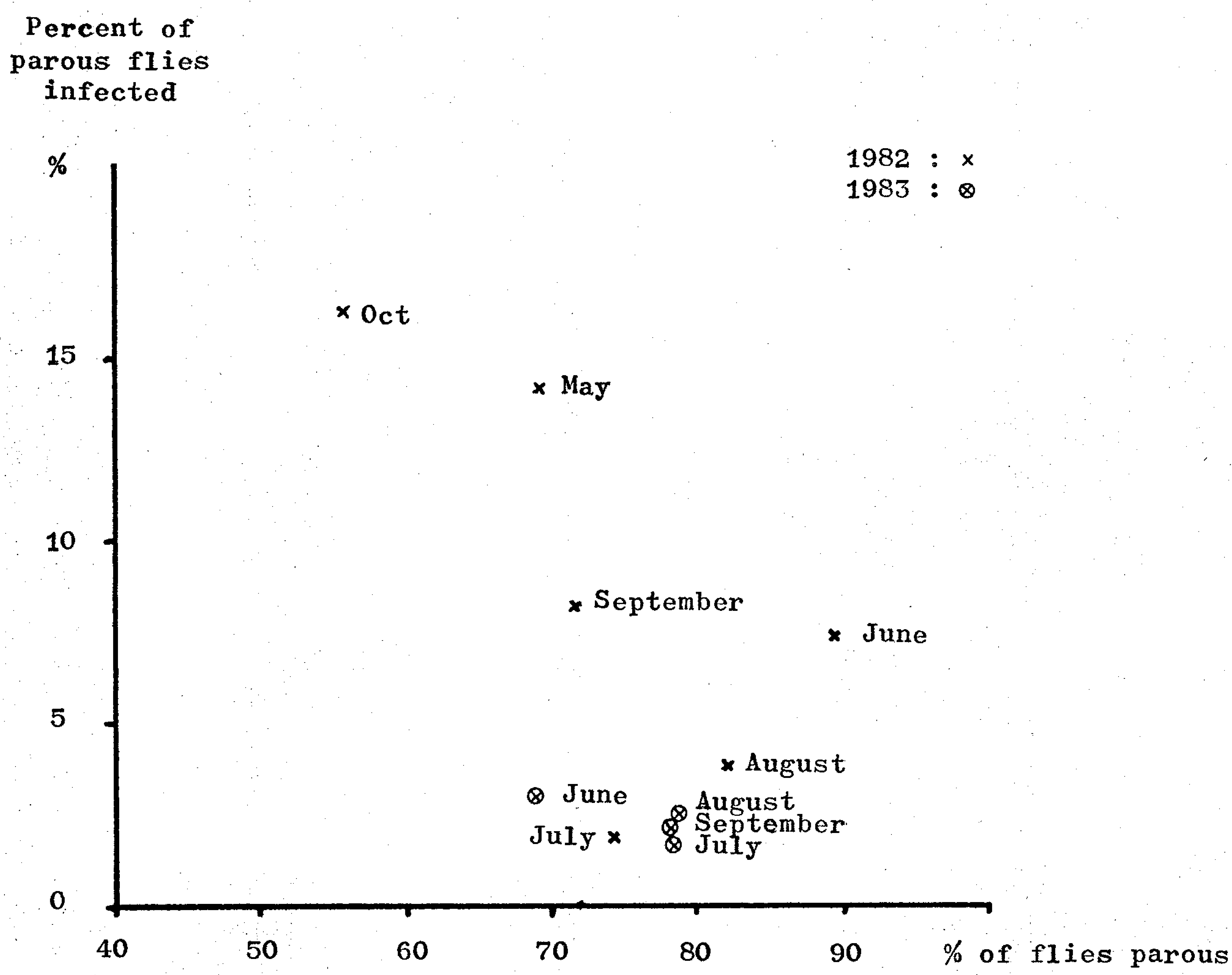
A comparison of the infection rates at Mô à Mô during different months of the years 1982 and 1983 (Table 10) shows, that the infection rate was rather high (14 - 16 %) at the beginning and at the end of the rainy season 1982, whereas the rates in July and August were similar to ours (2 - 4 %). Infection rates were high, when the parous rate was low (Fig. 7). This is in contrast to the usual observation, that infection rates do increase with increasing parous rate of a population. From the data of GARMS et al. (1981), it can be concluded, that the proportion of S. damnosum s.s./S. sirbanum in the population at Mô à Mô was about 70 % at the beginning of the rainy season in May, decreased steadily until mid-June and was low in July (CHEKE & GARMS 1983). It appears therefore, that S. squamosum has a lower ability to transmit the disease in this area, if compared to S. damnosum s.s./S. sirbanum.

Tab. 10: COMPARISON OF THE PAROUS AND INFECTION RATES OF FLIES FROM MO A MO IN 1982 AND 1983

(All dissections by the Sector-staff in Kara, Mr Adjonou)

Month	dissected	parous	(% parous)	infected	(% parous infected)	infective	(% parous infective)
RAINY SEASON 1982							
May	520	363	(69.8)	52	(14.3)	22	(6.1)
June	586	524	(89.4)	39	(7.4)	20	(3.8)
July	620	462	(74.5)	9	(1.9)	1	(0.2)
August	607	499	(82.2)	19	(3.8)	6	(1.2)
September	538	387	(71.9)	32	(8.3)	11	(2.8)
October	489	274	(56.0)	45	(16.4)	19	(6.9)
RAINY SEASON 1983							
May	4	3	(75.0)	0	-	0	-
June	369	255	(69.1)	8	(3.1)	6	(2.4)
July	602	473	(78.6)	8	(1.7)	4	(0.8)
August	757	598	(79.0)	15	(2.5)	5	(0.8)
September	352	277	(78.7)	6	(2.2)	1	(0.4)

