Yellow fever in the Gambia, 1978-1979 : A complementary entomological survey done in October 1979 (1)

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Résumé

LA FIÈVRE JAUNE EN GAMBIE, 1978-1979 : UNE ENQUÊTE ENTOMOLOGIQUE COMPLÉMENTAIRE FAITE EN OCTOBRE 1979

Une épidémie de fièvre jaune a sévi en Gambie de juin 1978 à janvier 1979, qui eut pour épicentre la partie orientale du pays. L'enquête rapportée ci-après a été conduite en octobre 1979 à la demande des autorités de ce pays et de l'OMS. Elle fournit des informations quant aux vecteurs potentiels ayant sans doute joué un rôle déterminant lors du pic épidémique de 1978, c'est-à-dire en fin de saison des pluies. Celles-ci font apparaître que des vecteurs « sauvages », au premier rang desquels le groupe Aedes furcifer-taylori, *permirent le développement d'un processus selvatique comportant de nombreuses contaminations humaines. Il est probable que le groupe d'espèces précité, dont les femelles pénètrent dans les villages et sont occasionnellement capturées jusque dans les maisons, ait en outre donné lieu à des transmissions interhumaines. Des gîtes larvaires* d'A. ægypti, *domestiques et péridomestiques ont été trouvés dans toutes les localités inspectées mais on observe, dans la partie orientale du pays, une fréquente discordance entre les indices larvaires constatés, lesquels sont souvent élevés, et le nombre d'adultes capturés piquant l'homme. En certains lieux, l'anthropophilie d'*A. ægypti *apparaît toutefois suffisante pour qu'il ait pu jouer son rôle classique de vecteur interhumain. A ce type épidémique intermédiaire qui semble avoir prévalu de juin à fin novembre, a succédé, avec la saison sèche, une seconde phase au cours de laquelle la transmission devint strictement le fait d'*A. ægypti. *La maladie faisait alors son apparition dans la partie occidentale du pays, où l'anthropophilie de ce vecteur est beaucoup plus marquée, et ne prit fin que par les effets d'une campagne de vaccination de masse. Il est rappelé que le virus amaril, lors de cette phase terminale, a été isolé à deux reprises de femelles d'*A. ægypti *capturées dans un village de cette partie du pays.*

Mots-clés : Culicidae – Larves – Adultes – Fièvre jaune – Épidémiologie – Gambie.

Summary

The survey the results of which are reported hereafter was done in the Gambia in October 1979 and contributes to show which were the prevailing vectors during the peak of the 1978 yellow fever outbreak, i. e. at the end of the rainy season. Feral vectors, chiefly those of the Aedes furcifer-taylori *group, permited a sylvatic process, including monkey*

(1) Cette enquête a été financée par l'Organisation Mondiale de la Santé, que les auteurs tiennent tout particulièrement à remercier, le Center for Disease Control (USA) et l'O.R.S.T.O.M. Le compte rendu auquel elle donne lieu fait suite et constitue le complément de trois articles en langue anglaise (Port et Wilkes, 1979, Monath *et al.* et Germain *et al.*, sous presse). Considérant en outre qu'il intéresse au premier chef, comme les articles précédents, un pays anglophone, il a été jugé préférable de le présenter dans la même langue.

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to man transmission. A. ægypti *larvae were found everywhere, in domestic or peridomestic situation, but in the eastern part of the country, a discrepancy frequently appears between rather high larval breeding indices and a low adult biting activity. Nevertheless, in some places, this species is anthropophilic enough to have been involved in a man to man transmission of the yellow fever virus. To this more or less mixed epidemiological pattern, which probably prevailed from June to end of November, succeeded a second period during which the transmission became strictly of a man to man type with* A. ægypti *as only vector. It is recalled that two strains of yellow fever virus were isolated from pools of females of this species caught in Western Gambia in January 1979.*

Key words : Culicidae – Larvae – Adults – Yellow fever – Epidemiology – The Gambia.

A yellow fever (YF) epidemic occured in the Gambia in 1978-1979, the description of which has been given by Monath *et al.* The progression of this outbreak can be summarized as follows : The first serologically confirmed YF case was recorded from June 1978, in east part of the country (McCarthy Island Division) ; from May to October, all the cases were confined in the same region (McCarthy Island Div., Upper River Div.). In November, a first case appeared in the Lower River Div. In December and January, some cases occured in the North Bank Division, western Gambia, while the sickness discreetly persisted in the east. Banjul was not affected. No new cases appeared after January (vaccination campaign). The peak of the attack rate was observed in October and the two western administrative divisions appeared clearly as being the epicentre of the outbreak.

