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## *Anopheles nili* as the main vector of human malaria in villages of southern Cameroon

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**Abstract.** In villages near Sanaga river, in the forest zone of south Cameroon, *Anopheles nili* Theobald is the main species of mosquito regularly found biting man inside houses. Its densities are related to the flow level of the river. It is also the main malaria vector in terms of intensity and seasonal duration of transmission. The yearly malaria inoculation rate due to *An. nili* alone is 104 infective bites/man, varying between 3 infective bites/man in October and 20 in March. *Anopheles gambiae* Giles is a less important vector in the area but reached its peak in the dry season, when the Sanaga river is at its lowest level. These observations underline the influence of local ecology on malaria transmission and the need for entomological studies in each situation.

**Key words.** *Anopheles nili*, *Anopheles gambiae*, malaria vectors, vector bionomics, malaria transmission, Cameroon.

### Introduction

Since the work of Hamon & Mouchet (1961), *Anopheles nili* Theobald has been regarded as merely a local or temporary vector of human malaria, relatively less important than *An. gambiae* Giles and *An. funestus* Giles which are considered to be the main vectors of malaria in Africa south of the Sahara (Gillies & De Meillon, 1968; Gillies & Coetzee, 1987). The local importance of *An. nili* has been documented in the forest zones of southern Cameroon (Hamon *et al.*, 1956), Nigeria (Service, 1964), Ethiopia (Krafsur, 1970), Congo (Carnevale, 1974; Carnevale *et al.*, 1978) and Burkina Faso (Gayral *et al.*, 1975).

The current upsurge of drug-resistant strains of *P. falciparum* in Africa has renewed interest in malaria vector control. One of the methods currently envisaged is the large-scale use of insecticide treated bed nets (Curtis, 1989) which reduce the contact between man and vectors, thus reducing both inoculation rate and malaria morbidity. In preparing the framework for such a vector control programme involving *An. nili*, we collected entomological base-line data in villages located near the Sanaga river, southern Cameroon, where malaria is holoendemic and Mouchet (1962) studied *An. gambiae* biology. The climate is characterized by two rainy seasons: March–

June and August–November, and two dry seasons: July and December–February (Fig. 1).

For financial reasons, the local villagers have no special protection against the bites of mosquitoes.

### Materials and Methods

Three villages were chosen in the forested area, near to the Sanaga river (Le Goff *et al.*, 1990). This is a permanent river, but when its waters are low during December–June (Fig. 1) there are plentiful rock pool breeding sites available for *An. gambiae*. Because its banks have much trailing vegetation, this river provides good breeding sites perennially for *An. nili*.

We performed night catches of mosquitoes on human bait in four houses per village once a month from April 1989 to March 1990. Specimens were identified immediately and *An. gambiae* and *An. nili* were dissected. Ovaries were observed for parity according to Detinova (1963), and the salivary glands were examined microscopically for the presence of sporozoites.

### Results

The mosquitoes collected were 94% *Anopheles* with 6% of various other genera (Table 1).

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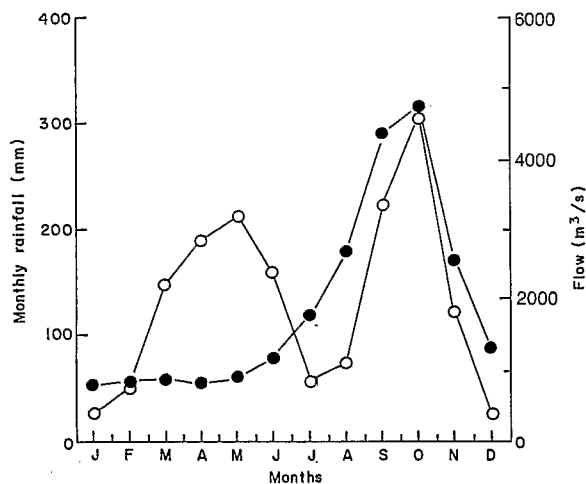


Fig. 1. Monthly rainfall (○) and flow level of Sanaga river (●).

Table 1. Mosquitoes caught on human bait inside houses: combined totals for 12 months × 2 man-night/month × 4 houses × 3 villages.

Species	No.	% of total
<i>Anopheles gambiae</i>	600	13.8%
<i>Anopheles nili</i>	3339	76.6%
<i>Anopheles funestus</i>	131	3.0%
<i>Anopheles paludis</i>	2	
Total Anophelinae	4072	93.4%
<i>Culex decens</i> group	5	
<i>Culex tigripes</i>	1	
<i>Culex quinquefasciatus</i>	2	
<i>Aedes vittatus</i>	8	
<i>Aedomyia furfurea</i>	2	
<i>Mansonia</i> spp.	268	6.1%
Total Culicinae	286	6.6%
Total Culicidae	4358	

#### Seasonal variations in biting rate

*An. funestus* represented only 3%, 131/4072 (Table 1) of anophelines collected and is discounted from further discussion.

