peut-être moins accusé que dans le cas des vibrions cholériques classiques, ce qui indiquerait une résistance du biotype El Tor supérieure à celle du biotype classique, mais il n'en existe pas moins et on peut en tirer des conclusions identiques sur l'extinction des épidémies de choléra.

Quant au mécanisme de ces phénomènes, plusieurs hypothèses ont été envisagées — action d'un bactériophage ou d'une vibriocine, recombinaison génétique? — sur lesquelles nos recherches en cours ne nous permettent pas encore de nous prononcer.

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Anopheles nili as a Vector of Malaria in a Lowland Region of Ethiopia*

by E. S. KRAFSUR [1]

Anopheles (*Cellia*) *nili* (Theobald, 1904) was described as a " major vector of regional importance " in West Africa by Hamon & Mouchet (1961). Lewis (1956) suggested that the species may transmit malaria in the southern Sudan. In the Northern Guinea savanna of Nigeria, Service (1963) found *An. nili* to be anthropophilic, endophagic, exophilic, and a vector of malaria secondary to *An. gambiae* and *An. funestus*. In general, the results of precipitin testing suggest that this species is highly anthropophilic, at least in West Africa (Bruce-Chwatt et al., 1966). Gillies & de Meillon (1968) reviewed the bionomics and vectorial status of *An. nili*; virtually all information concerns West or Central African forms and *An. nili* from other regions remain poorly known.

The present observations were made over the period from June 1967 through December 1968 and concern the role of *An. nili* in the transmission of malaria in an unsprayed lowland region of western Ethiopia, an area climatically similar to that described by Hanney (1960) and Service (1963) in Northern Nigeria, and indeed to much of the savanna of West and Central Africa (Choumara et al., 1959).

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Methods

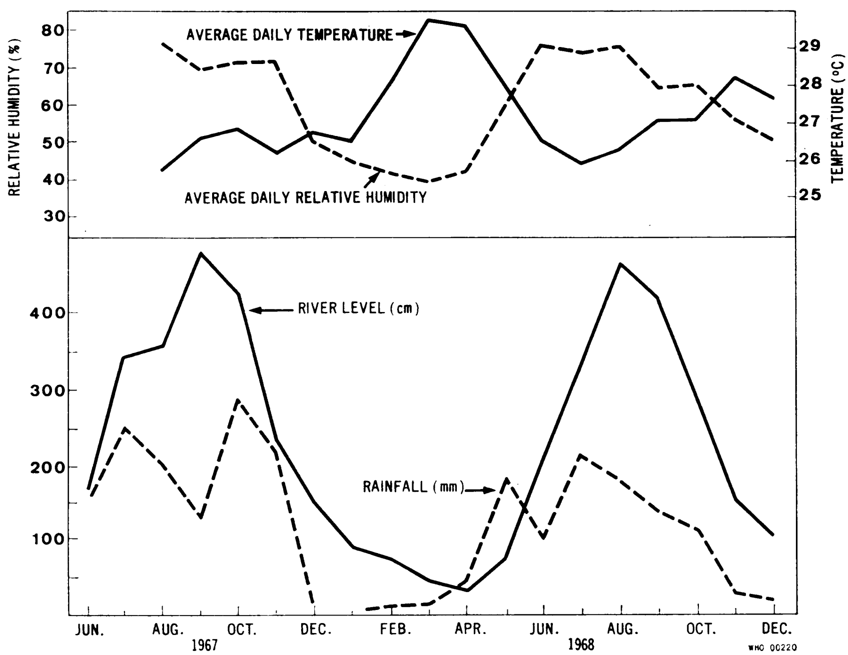
The study region lies at the foot of the highland escarpment at an elevation of approximately 525 m. Work was centred in Gambela, a town of approximately 1600 inhabitants, and in smaller villages within 8 km. A permanent river, the Baro, borders the study area. The region is a savanna with rainfall largely confined to the period from May through November and totalling 1016 mm to 1524 mm (40 in–60 in) a year. The region is populated mostly by members of the Anuak tribe, a Nilotic people who keep no domesticated animals other than chickens and, rarely, dogs. Most of the populated areas are seasonally inundated by the flooding Baro in August and September; floods seem to be correlated with rainfall in the nearby highlands rather than in the savanna (see the accompanying figure).