Fig. 7: CORRELATION BETWEEN PAROUS AND INFECTION RATES AT MO A MO DURING THE RAINY SEASONS 1982 - 1983



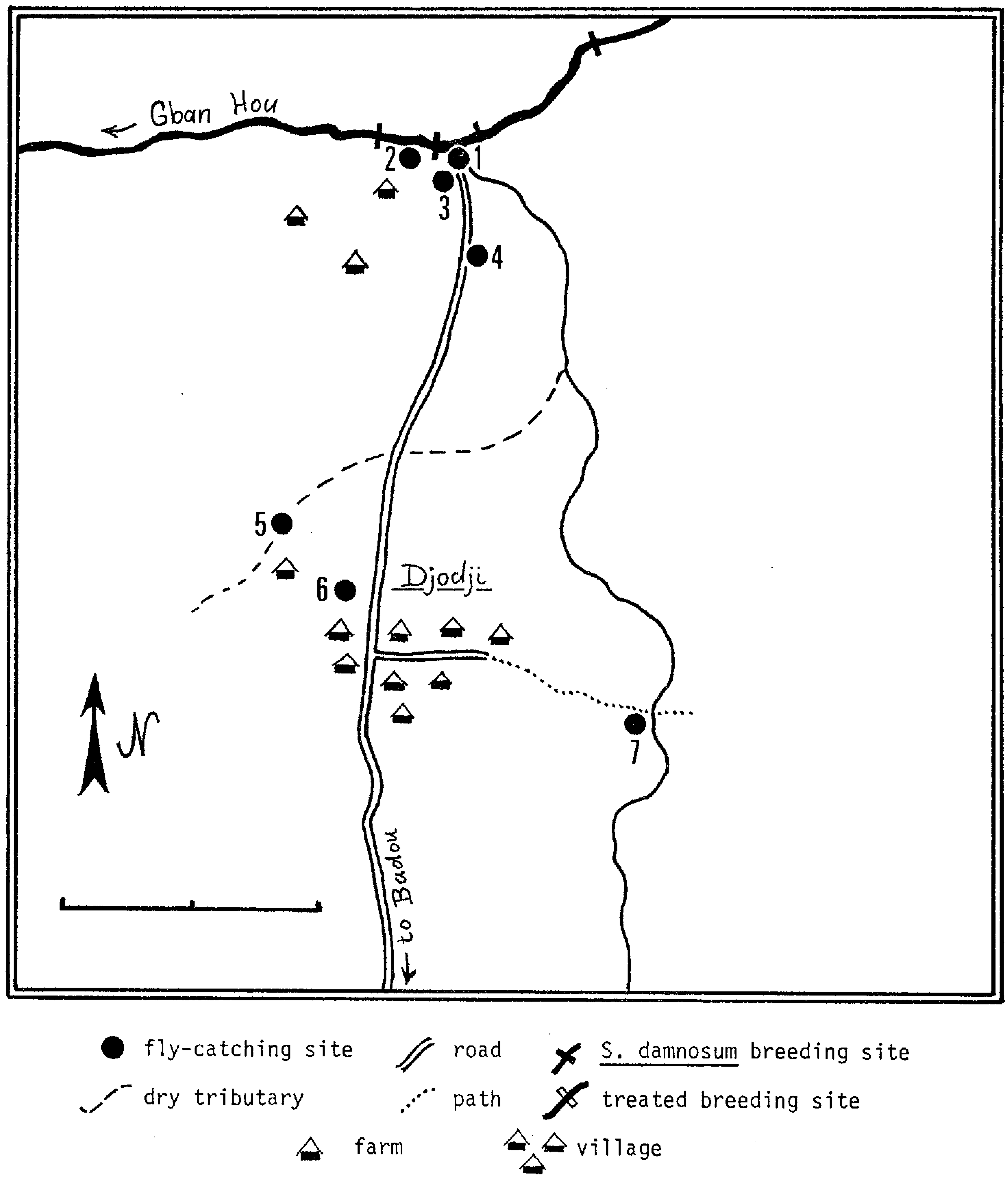
3.6. The dispersal of fly-populations away from the river in different bioclimatic zones

Studies on the dispersal were carried out at Mô â Mô (13./14. 8. 1983), Djodji (6./7. and 15./16. 8. 1983) and at Alamassou (16./17. 9. 1983). The location of the fly-catching sites and the numbers of flies caught are presented, together with the estimate proportion of parous flies at each site, in Figures 8 to 10.
At Mô â Mô, the number of flies caught decreased rapidly with increasing distance from the river. Only 6 % of the biting rate at the river was recorded near a small hamlet at 1,500 m from the river, and this proportion even fall to 4 %, if only parous flies were considered. Most of all flies came to bite very closely to the river.

At Djodji, the biting rates decreased much less with increasing distance from the river and as many as 55 % of the biting rate at the river was measured at a distance of 1,700 m near the primary school of Djodji. The proportion of parous flies at the village (25 - 28 %) was not much lower than that observed at the river (30 - 34 %). Catching sites near one dry (5) and one running tributary (7) gave the lowest biting rates (17 and 15 % of the river's rate).

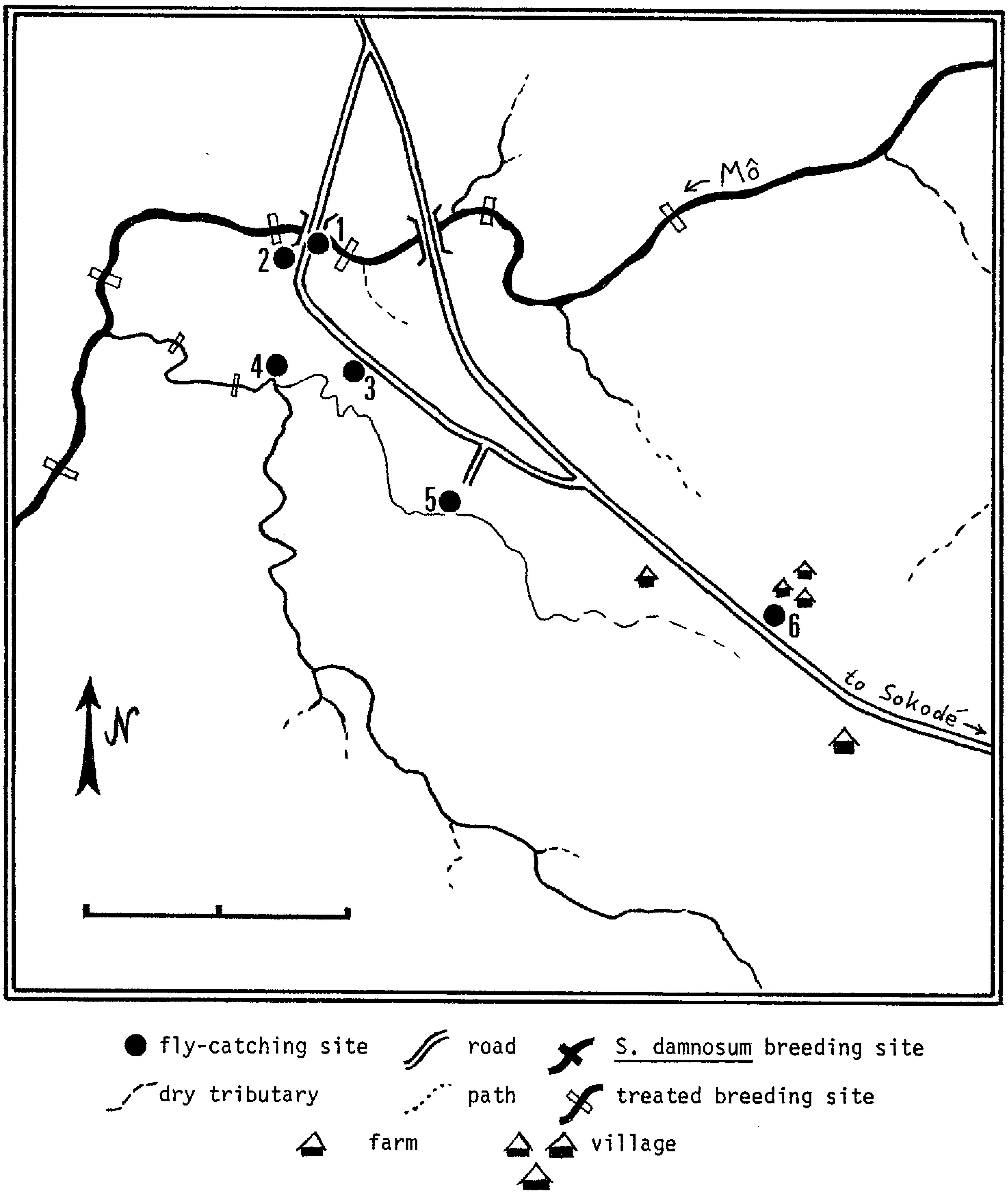
The results from the experiments at Alamassou are rather difficult to interprete: Whilst the biting rate decreased quickly along the path to the village, and only 36 % of the river's biting rate was measured inside the village at a distance of 300 m from the river (25 % of the parous biting rate), a very high biting rate was recorded at a dry tributary about 1000 m from the Anie (7). The following day, a catching team was placed at the river bank (2), near to some rapids which seemed to provide suitable breeding sites. However, only few flies were caught and, when larvae were searched in these rapids, only one single S. damnosum s.s. could be found. It might therefore be concluded, that most of the flies around Alamassou did not originate from breeding sites in the Anie river, but came from the nearby Mono which flows about 5 to 10 km north-east of Alamassou. When these breeding sites in the Mono were visited,