*An. nili* was always present (Fig. 2) with an average number of bites per man-night of  $23.9 \pm 9.1$ , a maximum of 42 in September and a minimum of 11 in November (Table 2). Thus the annual biting rate of *An. nili* was about 8754 bites/man.

*An. gambiae*, *sensu stricto*, was always present (Table 2) with an average of  $4.2 \pm 2.8$  bites/man/night. This species showed high densities from December to June (mean  $6.5 \pm 0.9$  bites/man/night) when the Sanaga river level was low and rock pools were productive breeding-sites, and low densities from July to November (mean  $1.1 \pm 0.7$  bites/man/night) which corresponded to the second rainy

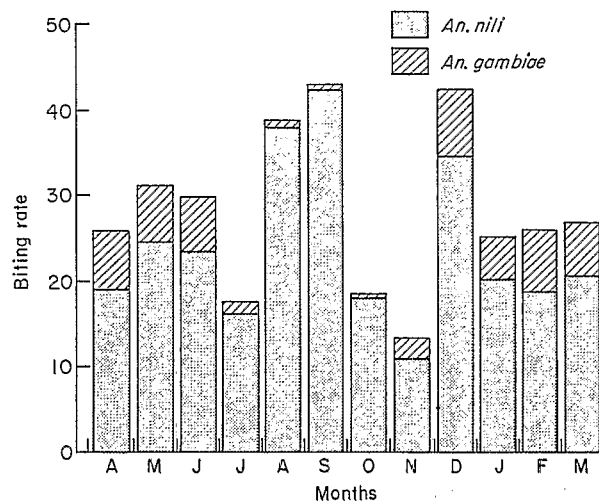


Fig. 2. Monthly mean daily biting rates of *An. nili* and *An. gambiae* indoors in Sanaga river villages.

Table 2. Daily mosquito biting rate and monthly malaria inoculation rate due to *Anopheles nili* and *Anopheles gambiae* in villages near the Sanaga river.

	<i>Anopheles nili</i>		<i>Anopheles gambiae</i>	
	Biting	Inoculation	Biting	Inoculation
April 1989	19.2	7.7	6.7	13.3
May	24.6	4.5	6.5	0
June	23.5	7.9	6.2	2.7
July	16.2	2.7	1.2	2.6
August	38.0	7.9	0.7	0
September	42.4	8.4	0.7	0
October	17.9	2.6	0.5	0
November	11.0	7.7	2.4	5
December	34.5	6.1	7.8	11.7
January 1990	20.2	10.8	4.8	8.0
February	18.6	17.1	7.2	15.2
March	20.6	21.3	6.2	18.9
Mean	$23.9 \pm 9.1$	$8.7 \pm 5.3$	$4.2 \pm 2.8$	$6.4 \pm 6.5$
Total	8754	104.7	1549	77.4

season and the higher levels of the Sanaga river. The annual biting rate of *An. gambiae* in this area was estimated to be about 1549. Thus inhabitants of these villages were bitten by malaria vectors throughout the year and could receive, in total, about 10,303 bites/person/year from *An. gambiae* plus *An. nili*.

#### Seasonal variations of longevity

The average parity rate of *An. nili* was about 64% ( $n = 3106$ ), i.e. a daily survival rate of  $p = 0.87$  according to the formula of Carnevale & Molinier (1980). The parity rate was at its highest (70–80%) when the mosquito

population density was lowest (20 bites/man/night) and parity was lowest (40–50%) when mosquito density was at its peak (40 bites/man/night) (Fig. 3).

For *An. gambiae* the average parity rate was 65.3% ( $n = 547$ ), i.e. a daily survival rate of  $p = 0.85$  calculated as above, not significantly different during the seasons of high (65.3%,  $n = 487$ ) and low (65.0%,  $n = 60$ ) mosquito population density.

The mean parity rates were similar for *An. nili* and *An. gambiae*, although the densities were very different with a ratio of 1:5 in favour of *An. nili*. From the average densities and parity rates the vectorial capacities, estimated with Garrett-Jones' (1964) formula, were 9.7 for *An. nili* and 1.5 for *An. gambiae* populations.

**Inoculation rate**

Of the 2977 dissected *An. nili*, 37 (1.24%) were found positive for malaria sporozoites and this species was found infective at all seasons. The monthly average inoculation rate due to *An. nili* was  $8.7 \pm 5.2$  infective bites/man (Table 2), surpassing 20 infective bites/man/month in March 1990 and falling to about 3 infective bites/man/month in July and October 1989.