Till now, the only informations we had on the vectors that prevailed during the 1978 rainy season laid in a paper of Port and Wilkes (1979) who established that *Aedes* (*Diceromyia*) *furcifer-taylori* group

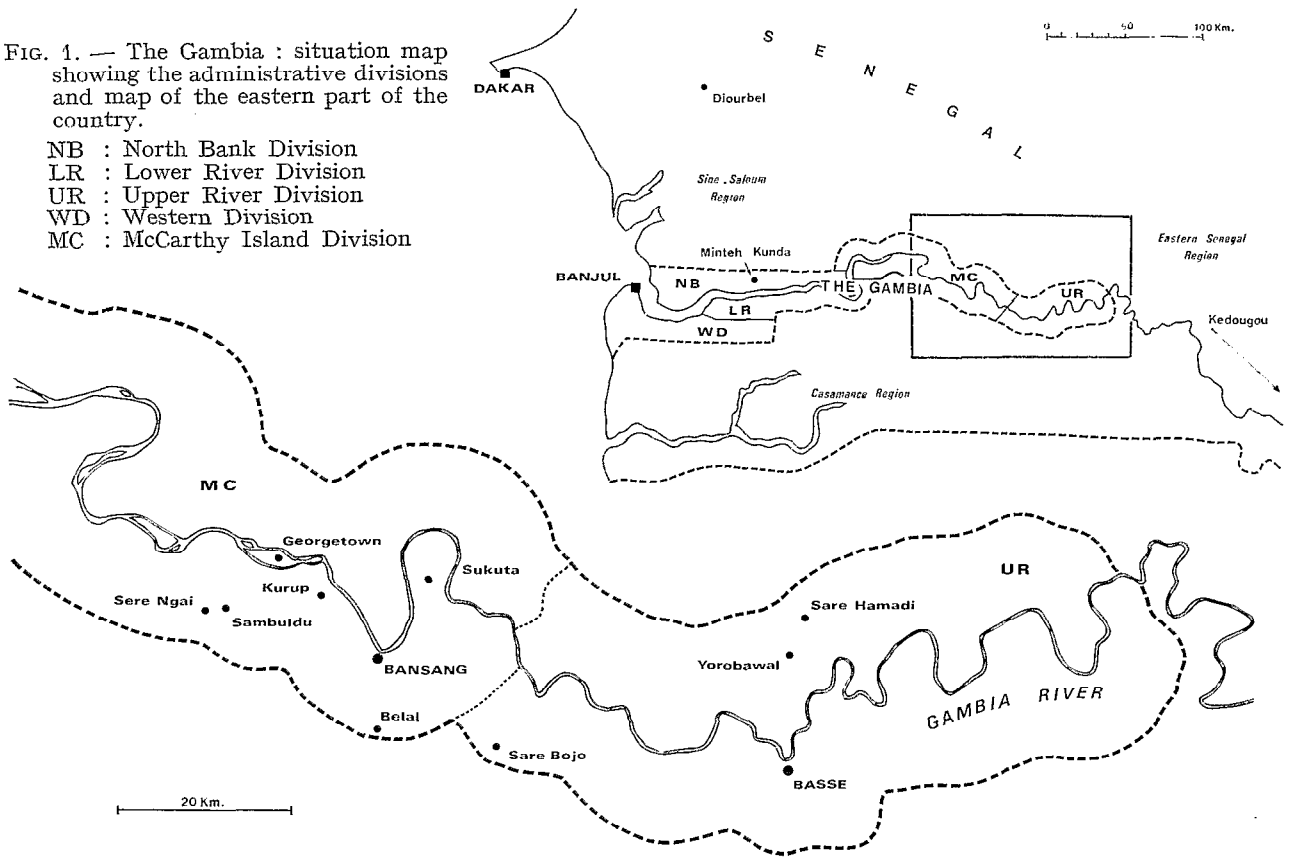

FIG. 1. — The Gambia : situation map showing the administrative divisions and map of the eastern part of the country.
NB : North Bank Division
LR : Lower River Division
UR : Upper River Division
WD : Western Division
MC : McCarthy Island Division

females could be caught biting man in Bansang area, McCarthy Island Div., by the end of November 1978. An extensive entomological survey was carried out in January 1979 (Germain *et al.*, in press, *b*) but it concerned only the dry season and showed that *Aedes aegypti* was then the only potential vector. Two YF virus strains were isolated from this species (Western Gambia) in Institut Pasteur, Dakar.