Fig. 8 : Dispersal of Fly-Populations at Djodji



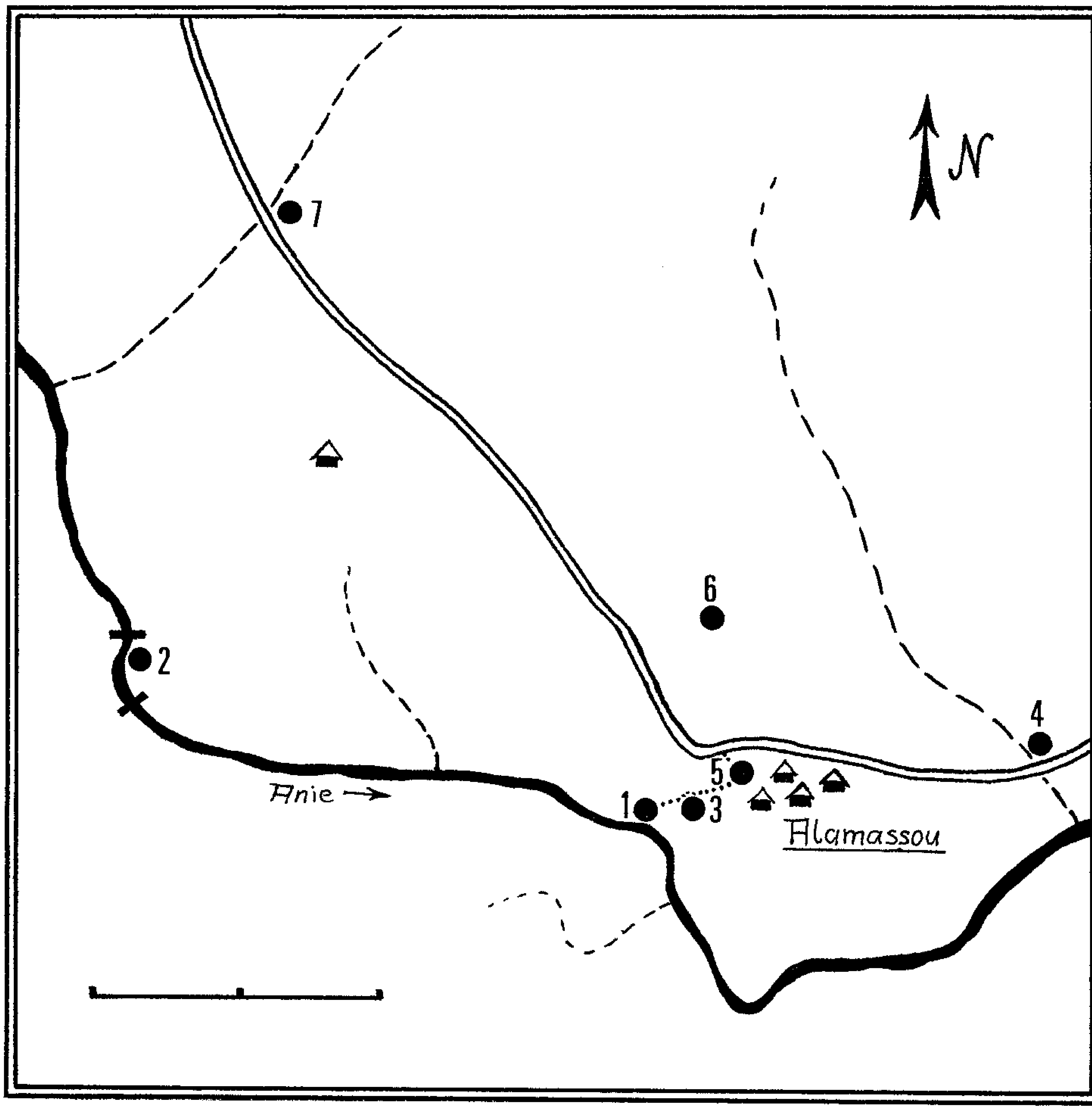
Distance from river		Catching site	Flies per man per day (% parous) 6.8.83	7.8.83	15.8.83	16.8.83	Percentage of biting rate at the river: total flies	parous only
5 m	(1)	Gban Hou ford	445 (30%)	396 (30%)	614 (30%)	510 (55%)	100 %	100 %
10 m	(2)	150 m downstream	486 (34%)	-	-	-	109 %	131 %
100 m	(3)	at the road	405 (23%)	234 (18%)	-	-	76 %	54 %
375 m	(4)	at the road	307 (14%)	147 (18%)	-	-	54 %	28 %
1500 m	(5)	waterhole	-	67 (25%)	-	-	17 %	14 %
1700 m	(6)	Djodji village	327 (25%)	136 (28%)	-	-	55 %	48 %
2300 m	(7)	tributary	-	-	123 (26%)	43 (23%)	15 %	12 %

Fig. 9 : Dispersal of Fly-Populations at Mô à Mô



Distance from river		Catching site	Flies per man per day (% parous) 13.8.83	14.8.83	Percentage of biting rate at the river: total flies	parous flies
5 m	(1)	under Mô bridge	647 (82%)	221 (81%)	100 %	100 %
100 m	(2)	near the road	82 (78%)	130 (80%)	24 %	24 %
400 m	(3)	near the road	139 (78%)	87 (83%)	26 %	25 %
600 m	(4)	tributary Bouzano	-	63 (65%)	29 %	23 %
900 m	(5)	small tributary	84 (75%)	-	13 %	12 %
1500 m	(6)	Mô hamlet	31 (68%)	19 (58%)	6 %	4 %

Fig. 1o : Dispersal of Fly-Populations at Alamassou



● fly-catching site — road — S. damnosum breeding site

dry tributary — path — treated breeding site

farm — village

Distance from river		Catching site	Flies per man per day (%parous) 16.9.83	17.9.83	Percentage of biting rate at the river: total flies	parous only
5 m	(1)	Aniê at Alamassou	158 (56%)	123 (62%)	100 %	100 %
10 m	(2)	rapids 2 km upstream	-	29 (21%)	24 %	8 %
100 m	(3)	path to village	64 (55%)	5 (80%)	25 %	24 %
200 m	(4)	dry tributary	113 (45%)	-	72 %	57 %
300 m	(5)	Alamassou village	78 (44%)	23 (30%)	36 %	25 %
700 m	(6)	village fields	-	15 (73%)	12 %	14 %
1000 m	(7)	dry tributary	183 (45%)	-	116 %	93 %

68 larvae of S. damnosum s.s., 3 S. sanctipauli and 3 S. soubrense/ sanctipauli were found.

Flies coming from the river Mono could either fly upstream the river Anie and would then come to bite at Alamassou or could come overland from the north-east and would then concentrate in the dense vegetation of the gallery forests along the rainy season tributaries.

3.7. The influence of mermithid-infections on the fly-populations at Bêtêrou and Têtêtou

A total number of 308 mermithid-infected flies were found at the dissection of 4,007 flies in 1982 and 1983. The vast majority of these flies were nulliparous and had atrophied ovaries, but a few parous flies were found infected too, and in one occasion, a developing stage of O. volvulus was found besides a (small) mermithid. These mermithid larvae resembled to Isomermis lairdi (MONDET et al. 1977). They were about 7 to 14 mm long and their average diameter was 0.1 mm. The total volume of these parasites (0.05 - 0.1 mm^3) corresponds to almost 10 % of the unfed fly's size (~ 1 mm^3).