The frequency of man–vector contact was estimated by indoor pyrethrum space-sprays and all-night biting catches from human bait conducted simultaneously indoors and outdoors twice weekly. Space-spray collections were performed in the early morning 4 days a week in the town of Gambela, and twice weekly in the river villages more typical of the region. Biting collections from human bait were made only in town, in 2 separate locations. Three collector-baits were stationed indoors, and 3 outdoors nearby; catches were made twice weekly from 18.00 hours to 07.00 hours local time and were supervised throughout.

Observations

Populations of *An. nili* were virtually absent during the dry season, but became abundant within 2

METEOROLOGICAL CONDITIONS PREVAILING IN GAMBELA



months of the onset of the rains in May. Proliferation thereafter was correlated with the height of the river Baro rather than with rainfall *per se*, and peak densities of *An. nili* (Table 1) corresponded with maximum flooding (see the figure). Larvae were found in the seasonal tributaries of the Baro and in the river itself, rather than in the inundated plains. The paucity of *An. nili* in the dry season, despite the presence of a permanent, albeit low-volume river, is difficult to explain.

Hut densities of *An. nili* in both 1967 and 1968 were approximately 16 times greater in the river villages than in the town of Gambela (Table 1). The differences may be explained by the much greater density of people in the town and the greater relative abundance of breeding sites near the river villages. In 1967, populations of *An. nili* were greater than in the following year, a fact related to the earlier and longer flooding period of 1967.

Biting catches from human bait in Gambela suggested very much higher densities of *An. nili* than are indicated by space-spray captures in the same location. Thus, when hut densities of *An. nili* were converted to derive an index of bites per man per night and averaged for the wet season of 1968, it was found that the bait-capture index over the same period was greater by a factor of 6.6. This suggests that *An. nili* here, as elsewhere, is exophilic in its post-feeding behaviour; the fact that indoor-resting *An. nili* was very rarely found in the semi-gravid or gravid condition lends further support to this contention. Endophagy was demonstrated by the fact that, when given equal opportunity to feed on human bait indoors or outdoors, 60% chose to do the former; however, *An. nili* was not as endophagic as *An. gambiae* or *An. funestus*, as is shown by the following tabulation, which expresses the indoor- and outdoor-biting preferences of the 3 species given a choice of 3 human baits indoors and 3 outdoors in Gambela (December 1967 through November 1968):

Species	*Percentage biting of total catch*	
	Indoors	*Outdoors*
An. nili	60.2	39.8
An. gambiae	80.0	20.0
An. funestus	82.5	17.5

Sporozoite rates for the wet seasons of 1967 and 1968 are given in Table 2, data on *An. gambiae* and *An. funestus* being included for comparison.

TABLE 1
RESULTS OF PYRETHRUM-SPRAY COLLECTIONS AND MAN-BITING CATCHES OF *ANOPHELES NILI*

	Gambela				River villages	
	Pyrethrum-spray		Bites per human bait per night		Pyrethrum-spray	
	No. of huts	Density per hut [a]	Indoor	Outdoor	No. of huts	Density per hut [a]
1967						
June	71	0.07	—	—	—	—
July	150	0.33	—	—	—	—
Aug.	155	0.15	—	—	—	—
Sept.	144	0.79	—	—	—	—
Oct.	160	0.48	—	—	—	—
Nov.	114	0.94	—	—	30	6.93
Dec.	108	0.74	1.48	0.37	36	2.25
1968						
Jan.	108	0.04	0.17	0.08	42	0.05
Feb.	102	0.00	0.00	0.00	33	0.00
March	96	0.00	0.00	0.00	32	0.00
April	78	0.00	0.05	0.00	34	0.00
May	114	0.00	0.00	0.00	32	0.47
June	96	0.03	0.00	0.00	36	2.69
July	96	0.07	0.13	0.21	46	2.44
Aug.	114	0.21	0.71	0.75	63	4.98
Sept.	90	0.37	0.83	0.83	46	4.76
Oct.	108	0.33	0.71	0.46	42	3.33
Nov.	96	0.19	0.22	0.22	38	0.79
Dec.	60	0.08	0.05	0.00	16	0.50

[a] Divide these values by 3 (the average number of human occupants per hut) to calculate density per man.

Although the monthly dissections of *An. nili* were too few to reveal within-season trends, this species was proportionately as infective as *An. funestus* when considered on a seasonal basis. Both species were potentially more infective in the wet season of 1968 than they were during the same period of 1967, whereas similar sporozoite rates were observed in *An. gambiae* each year.