In order to complete our information on the YF potential vectors which prevailed during the peak of the 1978 outbreak, i. e. in October, an entomological survey was carried out from 6 to 22 October 1979, the results of which are reported hereafter.

Ecogeographical informations about the Gambia (fig. 1) have been given in the previous notes to which the present one is complementary.

1. METHODS

The places to prospect have been selected in connection with the data from the previous epidemiological survey (Monath *et al.*, in press ; Germain *et al.*, in press, *b*) (Table I).

1.1. Larva survey

The following indices were used :

BRETEAU INDEX : number of positive containers per 100 houses. Is considered as a house each room in which one or more persons are habitually sleeping, as well as its neighbouring.

CONTAINER INDEX : number of positive breeding sites per 100 containers holding water.

DENSITY FIGURE (WHO) : this index integrates the previous indices. It is to recall that its scale extends from 0 to 9, with, according to the norms of WHO, an epidemic risk starting from 2 and a high threat on and after the value 6.

A total of 640 houses has been inspected (Table III).

1.2. Adult survey

Man biting catches have been carried out in 12 places. The schedule was from 3 p.m. to 8 p.m. (sunset around 6.45), in order to cover at one and the same time the peaks of activity of domestic and sylvatic YF potential vectors. The number of cat-

TABLE I

Places inspected in October 1979 with mention of N° of YF clinical cases and attack rate during rainy and dry seasons 1978-79 (1)

	Rainy Season		Dry Season	
	Clinical Cases	Attack Rate	Clinical Cases	Attack Rate
McCarthy I. Div.				
Sambuldu	4 (2)	54.8	0	0
Sukuta	7 (6)	81.4	1	11.6
Sere N'Gai	15 (8)	34.3	0	0
Kurup	some	?	0	0
Belal	3	19.7	1	6.6
Bansang	14 (6)	?	3 (1)	?
Upper River Div.				
Basse	1	?	0	0
Sare Bojo	2 (1)	8.5	3 (3)	12.8
Sare N'Gaba	14 (9)	108.5	0	0
Modi Jabbu	2	13.6	6 (1)	40.8
Sare Hamadi	?	?	?	?
North Bank Div.				
Minteh-Kunda	0	0	several	?
Kombo St Mary Div.				
Banjul	0	0	0	0

(1) Attack rate/1,000 inhabitants (based on total of cases).
Rainy Season : from May to end of November.
Dry Season : from December to end of January.
Between brackets : number of laboratory confirmed cases.

chers was 12 : 4 (2 × 2) indoors, 4 (id.) outdoors, inside the village, 4 (id.) on edge of savanna and crops. One time (Kurup forest) the catcher number was only 2.

The results of these potential vector catches are summarized in Table IV. In the text, other caught mosquitoes are mentioned in order of decreasing abundance.

1.3. Virological pools

1,305 female mosquitoes and some males have been caught (134 potential vector female *Aedes*) and distributed in monospecific pools, which were preserved in liquid Nitrogen, in order to be tested for virus infection in CDC, Fort Collins, Colorado, USA and Institut Pasteur, Dakar, Sénégal ; no virus was isolated.

2. METEOROLOGY AND *AEDES* PREVALENCE

In 1979, the rainy season started since May. But the whole of rainfalls was lower than the previous year and a shortage was obvious on and after August (Table II). This deficit probably explains that the number of potential vectors caught during the present survey was relatively low. The potential vector prevalence appeared to be the highest during the first half of the rainy season (see below, M. T. Gillies observations in Kurup) ; the same pattern is generally observed in Kedougou, south eastern Senegal (Cornet *et al.*, 1978). On the other hand, the level of the YF virus circulation resulting of any amplification process among monkeys reaches its maximum at the end of rainy season and the conditions for human infections and epidemic are then the best.

Analysing the results of the present survey, we shall must keep in mind that the mosquito activity level was probably higher the year before, at the same period.