Most of the infected flies came from Bêtêrou (219 infections) and from Têtêtou (67 infections). Apart from this localized distribution of mermithid infections, different infection rates were observed for the three groups of vectors: 185 infected flies were classed, according to their morphology, S. damnosum s.s./S. sirbanum, 119 S. squamosum and only 3 infections were recorded in S. soubrense/S. sanctipauli. This phenomenon was studied in detail at Bêtêrou and Têtêtou:

At Têtêtou, only 2 infected flies were found at the dissection of 551 flies in 1982 and both flies were classed S. damnosum s.s./S. sirbanum, although this species was very rare at this site in 1982 (2/9 ≙ 22 % infected for S. damnosum s.s./S. sirbanum, 0/14 ≙ 0 % for S. squamosum and 0/549 ≙ 0 % for S. soubrense/S. sanctipauli). In 1983, at the same site, only S. damnosum s.s./S. sirbanum flies were found and the infection rate was very high: 65 of 149 flies (≙ 43.6 %) carried mermithid infections (Table 11). At Bêtêrou, the corresponding infection rates were, in 1982,: 92/271 (≙ 34.0%) for S. damnosum s.s./S. sirbanum, 116/252 (≙ 46.0%) for S. squamosum and only 3/99 (≙ 3.0%) for S. soubrense/S. sanctipauli. In 1983, similar infection rates occurred: 21/102 (≙20.6%) for S. damnosum s.s./S. sirbanum, 2/17 (≙ 11.8 %) for S. squamosum and 0/6 (≙ 0%) for S. soubrense/S. sanctipauli.

It seems from these data, that S. soubrense/S. sanctipauli flies are much less parasitized than the two other vector groups - either due to a reduced susceptability of their larvae or to an increased mortality of infested larvae or adult flies.

Tab. 11: Mermithid infections of the fly-population at Tététou 1983 (May to September)

Date	DBR	Species	P	NP	%P	Mermithid infections			
						P	NP	%P	% NP
9.5.	3	da	3	0	100	0	0	0	-
17.5.	7	da	7	0	100	0	0	0	-
24.5.	6	da	4	2	67	0	0	0	0
31.5.	2	da	2	0	100	0	0	0	-
7.6.	8	da	8	0	100	0	0	0	-
14.6.	62	da	30	1	97	0	0	0	0
21.6.	78	da	24	15	62	0	0	0	0
28.6.	198	da	38	11	78	0	1	0	9
5.7.	121	da	33	7	83	3	5	9	71
12.7.	206	da	34	17	67	0	1	0	6
19.7.	122	da	16	24	40	2	7	13	29
19.7.+	"	da	38	36	51	1	21	3	58
26.7.	364	da	34	18	65	5	11	15	61
26.7.+	"	da	51	42	55	0	23	0	55
1.8.+	254	da	42	68	38	6	55	14	81
2.8.	287	da	25	34	42	8	24	32	71
8.8.+	190	da	45	65	41	0	45	0	69
9.8.	162	da	17	37	31	1	26	6	70
15.8.+	84	da	55	27	67	0	19	0	70
16.8.	123	da	22	18	55	0	12	0	67
22.8.+	62	da	29	31	48	1	16	3	52
23.8.	46	da	18	28	39	0	20	0	71
29.8.+	27	da	18	9	67	0	4	0	44
30.8.	21	da	14	7	67	0	6	0	86
5.9.+	15	da	6	9	40	0	5	0	56
6.9.	19	da	8	11	42	0	7	0	64
12.9.+	27	da	7	20	26	0	16	0	80
13.9.	20	da	5	15	25	0	13	0	87
19.9.+	23	da	12	11	52	0	4	0	36
20.9.	21	da+so/sa	13	8	62	0	3	0	38
26.9.+	22	da+so/sa	9	13	41	1	3	11	23
27.9.	15	da+so/sa	8	7	53	0	2	0	29

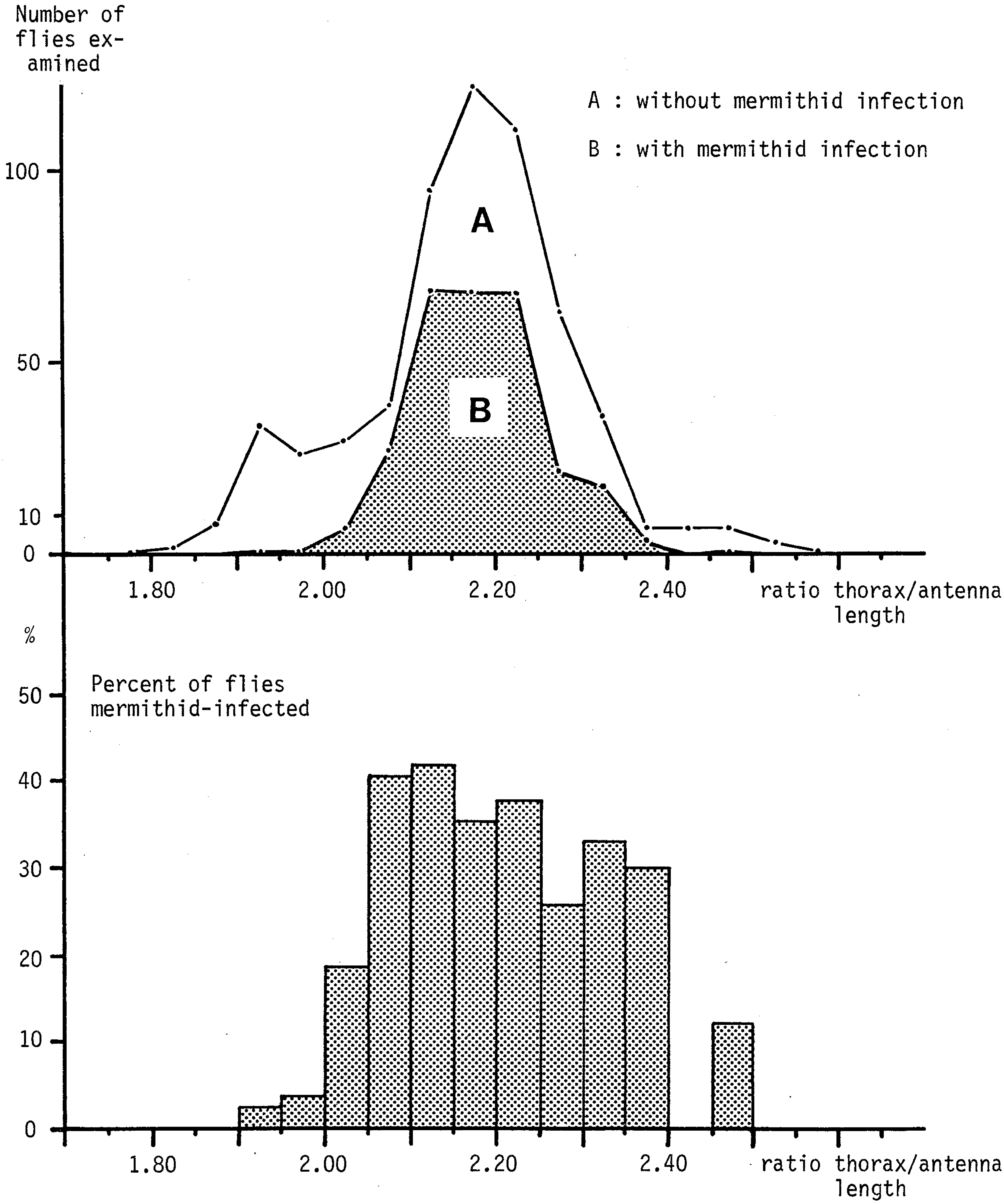
Results from the dissection of flies by the Sub-Sector team, Atakpamé