Bloods from 94 indoor-resting *An. nili* were subjected to precipitin testing against antisera to a wide range of vertebrate hosts. The results demonstrated that all specimens had fed exclusively upon human beings. Extremely few blood-fed *An. nili* were found resting in pit shelters, and it is concluded that the indices presented here do not represent biting contact with other hosts.

In order to estimate sporozoite inoculation rates by *An. nili*, indoor-resting densities were first converted into an index of bites per man per night. This was done by dividing the average number of people per hut into the seasonally averaged values of hut density. Although a census suggested that there were 2.8 people per hut, a value of 3 was employed in the calculations. In view of the exophilic behaviour of *An. nili*, the number of indoor-resting mosquitos per person was multiplied by 6.6 to compute a more accurate estimate of the man-biting rate (Table 3). This " computed rate " was

TABLE 2

SPOROZOITE RATES AMONG *AN. NILI*, *AN. GAMBIAE* AND *AN. FUNESTUS*, IN GAMBELA AND NEARBY VILLAGES, 1967–68

	An. nili		*An. gambiae*		*An. funestus*	
	No. pos./ No. dissected	%	No. pos./ No. dissected	%	No. pos./ No. dissected	%
1967						
July	0/4	—	1/155	0.65	—	—
Aug.	0/11	—	3/266	1.13	—	—
Sept.	0/17	—	11/435	2.53	0/5	—
Oct.	2/48	4.17	35/1 256	2.79	1/99	1.01
Nov.	0/117	—	10/422	2.37	2/220	0.91
Dec.	0/40	—	6/224	2.68	1/342	0.29
Total	2/237	0.84	66/2 758	2.39	4/666	0.60
1968						
May	0/4	—	4/423	0.95	2/245	0.82
June	0/74	—	2/290	0.69	2/313	0.64
July	2/59	3.39	4/179	2.24	5/146	3.42
Aug.	0/79	—	3/789	0.38	3/233	1.29
Sept.	2/93	2.15	23/719	3.20	17/649	2.62
Oct.	1/49	2.04	28/563	4.97	19/1 346	1.41
Nov.	1/24	4.17	15/276	5.43	34/1 297	2.62
Total	6/382	1.57	79/3 239	2.44	82/4 229	1.94

TABLE 3

AVERAGE MAN-BITING RATES OF *AN. NILI* AND ESTIMATED TOTAL NUMBER OF SPOROZOITE INOCULATIONS PER PERSON DURING THE 1967 AND 1968 WET SEASONS [a]

	Mean bites per man per day				Sporozoite rate (%)	Total estimated inoculations per person per season
	Pyrethrum-spray catch	Direct biting catch		Computed rate [b]		
		Indoor	Outdoor			
1967						
Gambela	0.167	—	—	1.10	0.84	2.0
River villages	2.670	—	—	17.66	0.84	32.0
1968						
Gambela	0.057	0.38	0.35	0.38	1.57	1.3
River villages	0.927	—	—	6.13	1.57	20.6

[a] Wet seasons: June–December 1967; May–November 1968.

[b] See text for method of computation.

then multiplied by the observed sporozoite rate and the product in turn multiplied by the number of days in each season. The final product is the total estimated number of sporozoite inoculations per person per season (Table 3). The ratio of actual bites as estimated by the all-night man-biting catch to bites as measured on the basis of indoor-resting specimens (6.6 : 1) was observed only in Gambela and was assumed to be true of the river villages as well.

To assess the relative importance of *An. nili* as a vector of malaria, inoculations per season were compared with those estimated from studies (Krafsur, unpublished) on *An. gambiae* and *An. funestus* (Table 4). In Gambela, *An. nili* was responsible for nearly one-fifth of the total inoculations during the wet season of 1968. In the much smaller river villages, *An. nili* was relatively more important than *An. gambiae*, contributing about 30% of the total inoculations.

Discussion

The computed man-biting rates and rates of inoculation presented here rest critically upon the postulates (1) that *An. nili* is endophagic but exophilic; (2) that results of the indoor man-biting catches established a reasonably accurate multiplier with which to correct the pyrethrum-catch data; and (3) that the salivary gland infections found were in fact of human origin. Garrett-Jones & Shidrawi (1969) pointed out that captures from human bait may often give exaggerated estimates of the man-biting rate. In the present circumstances, this is held to be unlikely because observations in Gambela suggested that man–vector contact of *An. gambiae* and *An. funestus* was no greater when measured by catches from human bait than by the pyrethrum-spray method (Krafsur, unpublished).