3. RESULTS OF THE SURVEY (Tables III and IV)

3.1. Banjul (13° 28′ N, 16° 37′ W)

The capital was inspected for larval breeding on 6 October. The surveyed quarters were the same as those evaluated in January, in order to permit comparisons (Gloucester Street and Omar Saw Avenue). *A. aegypti* control has been done since January, covering the towns of Banjul, Bakau and Yundum (Airport). Control has consisted in DDT and Malathion spraying, Abate applications and removal of peridomestic containers. Despite these efforts the *A. aegypti* indices are unchanged (Breteau index : 1.1 ; WHO Density figure : 1) from January. Peridomestic breeding containers are less abundant which is undoubtely a result of the sanitary control. *A. aegypti* is generally resistant to DDT in Africa. The use of insecticides for yellow fever control during non epidemic periods is expensive and a good vaccination program remains the best way to prevent epidemic YF.

TABLE II

Monthly rainfalls (mm) in the Gambia from January to October, in 1978 and 1979 (according to the Gambia Meteorological Services)

Tr. means « traces »

		J	F	M	A	M	J	J	A	S	O	TOTAL
Banjul :	1978	—	—	—	Tr	Tr	57	262	428	200	127	1,074
	1979	12	—	Tr	—	9	126	283	188	89	69	776
Georgetown :	1978	—	—	—	—	Tr	165	179	248	195	82	869
	1979	1	—	Tr	—	Tr	97	162	224	88	115	687
Basse :	1978	—	—	—	—	19	127	253	361	231	73	1,064
	1979	1	—	—	—	25	96	289	236	105	115	867

TABLE III

A. aegypti indices (1)

	N° houses visited	Breteau Index	Container Index (%)	WHO Density Figure
Kombo St. Mary Div.				
Banjul	75	1.3	1.1	1 (1)
McCarthy I. Div.				
Sambuldu	40	7.5	6.9	2 — 3 (0)
Sukuta	40	15.0	9.5	3 (0)
Sere N'Gai	60	8.3	4.8	2 (1)
Kurup	45	4.4	2.5	1
Belal	50	10.0	3.3	2 — 3 (3)
Bansang	50	4.0	2.7	1 — 2 (1)
Upper Riv. Div.				
Sare Bojo	50	38.0	14.8	4 — 5 (3)
Basse	50	26.0	10.5	4 (0)
Sare Hamadi	42	26.2	7.3	3 — 4 (3)
Sare N'Gaba	48	6.2	3.8	2 (0)
Modi Jabbu	40	47.5	19.0	5 (3)
North Bank Div.				
Minteh Kunda	50	50.0	29.7	7 (8)
	640			

(1) Between brackets : Density figure in January 1979.

In Fajara, near Banjul, in the gardens of the Medical Research Council, female *A. aegypti* can be abundantly caught biting man at the end of the afternoon (19 females/man/20 min.). Their pattern value according to McClelland seems to vary from 1 to 2. They probably belong to « wild » populations.

3.2. McCarthy Island Division

SAMBULOU (13° 28' N, 14° 48' W)

This village (mainly Fulani) was visited on 9 October. During the rainy season of 1978, the YF attack rate was 54.8/1,000. *A. aegypti* is found mainly in peridomestic containers. A WHO density index of 2-3 (Breteau index : 7.5 ; container index : 6.9 %) was established by the current survey. No adult *A. aegypti* was collected during the biting catch. Three *Aedes furcifer-taylori* were caught, one of them biting indoors. There were two *A. metallicus* caught biting. Other adults caught, in order of abundance, are *Mansonia africana, Anopheles funestus, Mansonia uniformis, Culex poicilipes, C. nebulosus.*

SUKUTA (13° 30' N, 14° 36' W)

This village (mainly Mandika), which had quite a high attack rate (81.4/1,000) during the rainy season in 1978, was visited on 10 October. The *A. aegypti* larval Density was 3 (Breteau index : 15.0 ; container index : 9.52). No adult *A. aegypti* was collected in the biting catch. Again, *A. furcifer-taylori* was found, with 14 females + 2 males taken in the biting catch. Other species obtained were *M. africana, An. funestus, An. gambiae* group, *M. uniformis, An. rufipes, A. ochraceus.*

SERE N'GAI (13° 29' N, 14° 51' W)

The YF attack rate was 34.3/1,000 during the 1978 rainy season for this Fulani village. This place was surveyed on 11 October. Larval *A. aegypti* were again found, with, a Density figure of 2 (Breteau index : 8.3 ; container index : 4.8). On the other hand, no adult *A. aegypti* was caught. *A. furcifer-taylori* was taken in the biting catch (2 females). Other species were : *M. africa, M. uniformis, An. funestus, An. gambiae* gr.