+: own dissections

DBR: Daily Biting Rate, number of flies caught
P : number of parous flies
NP : number of nulliparous flies

In order to examine the influence of the mermithid infection on the morphology of the infested flies, the ratios of the thorax/antenna length measurements were compared for uninfested and infested flies (Fig. 11). Mermithid infections were mainly found in flies with a ratio between 2.05 and 2.25 and only few infested flies had a ratio of more than 2.40. Hardly any flies with a ratio below 2.00 carried these parasites corresponding to the fact, that S. soubrense/S. sanctipauli were rarely infested. The decrease in the infection rate of flies with a ratio of over 2.15 might be explained by a reduction of the size of the thorax of infested flies by atrophy, whereas the length of the antenna is less influenced by parasitism: 46.5 % of all uninfested flies from Bétérou and Tététou had a thorax-length of more than 1020 µm, whereas only 24.2 % of the infested ones were found in this same group.

Fig. 11: MERMITHID INFECTED FLIES AT TETETOU AND BETEROU : FREQUENCY DISTRIBUTION OF THE RATIO THORAX/ANTENNA LENGTH OF UNINFECTED (A) AND INFECTED (B) FLIES



Tététou 1983: 64/133 flies infected (48%); S. damnosum s.s. exclusively
Bétérou 1982/1983: 221/743 flies infected (30%); mixed population

4. DISCUSSION

The reinvasion in 1983

The course of the reinvasion in Togo and Benin differed from the pattern of biting activities at the reinvasion sites observed during the preceding years (GARMS et al. 1981, 1983; RENZ 1983), presumably due to the long drought during the dry season and to the late on-set of rains this year. In view of the limited period, covered by this consultantship (end of July to September), a detailed description of the reinvasion and of the participation of different vectors in this phenomenon could only be given by combining these results with those of Dr Cheke's consultantship, which covers the period May to end of July, but which was not yet available to me until this data.

By the beginning of these studies in July, the biting rate was still unusually low at Landa Pozanda, but high biting rates, exceeding 300 flies/man/day were observed along the river Mô at Bagan and Mô â Mô. The majority of flies were S. squamosum and some of them probably came from untreated breeding sites in the nearby tributaries Loukoulou and Sako of the river Mô, or from breeding sites in the affluents of the upper Mono. Only very few flies were caught at Landa Pozanda before August, and the increase in the biting rate at this site in late August coincidates rather with the pattern of biting rates observed in northern Benin than with the dynamics of the fly-populations at Fazao, Landa Mono or Mô â Mô. This indicates two separate sources of reinvading flies at Landa Pozanda, similar to the results of CHEKE & GARMS (1983) for the years 1980 and 1981. Local failures of the treatments of the river Kara or of its tributaries are most probably responsible for the flies caught during May and October.

The total biting rate during the rainy season at Landa Pozanda (1,215 flies during May to September) was not much over the 'tolerable' level of 1000 flies per man per year, but this very positive result should be compared with the biting rates at other sites in this region (Alêhêridê, Kapayando, Kêtao ...) in order to see whether this is representative for the whole area.

In Benin, the biting rate at Gbassê continued to be exeedingly high, though the situation at Zougou and, in particular, at Alibori and Kêrê-mou was much better than the preceding years. The high biting rate at Gbassê in June and July is probably due to local breeding, since the first application of insecticide was on 29th of June and the river Sota was already flowing in May. The numbers of reinvading flies in August decreased from the catching sites in the east (Gbassê, Zougou) towards those in the west (Alibori, Kêrêmou). This might indicate a possible source of these flies in the eastern area, either in the untreated river Olim or further east in Nigeria. Like during the past years, lack of time prevented a more detailed examination of the situation in northern Benin.

The distribution of vector species in Togo and Benin

The species involved in the reinvasion in Togo were, like during the preceding years, mainly exclusively S. squamosum and few S. damnosum s.s./S. sirbanum at Mô â Mô during August and September. The same was observed at Landa Pozanda, where there were about 80 % of S. squamosum, whereas all flies at Gbassê were S. damnosum s.s./S. sirbanum.

The experience of five years of investigations on the species composition of reinvading fly-populations in the northers areas of Togo and Benin has provided evidence, that S. soubrense/S. sanctipauli flies might only constitute a minute proportion of the total ABR at sites within the OCP area. Important populations of this vector were only found, in the larval and adult stage, at Djodji, along the lower Mono and along the Ouêmê and Okpara. Furthermore, this vector seems to be very sensitive to changes in its environment, as it is indicated by its disappearence from the Gban Hou after the experimental treatments in 1981 and from the lower Mono after the extinction of the breeding sites during the dry season 1983. At Djodji, it took almost two years for this species to reach its original size of population and at Têtêtou, the first individual of this vector (one adult fly) was observed by the end of September. The population of S. squamosum (at Djodji) and of S. damnosum s.s., which became the predominant species after the disappearence of S. soubrense/S. sanctipauli, did not reach the original density of the former population, as indicated by lower biting rates on man at these sites.

In conclusion, it appears, that S. soubrense/S. sanctipauli is at its north-eastern limits of its distribution area, the Dahomé gap forming a natural barrier to its occurrence. According to CROSSKEY (1981) this group is not found in Nigeria or Cameroon. If this observation could be confirmed, then it could be tried to attack the remaining breeding sites of this vector in Togo and Benin during the dry season in order to see, how long it would take until these sites would be repopulated. The Volta Lake could possibly form a natural barrier for the repopulation, if the breeding sites in the east would have been treated.

The 'Beffa' form of S. soubrense/S. sanctipauli

The different proportions of larvae, assigned according to cytotaxonomic identification to either 'S. soubrense' or 'S. sanctipauli' or to S. soubrense/sanctipauli is inconsistent with the supposition of MEREDITH et al. (1983), that the populations in Togo and Benin are a single interbreeding group and that the diagnostig inversions occure in Hardy-Weinberg equilibrium. If this would be the case, one should expect an higher proportion of 'S. sanctipauli' at Têtêtou and of 'S. soubrense' at Mbêtêkoukou (Tables 3 and 4), and at Djodji, S. soubrense/sanctipauli should have been seen in much higher proportions (Table 4). As well, the adult S. soubrense/S. sanctipauli flies from Djodji had, in 1982 (RENZ, 1983) and in 1983, dark (D,E) wing-tufts in a great majority, whereas pale (A,B) tufts should be found in about 30 % of all typical Beffa females (RENZ 1983, MEREDITH et al. 1983). Such pale tufts were frequently found at Têtêtou during the preceding years, whilst also the Beffa populations at Kaboua always showed darker wing-tufts (RENZ 1983, GARMS pers. comm.). A possible explanation for this phenomenon would be, that, even if this group forms an interbreeding population in Togo and Benin, there exist adaptations of subpopulations to different environmental conditions in the various areas. The inversion 4.6.7., typical for 'S. sanctipauli', is more frequent in 'rain-forest' types of breeding sites and the inversion 4.6. ('S. soubrense') seems to be better adapted to 'savanna' types of sites. This is similar to the distribution of these cytotypes in the Ivory Coast (QUILLEVERE 1979), although the differences in the vectorial efficiency of the two types in the Ivory Coast were not observed for the Beffa population. More should be known about the occurrence of different types within this population in Ghana, Togo and Benin, in particular as concerns the eastern areas of the occurrence of S. soubrense and S. sanctipauli sensu Vajime and Dunbar (1975) and the western areas of the Beffa form.