Thus it is thought unlikely that the corrected man-biting rates of *An. nili* are greatly exaggerated. On the contrary, the biting index suggested here may be a conservative estimate, being 6.6 times that inferred on the basis of the pyrethrum-spray catch. Hanney (1960) found *An. nili* biting man in 10 times the numbers indicated by collection of indoor-resting specimens. In the northern savanna of Upper Volta, Choumara et al. (1959) estimated that only 5% of those *An. nili* biting indoors remained there until the following morning, a ratio of 20 : 1.

Somewhat less confidence can be placed on the estimated number of inoculations by *An. nili*. The sporozoite rate was low and based on relatively few dissections. Thus the possibility of a biased sample was correspondingly great and errors were possibly exaggerated in multiplying together the sporozoite rate, the man-biting index, and the number of days per season in estimating the total number of inoculations. On the other hand, the sporozoite rate as determined here does not appreciably differ from that found among *An. nili* in Ghana (1.5% of 1685 dissections), Upper Volta (1.7% of 722 dissections), and Northern Nigeria (0.8% of 998 dissections) (Gillies & de Meillon, 1968).

More important than the exact quantities of the foregoing estimates is the fact that *An. nili* is a potent vector with certain undesirable behavioural features from the standpoint of control. The tendency to feed indoors but rest elsewhere raises the possibility that residual insecticides with a low vapour pressure may be ineffectual against this species. In DDT-treated villages of Bobo Dioulasso, Choumara et al. (1959) observed that *An. nili* became the primary vector of malaria because of its exophilic behaviour. A shift to increased exophagy was also observed. On the other hand, Service (1964) observed a similar resting behaviour on the part of

TABLE 4

ESTIMATED SPOROZOITE INOCULATIONS AND PERCENTAGE OF ESTIMATED TOTAL NUMBER OF INOCULATIONS DURING THE WET SEASON OF 1968, FOR EACH VECTOR SPECIES

	No. (and %) of inoculations			
	An. nili	*An. funestus*	*An. gambiae*	Total
Gambela	1.3 (18.6%)	1.7 (24.3%)	4.0 (57.1%)	7.0
River villages	20.6 (29.3%)	39.8 (56.6%)	9.9 (14.1%)	70.3

An. nili in Nigeria, and determined that, none the less, DDT plus malathion were quite effective against it.

It is of interest to examine the risk of malaria transmission by outdoor-biting *An. nili.* The inhabitants of the region studied rarely sleep out-of-doors during the wet season although some will retire to temporary field huts of grass while crops mature. Young adults are given to walking or canoeing long distances, and as a result they are exposed to outdoor-biting vectors. The situation is exacerbated by the constant movements of Nilotes to and from the southern Sudan and from other less accessible malarious areas within Ethiopia. Thus, under conditions of total insecticidal coverage, the possibility of transmission remains.

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The Effect of Small Single Doses of Chloroquine on *Plasmodium falciparum* Infections in North-eastern Tanzania *

by JAN LELIJVELD [1] & FABIAN MZOO [2]

Since the detection of strains of *Plasmodium falciparum* resistant to drugs of the 4-aminoquinoline group in South America and South-East Asia, awareness of the problem has spread to malariologists and clinicians in Africa.

Cases of apparent resistance have since been reported in publications and in service reports of medical and public health workers from various regions of Africa, including East Africa. Although none of these reports could be substantiated (see, for instance, the work of Jeffery & Gibson (1966) in Liberia and Upper Volta and of Wolfe & Hudlestone (1969) in Zambia), the possibility that such strains might occur causes concern.

The present investigations were carried out from November 1967 to August 1968, mainly in the Tanga region of north-eastern Tanzania where malaria is hyper- to holoendemic. An additional investigation carried out in the Mto wa Mbu settlement, in the Arusha region, is also reported.

In some localities the standard field test was used to determine the response of malaria parasites (WHO Scientific Group on Resistance of Malaria Parasites to Drugs, 1965). In other localities we followed a suggestion made by Pringle & Lane (1966) and tried to establish a 50% trophozoite clearance dose

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