KURUP (13° 30' N, 14° 42' W)

Several YF cases occured during the 1978 epidemic in this small Fulani village. The presence of YF vectors during the rainy season is well documented thank to the previous observations of Port and Wilkes (1979) and those subsequently followed

TABLE IV

YF potential vector *Aedes* and *Mansonia africana* caught biting man during the survey (females only)

	Before Sunset			After Sunset		
	I	O	S	I	O	S (1)
McCarthy I. Division						
Sambuldu						
A. furcifer-taylori	—	1	—	1	—	1
A. metallicus	—	—	1	—	—	1
M. africana	2	—	5	19	29	119
Sukuta						
A. furcifer-taylori	—	—	—	—	2	12
M. africana	3	1	1	—	4	5
Sere N'Gai						
A. furcifer-taylori	—	—	—	—	1	1
M. africana	3	6	5	14	26	31
Kurup, village						
A. furcifer-taylori	—	—	—	—	17	6
A. metallicus	—	—	—	—	—	4
A. luteocephalus	—	—	—	—	—	1
A. aegypti	—	—	1	1	—	—
M. africana	6	3	1	39	54	102
Kurup, forest						
A. luteocephalus	—	—	1	—	—	1
M. africana	—	—	97	—	—	53
Belal						
A. furcifer-taylori	—	—	—	1	7	9
M. africana	—	—	—	—	—	3
Bansang						
A. furcifer-taylori	—	—	—	—	—	3
A. metallicus	—	—	—	—	—	1
A. luteocephalus	—	—	—	—	—	1
A. vittatus	—	—	—	—	—	1
A. aegypti	—	—	5	—	—	1
M. africana	—	1	—	1	2	28
Upper River Division						
Sare Bojo						
A. furcifer-taylori	—	—	—	2	2	1
M. africana	—	—	—	—	1	3
Sare Hamadi						
A. furcifer-taylori	—	—	—	—	2	—
Sare N'Gaba						
A. furcifer-taylori	—	—	—	1	3	4
A. aegypti	—	3	3	—	—	—
Modi Jabbu						
A. furcifer-taylori	—	—	—	—	3	8
A. luteocephalus	—	—	—	—	—	1
A. vittatus	—	—	—	—	—	1
A. aegypti	—	—	—	1	—	—
North Bank Division						
Minteh Kunda						
A. furcifer-taylori	—	—	—	—	—	3
A. metallicus	—	—	2	—	—	—
A. luteocephalus	—	—	1	—	—	—
A. aegypti	—	—	1	6	11	—
M. africana	—	—	—	—	—	3

(1) I : indoor O : outdoor (in village) S : edge of savanna.
4 catchers in each site, except Kurup forest (2 catchers).

up by our British colleagues. Observations made since June, 1979 by M. T. Gillies and his collaborators have demonstrated *A. furcifer-taylori* biting man inside or near the village. *A. luteocephalus* and *A. metallicus* were present with a much lower incidence. Peaks of abundance of *A. furcifer-taylori* were observed in June, July and early October (personal communication).

The village of Kurup was surveyed on 12 October. The *A. aegypti* larval indices were found to be quite low with a Density figure of 1 (Breteau index : 4.4 ; container index : 2.5 %). During the survey of the entire village two positive domestic breeding sites were observed, both being outdoors. The results of the biting catch were as follows : 23 *A. furcifer-taylori*, 4 *A. metallicus*, 1 *A. luteocephalus* and 2 *A. aegypti*. All the YF potential vectors were caught outside except 1 *A. aegypti*. Two supplementary catchers were placed in a forest area about 500 m. from the village. The only YF vectors caught in this site were two female *A. luteocephalus*. Other species collected from the Kurup sites are *M. africana, M. uniformis, An. funestus, An. gambiae* gr., *A. cummінsi, An. pharoensis, A. ochraceus, An. rufipes, C. poicilipes, A. argenteopunctatus, A. circumluteolus.*

BELAL (13° 20′ N, 14° 35′ W)

This Wolof-Fulani village was visited on 13 October. The YF attack rate during the rainy season 1978 was 19.7/1,000. During the present survey, the *A. aegypti* Density figure was 2-3 (Breteau index : 10 ; container index : 3.3 %). The only potential YF vectors taken during the biting catch were 17 female *A. furcifer-taylori*. Two males of this species were also caught on human bait. Other species collected in the biting catch were *An. gambiae* gr. and *M. uniformis.*

BANSANG (13° 26′ N, 14° 39′ W)

The town of Bansang, where 14 clinical YF cases were reported during the 1978 rainy season, was visited in November 1978 by G. R. Port. Then, no *A. aegypti* was collected in biting catch but *A. furcifer-taylori* were taken.