The trend of decreasing biting rates

One of the key-parameters of the vectorial capacity of a given fly-population is the biting rate on man, which should be assessed, in view of the accumulative pattern of human onchocerciasis, for a period exceeding the life-expectancy of the parasite in man (estimate 5 to 10 years). A comparison of the Annual Biting Rates since the first regular catches in 1979 has revealed a rather remarkable reduction in the size of many of the observed fly-populations over the past years. Several reasons might be responsible for this phenomenon, although it is impossible to quantify the influence of each of these suppositions: The increasing drought in many of the West-African countries during the past years, together with the progression of the desertification of the northern sahel zone and the destruction of the remaining forest, resulted in a more seasonal flow of the rivers, which made the seasonal variations in the fly-populations more marked. Thus, the 'dry-season gap' in the fly-population became longer at most of the sites. Similarly, the important variations in the population of S. soubrense/S. sanctipauli might reflect the difficulties, this group has to adapt to this new situation. The experimental treatments outside the OCP area in 1980 and 1981 (GARMS et al. 1981) certainly reduced largely the fly-populations in Togo, but it could hardly have had any effect on the populations in Benin.

More data from other catching sites outside the OCP-area in West Africa should be consulted in order to see, whether decreasing biting rates are characteristical for the present situation on a larger scale.

The influence of the mermithide-infections on the fly-populations at Tétêtou and Bétérou is difficult to assess, but there is no doubt, that those flies parasitized by these nematodes, are not able to transmit onchocerciasis. The survival rate of parasitized larvae, pupae and adults of both sexes as well as the reasons for the different infection rates of different fly-species merit further attention.

Different S. damnosum s.l. - O. volvulus complexes in Togo and Benin ?

The different manifestation of onchocerciasis in rain-forest and savanna might be explained by the existence of different parasite-vector complexes (DUKE et al. 1972, 1975, OMS 1983), the one in the savanna being highly pathogenic to the eye and transmitted by S. damnosum s.s./S. sirbanum, the other in the rain-forest being less dangerous to the eye and transmitted by S. soubrense/S. sanctipauli or S. yahense in the Ivory Coast (OMS 1983) and by S. squamosum in Cameroon (DUKE 1972). Unfortunately, there are not enough ophthalmological, parasitological and clinical data available from Togo and Benin, that really could sustain the co-existence of two different manifestations of the disease there. In the northern savanna areas, where the transmission is (or by now, was) maintained by S. damnosum/S. sirbanum, onchocerciasis is as dangerous to the eye as it is in other savanna areas of West Africa (BA, pers. comm.), but on the other side, there exists hardly any site in the two countries, where S. damnosum s.s./S. sirbanum is not, at least partially, involved in the transmission. Our data, stemming from the rainy-season do not permit to estimate the relative proportion of transmission, attributable to the various vectors, but this could be attempted by combining the results from different sources, i.e. OCP-data, the reports of GARMS et al. (1979-83), CHEKE (1983), BARBIERO (1983) and the results from the cytotaxonomic identification of larvae samples from nearby breeding sites.

Probably, the most typical 'rain-forest' situation is found at Djodji. Most of the transmission, perennial at this site, is maintained by S. soubrense/S. sanctipauli and only few infective S. squamosum were found, but nevertheless, S. damnosum s.s. probably represented 1/4 of the population and of transmission (?), as it is indicated by the composition of the larval population in the Gban Hou (Table 4).

The ATP at this site was higher than 10,ooo before the break-down of the fly-population in 1981 and from the results of the study on the dispersal of the flies, it can be estimated, that the human population at the village Djodji is exposed to almost 50 % of the biting rate measured at the river. According to all experience, such a situation would result in an intolerable manifestation of severe eye-lesions and blindness, if encountered in the savanna. However, the medical examination of 411 people from this villages showed 'only' a prevalence of 77.2 %, an average microfilarial density of 18.4 mf and 2.0 % of blind people, whilst the pre-blindness rate ('précécité') was 3.8 % (BA 1981). In the savanna, similar values could already be reached by an ATP of less than 1,ooo (THYLEFORS et al. 1978, DUKE et al. 1975, RENZ 1981, DIETZ 1982).

At Tétêtou, the prevalence (82.4 %) was similar to Djodji, but the average microfilarial density was lower (11.4 mf) and there were more blind (3.7 %) and pre-blind (4.1 %) people. The entomological data indicate an higher proportion of transmission by S. damnosum s.s./ S. sirbanum at Tétêtou if compared to Djodji.

The village Alamassou, which is situated at 300 m from the river Anié, and which is exposed to almost 30 % of the biting rate, measured at the OCP catching-site close to the river, showed the highest parasitological findings of all villages examined in the southern extension areas of Togo (BA 1981): prevalence 85.9 %, microfilarial density 31.5 mf, and 5.2 % of pre-blindness, although the blindness rate was rather low (1.5 %). I do not have the values of the ATP, measured at this site during the last years, but these data could be found in the OCP-files.

In conclusion, there are some indications for a different epidemiological picture of onchocerciasis at Djodji, as well as the staining pattern of microfilariae was found different at Landa Pozanda and Djodji (OMAR 1983), but much more clinical and in particular, ophthalmological data should be compared. Concerning the entomological data, it should be considered, that the now-observed composition of the fly-populations does not necessarily reflect the original situation during the time, when those people actualy found blind became infected. It is possible, that the area of distribution of S. soubrense/S. sanctipauli was much more wide-spread in the past and that the actual situation rather favours the extension of savanna vectors towards the south than the inverse.

The vectorial efficiency of different vectors

A definition of the term 'vectorial capacity of S. damnosum s.l.' will be presented in a seperate paper (RENZ, in prep.), together with a detailed discussion of the parameters, based on the data from the present investigations. In the following, I shall therefore only compare the proportion of infected and infective flies of different groups, with special regard to the group S. soubrense/S. sanctipauli.

In the Ivory Coast, S. sanctipauli has a reduced ability to transmit onchocerciasis because of its low parous rate (GARMS 1983, QUILLEVERE 1979) and its high degree of zoophily (TRAORE et al. 1982). Only 2.8 % of all parous flies identified, according to their morphology, as S. soubrense/S. sanctipauli, carried infections of O. volvulus in the savanna areas of northern Ivory Cost and its vectorial role in this region was thought to be practically zero (TRAORE et al. 1982).

The data from Togo are different in so far, as the anthropophily of the Beffa-form is high, as seen by the high infection rates (23.5 % of all parous) and by the propensity of these vectors to feed on man (BARBIERO 1983). The parous rate was more than 30 % at all sites. However, no infective fly of this group was identified amongst the re-invasion-flies and this could indicate a reduced life-expectancy in the northern savanna areas. Another interesting fact is the low infection rate of S. soubrense/S. sanctipauli at Bêtêrou (2.8 %), but this should be confirmed by more data. On an average, 1000 biting flies of this group carried 123 infective larvae, which is a value a bit lower than the one given by QUILLEVERE (1979) for S. soubrense in the 'zone de contact forêt-savane' in the Ivory Coast (204 larvae). This difference is mainly due to the different number of infective larvae per infective fly (see below).