We surveyed Bansang on 15 october and found the *A. aegypti* figure to be low (Breteau index : 4 ; container index : 2.7 %). All the recorded breeding sites were peridomestic. Our biting catch revealed an interesting pattern of mixed potential vectors. All of them were caught in peripheral sites, at the edge of savanna and included *A. aegypti* (6), *A. furcifer-taylori* (3), *A. vittatus* (1), *A. metallicus* (1) and *A. luteocephalus* (1). No YF vectors were obtained indoors or in the center of the town. Other species taken were *An. pharoensis* (all sites, abundant), *M. africana, An. gambiae* gr., *M. uniformis, An. funestus, C. pipiens quinquefasciatus* (= *C. p. fatigans*), *An. rufipes, C. poicilipes, A. circumluteolus.*

3.3. Upper River Division

SARE BOJO (13° 19′ N, 14° 31′ W)

This village, consisting mainly of Sarahuli but also Fulani and Mandinka, was visited on 14 October. The attack rate for this village during the 1978 rainy season was 8.5/1,000. During the current survey the *A. aegypti* Density figure was relatively high : 4-5 (Breteau index : 38.0 ; container index : 14.8 %). Despite this, no *A. aegypti* was taken during the man-baited catch. The only potential YF vectors obtained in the biting collection were 5 *A. furcifer-taylori*, 2 of which were taken biting indoor. Other mosquito species were *M. africana* and *An. funestus.*

BASSE (Santa Su, 13° 19′ N, 15° 52′ W)

One YF clinical case was reported from this town, administrative headquarter of the Upper River Division, during the 1978 rainy season. When Basse was inspected in our previous survey in January, 1979, it was found free of *A. aegypti* despite an abundance of potential breeding containers. These last were then mainly dried.

Basse was surveyed on 16 October. The *A. aegypti* Density figure was at a moderate level of 4 (Breteau index : 26.0 ; container index : 10.5 %). The occurrence of *A. aegypti* during the rainy season was suspected during the survey last January because of the abundance of potentiel breeding sites (1,200/100 houses). One particular breeding site was noted during our survey : bottle fragments were frequently fixed in concrete along the tops of walls enclosing compounds. A total of 102 of these containers were examined and 39.2 % were found holding water while 5 % of those holding water were *A. aegypti* positive.

SARE HAMADI (13° 28′ N, 14° 12′ W)

This Fulani village is located, as are the next two villages, north of Yorobawal, on the north bank of the Upper River Division. It was surveyed on 17 October. During the January, 1979 survey, this village was found to have a relatively high prevalence of

biting adult *A. aegypti*. In October the *A. aegypti* Density figure was 3-4 (Breteau index : 26.2, container index : 7.3 %). Quite surprisingly no adult *A. aegypti* was taken in the biting collection on this visit to Sare Hamadi. *A. furcifer-taylori* was taken during biting collection (2 females). Two additional female *A. furcifer-taylori* and one male were caught outside of the village by two of us. Other mosquito species were *An. pharoensis* and *An. gambiae* gr.

SARE N'GABA (13° 27' N, 14° 13' W)

Another small Fulani village in the same region as Sare Hamadi. During the 1978 rainy season, this village was one of the places where the attack rate was the highest (108.5/1,000, 14 cases, 9 of which were laboratory confirmed ; see Table I).

The *A. aegypti* Density figure observed during our survey of this village on 18 october was 2 (Breteau index : 6.3 ; container index : 3.8 %). Both *A. aegypti* (6 females, 2 males) and *A. furcifer-taylori* (8 females) were caught during the biting collection. One of the *A. furcifer-taylori* females was obtained indoor. There were no other mosquito species caught. It seems to be clear that, in this village, *A. aegypti* was acting as vector in association with *A. furcifer-taylori* during the 1978 rainy season.

MODI JABBU (13° 29' N, 14° 48' W)

This was the third of the villages surveyed in the Yorobawal area and was visited on 14 October. During the 1978 rainy season, the YF attack rate was 13.6/1,000. A relatively high *A. aegypti* Density figure of 5 (Breteau index : 47.5 ; container index : 19.0 %) was found on this survey. The main potential YF vector taken in the biting catch was again *A. furcifer-taylori* (11 females). We also obtained 1 each of *A. luteocephalus*, *A. vittalus* and *A. aegypti*. The other species collected were *An. gambiae* and *M. uniformis*.

3.4. North Bank Division

MINTEH KUNDA (13° 34' N, 15° 52' W)

YF cases were currently occuring when this Mandinka village was previously surveyed in January, 1979. *A. aegypti* was also found to be abundant at that time with a Density figure of 8, while adults were collected biting man. A single strain of YF virus was recovered from a human case (Vector Borne Disease Division, CDC, Fort Collins, Colorado) and two YF virus strains were isolated from *A. aegypti* (Institut Pasteur, Dakar).

Minteh Kunda was inspected on 21 October during the current survey and larval *A. aegypti* indices were found slightly lower than previously, with Density figure of 6-7 (Breteau index : 50.0 ; container index : 29.7 %).

The potential vectors caught during the biting catch were (females) : 18 *A. aegypti*, 3 *A. furcifer-taylori*, 2 *A. metallicus*, 1 *A. luteocephalus*. Four male *A. aegypti* were also obtained. Other species caught were *A. abnormalis* gr., *M. africana*, *M. uniformis*, *A. ochraceus*, *An. gambiae* gr., *An. rufipes*.

4. COMMENTS

4.1. A. aegypti

As can be seen from Table III, *A. aegypti* was found breeding in all of the sites checked. The larval indices appear to be generally higher than those found in January, which can be assigned to the fact that many peridomestic containers were holding water in October. Its potential for serving as a YF vector seems however to vary according to the geographical location.

EASTERN GAMBIA

In the McCarthy Island and Upper River Divisions one frequently finds a discrepancy between the larval breeding indices and adult biting activity. In Sambuldu, Sukuta, Sere N'Gai, Belal, Sare Bojo and Sare Hamadi no *A. aegypti* was taken biting man, despite the fact that larval Density figures between 1 and 5 were obtained. It is worthy to note that in Sukuta the YF attack rate was relatively high during the 1978 rainy season : no doubt that, in this village, the main vector was a sylvatic mosquito, obviously *A. furcifer-taylori* (Table IV). The *A. aegypti* incidence into the catches varies also seasonally (see above, Sare Hamadi). Further, in all of these villages, breeding sites were found mainly outdoor : 38 positive outdoor (peridomestic and domestic) compared with 6 positive indoor containers. The adults collected are mainly belonging to dark forms : the pattern value varies from 1 to 2 on 17 examined individuals (mean pattern value : 1.2). In such instances, *A. aegypti* seems to be mainly from « feral » (more or less anthropic) forms, the anthropophily of which appears to be relatively low.

But in some places, such a discrepancy is less marked. *A. aegypti* females have been caught biting man in Kurup, Bansang and particularly in Sare

N'Gaba, where the YF attack rate was found to be quite high in the 1978 rainy season. Further more, YF cases were recovered from several places in Eastern Gambia during the 1979 dry season, when we have evidence that *A. aegypti* was the only probable vector present (Germain *et al.*, in press, *b*) : it can be considered that the anthropophily of *A. aegypti* is eminently variable according to location and that in some of the areas it indoubtedly served as a vector in a man to man transmission process.

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No discrepancy was noted between larval indices and results from biting catches. In Minteh Kunda, *A. aegypti* breeds mainly indoor (19 positive indoor compared with 6 outdoor containers) and about 50 % of the caught females are of the light form (*queenslandensis*). The pattern value varies from 1 to 10 (L_3) with a mean pattern value of 4.75 on 12 examined specimens, denoting a more domestic and anthropophilic population. YF cases were recorded during the dry season when *A. aegypti* was the only probable species acting as a vector. Furthermore, YF virus, as seen before, was isolated from it. *A. aegypti* was undoubtedly the epidemic vector during the 1978 outbreak in this part of the Gambia.

4.2. A. (Diceromyia) furcifer-taylori group

This group of species, which cannot be separated on female morphology, was collected in all surveyed locations, except the forest near Kurup. It was frequently caught in villages, from four of which (Sambuldu, Belal, Sare Bojo, Sare N'Gaba) it was collected in biting collections inside houses. The feeding activity of this species group is typically crepuscular, apparently in a short wave. In Eastern Gambia, it was obviously the main YF vector during the 1978 rainy season, as had yet been suggested by Port and Wilkes (1979). The observations of M. T. Gillies in the village of Kurup corroborate this findings. The prevalence of this species during the current survey was higher than for *A. aegypti* (80 females compared to 15). In several villages where the YF attack rate was fairly high during the 1978 rainy season, *A. aegypti* didn't appear in the catches of the current survey (Sambuldu, Sukuta, Sare N'Gai, Belal). *A. furcifer-taylori* was certainly the main monkey to man vector and its probable part in a man to man transmission process must be borne in mind.