No obvious difference could be detected for the susceptibility to infections by O. volvulus for S. soubrense/S. sanctipauli from different sites in Togo and Benin. The experimental-transmission data clearly show, that this vector allows the development of 'savanna' and 'forest' micro-filariae without difference (RENZ 1983, BARBIERO 1983), and the variations in the proportion of wild-caught infected parous flies, observed at Djodji (41.7 % of parous infected), Têtêtou (23.9%) and Kaboua (17.2%), could as well be explained by a different density of the human population at these sites as by a different degree of anthropophily of the fly-populations.

The low infection rate of S. squamosum fits to the observation, that this species has a reduced ability to transmit in the savanna of the Ivory Coast (35 infective larvae per 1000 biting flies, QUILLEVERE 1979). According to our data, 1000 biting flies carried 29 infective larvae on an average in Togo and Benin. However, whereas the vectorial efficiency of S. squamosum was much higher in the rainforest in the Ivory Cost (240 infective larvae per 1000 flies, loc. cit.), no such increase could be observed in Togo (Djodji: 0/1000 flies). The low susceptibility of S. squamosum at Djodji was confirmed by the results of the experimental transmission (RENZ 1983, BARBIERO 1983): only very few microfilariae successfully developed to infective stages although large numbers of microfilariae were ingested.

S. squamosum populations from Togo are morphologicaly and possibly also genetically different from those in southern Ivory Coast (GARMS et al. 1982) and from Cameroon (pers. obs.). Therefore, it remains unclear, whether the low susceptibility of S. squamosum in Togo is due to either a different strain of O. volvulus or a different population of the vector. Cross-transmission experiments could provide further information, if S. squamosum from Mô â Mô would be allowed to feed on microfilariae from Ivory Coast savanna and rain-forest.

The average number of developing stages and of infective larvae per infected resp. infective fly was different for the three groups of vectors, but was similar within one group at the different sites. S. damnosum s.s./S. sirbanum carried about two larvae per infected or infective fly and similar values were found in S. squamosum. S. soubrense/S. sanctipauli carried the highest numbers, about 6 larvae per infected or infective fly. This is nevertheless lower than the number observed in S. soubrense of the Ivory Coast (10.2, QUILLEVERE 1979) and this again shows the differences in the vector-parasite complexes of the two areas. Interestingly, such differences in the susceptability of S. soubrense/S. sanctipauli were also observed within the Ivory Coast (PROD'HON et al. 1983).

More about the frequency distribution of infective larvae in the vectors, the degree of anthropophily and the age-structure of the various fly-populations will be presented in the paper on the 'vectorial capacity'.

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6: LITERATURE

BA, O.: Données epidemiologiques sur l'onchocercose dans les zones d'études de l'OCP au Benin, au Ghana et au Togo. Unité d'évaluation Epidemiologique, Document technique OCP/EPI/81.51, 43 pp (unpublished document)

CHEKE, R.A., R. GARMS: Reinfestations of the southeastern flank of the Onchocerciasis Control Programme area by windborne vectors Phil. Trans. R. Soc. Lond. B 302, (1983) 471-484

CROSSKEY, R. W.: Geographical Distribution of Simuliidae. In: Blackflies; The future for biological methods in integrated control. M. LAIRD ed. Academic Press (1981) 57-68

DANG, P.T., B.V. PETERSON: Pictorial keys to the main species and species groups within the Simulium damnosum Theobald complex occurring in West Africa (Diptera: Simuliidae). Tropenmed. Parasit. 31 (1980) 117-120

DIETZ, K.: The population dynamics of onchocerciasis. In: Population Dynamics of Infectious Diseases. Ed. R.M. Anderson Population and community biology series, Chapman and Hall, London, New York (1982) 209-241.

DUKE, B.O.L., P.J. MOORE, J. ANDERSON: Stdies on factors influencing the transmission of onchocerciasis. VII. A comparaison of the Onchocerca volvulus transmission potentials of Simulium damnosum populations in four Cameroon rain-forest villages and the pattern of onchocerciasis associated therewith. Ann. trop. Med. Parasit. 66 (2), (1972) 219-234

DUKE, B.O.L., J. ANDERSON, H. FUGLSANG: The Onchocerca volvulus transmission potentials and associated patterns of onchocerciasis at four Cameroon Sudan-savanna villages. Tropenmed. Parasit. 26 (2), (1975) 143-154

GARMS, R., R.A. CHEKE, M. KERNER: A study of the re-invasion in the south-eastern areas of the Onchocerciasis Control Programme. WHO/OCP Working Group on Reinvasion. Ouagadougou, 13-15 November 1979, 64 pp. (unpublished document)

GARMS, R., R.A. CHEKE, M. KERNER: Investigations in 1980 on the reinvasion by Simulium damnosum s.l. into the Eastern areas of the Onchocerciasis Control Programme, including experimental treatments of potential sources.(1980) 77 pp (unpublished document)

GARMS, R., R.A. CHEKE, M. KERNER: Studies in 1981 of the reinvasion by Simulium damnosum s.l. into the Eastern areas of the Onchocerciasis Control Programme and the results of experimental treatments of potential sources. (1981) 22 pp (unpublished document) + supplement

GARMS, R., R.A. CHEKE, C.G. VAJIME, S. SOWAH: The Occurrence and Movements of Different Members of the Simulium damnosum Complex In Togo and Benin. Z. Angew. Zool. 69 (2), (1982) 219-236

GARRETT-JONES, C.: The human blood index of malaria vectors in relation to epidemiological assessment. Bulletin WHO 30 (1964) 241-261

GUILLET, P., H. ESCAFFRE, M. OUEDRAOGO, D. QUILLEVERE: Note preliminaire sur une resistance au temephos dans le complexe Simulium damnosum (S. sanctipauli et S. soubrense) en Côte d'Ivoire (Zone du Programme de lutte contre l'Onchocercose dans la Region du Basin de la Volta). WHO/VBC/80.784 (1980) 9 pp (unpublished mimeographed document)

MEREDITH, S.E.O., R.A. CHEKE, R. GARMS: Variation and distribution of forms of Simulium soubrense and S. sanctipauli in West Africa. Ann. Trop. Med. Parasitol. 77 (1983) 627-640

MONDET, B., G.O.Jr. POINAR, J. BERNADOU: Etude du parasitisme des simulies (Nematoda) en Afrique de l'Ouest. IV. Decription de Isomermis lairdi n.sp., parasite de Simulium damnosum. Can. J. Zool. 55, (1977) 2011-2017

NELSON, G.: Staining of filarial larvae in insects before dessection. Bull. Wld Hlth Org. 19, (1958), 204

OMAR, M.S.: Report on studies on the histochemical differentiation of filarial larvae in Simulium damnosum s.l. and on the vectorial capacity of the main species of the complex in Togo and Benin. Report, Consultant OCP (1982)(unpublished document)

OMS/OCP: Rêunion de travail conjointe sur l'onchocercose forestière dans l'aire du Programme de Lutte contre l'onchocercose dans la Rêgion du Bassin de la Volta. Ouagadougou, le 14-18 novembre 1982 (unpublished document)

PROD'HON, J., G. HEBRARD, J.M. PRUD'HON, D. COURET: Etude de la capacité vectrice experimentale de Simulium soubrense - Simulium sanctipauli en zone de savane humide (Rêgion de Touba, Côte d'Ivoire) Rapport final No 9 /IRTO (1983) (unpublished document)