In Western Gambia, the recurrence of this species and other potential sylvatic vectors made possible a process of sylvatic transmission. Accordingly, in January 1978, a part of the sampled monkeys were found serologically positive to YF virus. At this time however, *A. furcifer-taylori* was not present in the biting catches while YF virus could easily be introduced in a village such as Minteh Kunda by an infected person, in a parallel process.

4.3. Other potential vectors

A. luteocephalus was caugh (6 females) in Kurup, Kurup forest, Bansang, Modi Jabbu, Minteh Kunda. *A. metallicus* was obtained (9 females) in Sambuldu, Kurup, Bansang and Minteh Kunda. *A. vittatus* (2 females) was caught in Bansang and Modi Jabbu. A positive breeding site (*A. vittatus* larvae and adult ex-pupa) was found in an outdoor clay pot, in the town of Basse.

All these species can have played a subsidiary role in the YF transmission.

M. africana is also known to be able to transmit YF virus in laboratory experiments, but the extrinsic incubation period, in this species, is quite long. This species was taken in biting catches in all locations except Sare Hamadi and Sare N'Gaba. *M. africana* also remained relatively abundant during the dry season (Germain *et al.*, in press, *b*) and it cannot be absolutely excluded that it played then a part in the YF virus maintenance. Nevertheless, its possible role in sylvatic transmission, if any, is probably negligible.

5. CONCLUSION

We shall summarize as follows the most probable mechanism of the 1978-1979 outbreak in the Gambia.

5.1. Rainy season

The epidemic started and developed in Eastern Gambia. The 1976-78 increase of the rainy season duration very likely favoured the YF virus circulation and its annual amplification cycles among the monkey populations. Such a mechanism, as a whole, could be assimilated to a fluctuation of the YF Emergence Zone northern limit (Germain *et al.*, in press, *b*). The Gambia appartenance to this last zone would seem to be more instable than that of South and South-eastern Senegal where numerous YF strains have been isolated from wild mosquitoes and monkeys since 1976 (Cornet *et al.*, 1979 ; Germain

et al., in press, *b*). Feral vectors, chiefly *A. furcifer-taylori* group, permited both such a sylvatic process and monkey to man transmission (perhaps also man with the *Diceromyia*). In some places, *A. aegypti* appears to be anthropophilic enough to have been associated as a man to man vector.

5.2. **Dry season**

To this more or less mixed epidemiological pattern (« intermediate type », Cornet *et al.*, 1977), which probably prevailed from beginning of the outbreak to end of November, succeeded a second phase during which (*M. africana* being a very improbable vector) the transmission strictly became of a man to man type, with *A. aegypti* as only and classical vector. It was the moment when the epidemic appeared in Western Gambia and only reached at a end with the vaccination campaign.

As a whole, the entomological survey done in October 1979 corroborates the conclusions of the previous investigations.

As it has been stressed in one of our previous papers, the most original interest of the Gambia outbreak is to have permited the analysis of an epidemic mechanism in an area which assumes a border line situation between the YF « Emergence Zone » and the « Potential Epidemic Area » as previously defined in recent theoretical approaches of the YF support mechanism in Africa (Chippaux *et al.* 1976 ; Germain *et al.*, 1976 ; Cordellier *et al.*, 1977 ; Cordellier, 1978 ; Germain *et al.*, in press, *a*).

ACKNOWLEDGMENTS

We are indepted to Dr. G. Port for assistance in the larval survey in Banjul and to Dr. M. T. Gillies and Dr. J. Bryan for discussion of their results of earlier biting catches in some of the villages. We wish to acknowledge the assistance of the Gambian Ministery of Health and particularly Dr. E. M. Samba and P. Gowers for the logistical support. Dr. N. B. Akim, WHO coordinator and Dr. M. Saifullah also greatly assisted us, as did also Dr. S. Fitzgerald (U.S.A.I.D.). We also wish to thank the Medical Research Council, Fajara, and particularly Dr. I. McGregor, its Director, Mr. P. Moore, Mr. C. Ross and Mr C. Pine for special help.

Manuscrit reçu au Service des Publications de l'O.R.S.T.O.M. le 25 février 1980.

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