QUILLEVERE, D.: Contribution â l'ëtude des caractêristiques taxonomiques, bioêcologiques et vectrices des membres du complexe Simulium damnosum prêsents en Côte d'Ivoire. O.R.S.T.O.M. 109 (1979) 304 pg

RENZ, A.: Studies on the dynamics of transmission of onchocerciasis in a Sudan savanna area of North Cameroon. Part 1: Entomological data (1981) 46 pp, (unpublished document)

RENZ, A.: Studies on the reinvasion by Simulium damnosum s.l. into the eastern areas of the Onchocerciasis Control Programme and on the vectorial capacity of different species of the S. damnosum complex in Togo and Benin 1982. Unpublished report (1983) 62 pg

THYLEFORS, B., B. PHILIPPON, A. PROST: Transmission potentials of Onchocerca volvulus and the associated intensity of onchocerciasis in a Sudan savanna area. Tropenmed. Parasit. 29 (1978) 346-354

TRAORE, S., G. HEBRARD, J. DUVAL, O. FAYE: Etude de la bio-êcologie et des caractêristiques vectrices naturelles des femelles du groupe Simulium soubrense-sanctipauli en zone de savene Rapport final No 37/IRTO (1982) (unpublished document)

VAJIME, C.G., R.W. DUNBAR: Chromosomal identification of eight species of the subgenus Edwardsellum near and including Simulium (Edwardsellum) damnosum Theobald (Diptera: Simuliidae). Tropenmed. Parasit. 26 (I), (1975) 111-138

WALSH, J.F., J.B. DAVIES, R. LeBERRE: Entomological aspects of the first five years of the Onchocerciasis Control Programme in the Volta River Basin. Tropenmed. Parasit. 30 (1979) 328-344

WHO: Terminology of malaria and of malaria eradication, Geneva (1963)

7. CONCLUSIONS

Reinvasion into the south-eastern flanc of the OCP occurred, like during the preceding rainy seasons, at the same sites and by the same vector groups, but at a much reduced biting rate, along the river Kara (at Landa Pozanda) in Togo and along the rivers Mēkrou (at Kērēmou), Alibori (at Alibori) and Bouli (at Zougou) in Benin. In contrast to these sites, high numbers of biting flies, exceeding those measured during the past two years, were observed at Gbassê (r. Sota, Benin) and at Mô â Mô (r. Mô, Togo), partially being of local origin.

The pattern of the dynamics of the biting rates at the reinvasion sites and the species-composition of the reinvading populations indicate at least three different sources of reinvading flies: Those caught at Mô â Mô were mainly S. squamosum, during the period of this consultantship , and came presumably from untreated rivers in the south. At Landa Pozanda, the different pattern of the biting rate and the higher proportion of S. damnosum s.s./S. sirbanum indicates source areas in the upper Mono and its tributaries or in the Benin, although some local breeding might be responsible for the biting rates in May and October. All flies identified from reinvasion areas in Benin were S. damnosum s.s./ S. sirbanum and probably came in August from the upper Ouémé basin and from yet unidentified breeding sites (river Olim or from Nigeria ?), whereas those observed at Gbassê during June and July presumably came from untreated breeding sites in the river Sota.

S. soubrense/S. sanctipauli disappeared completely from its former breeding sites in the lower Mono, after these sites fall dry during April 1983, and it was replaced at these sites by an almost pure population of S. damnosum s.s., at a much lower density of population, however. Coincidentally, the population was heavily parasitized by mermithids, both in the larval and adult stage. At Djodji, the population of S. soubrense/S. sanctipauli recovered and came back, almost two years after the experimental treatment of this area, to its original level (> 500 ♀♀/man/day).

The vectorial efficiency was highest for S. soubrense/S. sanctipauli (ø 123 infective larvae per 1ooo biting flies), followed by S. damnosum s.s./S. sirbanum (ø 58 larvae), but was lowest for S. squamosum (ø 29 larvae), probably as a result of the low receptivity and the high proportion of bloodmeals on non-human hosts of this species. Both S. soubrense/S. sanctipauli and S. damnosum s.s./S. sirbanum seem to possess an higher vectorial efficiency in the southern areas of Togo than in the northern savanna, where S. soubrense/S. sanctipauli hardly plays any role in the transmission of disease, due to its rareness and to its reduced life-expectancy. However, more data are necessary to substantiate these supposed variations in the vectorial efficiency within one group in different bioclimatic zones.

The studies on the dispersal of the fly-populations showed, that the village Djodji is exposed, at a distance of 1700 m from the river, to nearly 50 % of the total parous biting rate, measured at the usual OCP-fly-catching site at the river bank (S. soubrense/S. sanctipauli mainly). At Mô â Mô, where there were mainly reinvading S. squamosum flies, a small hamlet at the same distance (1500 m) from the river was only exposed to about 5 % of the corresponding biting rate. At Alamassou, where all three vector groups were prevalent, the village was exposed, at a distance of only 300 m from the river, to about 30 % of the parous biting rate. These results show again the low vectorial efficiency of S. squamosum and the very local transmission by reinvading flies.

Although some arguments indicate the existence of two 'strains' of O. volvulus in Togo, the situation is far from being clear and more data, both medical and entomological ones, are necessary to substantiate this supposition.

8. RECOMMENTATIONS

The huge amount of entomological data, collected by routine OCP-fly-catching and dissections, by the cytotaxonomic identification of larvae samples and by the number of consultants over the past years, should be criticaly analysed, in the light of the following questions: What is the vectorial efficiency and the amount of transmission by each of the three vector groups, during dry- and rainy-seasons and in different bioclimatic zones of Togo and Benin ? Is there any further evidence for the existence of different Simulium-Onchocerca complexes in this part of West-Africa ? If necessary, existing preserved material (flies) could still be examined. Actually, those flies only classed nulliparous or parous during the past rainy season, are identified and dissected at Tübingen.

The occurrence and the species-composition of fly-populations should be studied during the dry season, especially during the months of March and April, and the few remaining breeding sites should be mapped in view of a future larviciding campaign during this period of the year. There is fonded hope, that the populations of S. soubrense/S. sanctipauli could be substantially reduced with a long-lasting effect by only few treatments and there is enough evidence, that a possible re-population of the treated sites by S. squamosum or S. damnosum s.s./S. sirbanum would probably result in a reduced rate of disease transmission. However, the needs of the insecticide-screening team at Lomé should be duly considered.

The different receptivity of S. squamosum to infections by O. volvulus could be investigated in a series of cross-transmission experiments, by feeding flies from Mô â Mô and southern and northern areas of Ivory Coast (and possibly from the Kumba area in Cameroon) on human infections from the same and different areas. Such experiments would indicate, whether there exist different strains of S. squamosum (in this case: S. squamosum s.l.) or of O. volvulus (: s.l. ?) - or even different strains of both parasite and vector.

The trend of decreasing biting rates, observed at most of the catching sites in Togo and Benin during the last years, should be compared to more data from other fly-populations in similar zones of Ghana and Ivory Coast. The variation of the ABR at a given site could be compared to other parameters like the river's water level and discharge, the species composition of the fly-population and the density of human and animal populations around this site.

The differences in the morphology and in the caryotype of various S. soubrense/S. sanctipauli ('Beffa') populations merit further attention, in particular in the western zones of the distribution of this form, where it approaches the areas of distribution of S. soubrense and S. sanctipauli sensu Vajime & Dunbar.

The influence of mermithids on the size of the fly-populations and the reasons for the low proportion of parasitized S. soubrense/S. sanctipauli flies should be investigated further.