Thus *An. nili* is responsible for perennial transmission of malaria in these villages (Fig. 4) and the total inoculation rate due to this species reached 105 infective bites/man/year (Table 2).

For *An. gambiae* the average sporozoite rate was 5.1% ( $n = 571$ ). The inoculation rate due to this species reached 19 infective bites/man/month at the beginning of the year (Table 2), i.e. a value similar to that of *An. nili*. However the rate varied greatly with population density of *An. gambiae* and was at its highest from December to April when people received a total of about of 67 infective

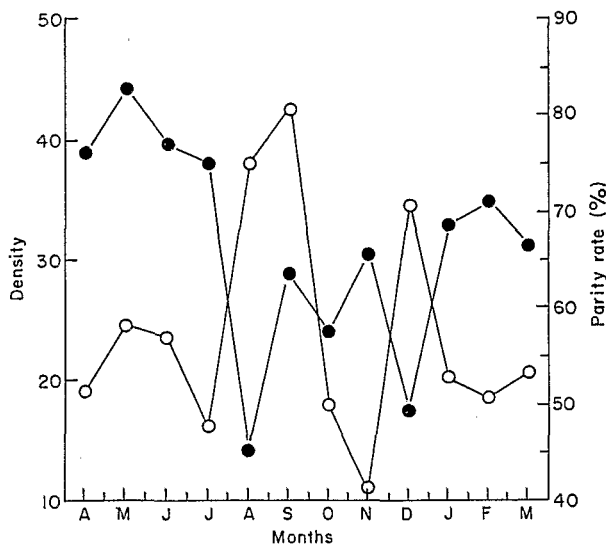


Fig. 3. *An. nili* monthly density (mean daily indoor biting rate on human bait) (○) and parity rate (●) in Sanaga river villages.

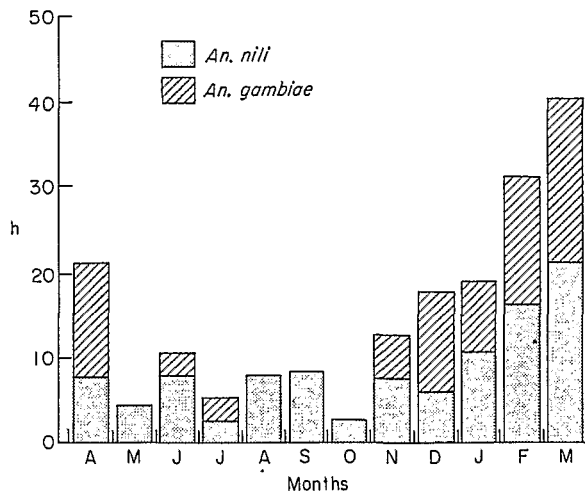


Fig. 4. Monthly malaria inoculation rate due to *An. nili* and *An. gambiae* in Sanaga river villages.

bites, i.e. 87% of all the infective bites due to this vector species in a year (Table 2). For the 6 months from May to October, during the second rainy season, the transmission due to *An. gambiae* was very weak and in 4 months not one of the 89 specimens examined was found positive (Fig. 4). The total inoculation rate due to *An. gambiae* was estimated at 77 infective bites/man/year, i.e. only 73% of that due to *An. nili*.

Adding the malaria inoculation rates due to both vector species, one can estimate that people of this region receive, on average, about 182 infective bites per person per year.

**Discussion**

This study confirms the importance of *An. nili* as the principal malaria vector in riverside villages of southern Cameroon.

Also in the forest zone of Congo, near a permanent river, it was found that the average parity rate of the *An. nili* population was about 66% ( $n = 4285$ ) (Carnevale, 1974) and this species was the main vector during the dry season when *An. gambiae* was absent. These two species of vectors thus acted in a complementary way, although the bulk of malaria transmission was due to *An. gambiae* in Congo villages.

In villages of the forest zone in southern Cameroon, near the Sanaga river, the parity rate of *An. nili* was similar to that observed in Congo and *An. nili* was the main vector in terms of perennial intensity of human malaria transmission. The seasonal increase of transmission due to *An. gambiae* is linked to the level of the Sanaga river which recedes to leave rock pools available for *An. gambiae* breeding. In this area Mouchet (1962) found a density of 5–6 *An. gambiae* females per house. Thirty years later we found a similar biting rate with an average of  $4 \pm 3$  *An. gambiae* bites/man/night. Adam (1956) found sporozoite rates of 3.1% ( $n = 1047$ ) and 2.6% ( $n = 470$ ) for

*An.gambiae* and *An.nili* respectively. Hamon et al. (1956) noticed that the *An.nili* density by house can reach 20 in the forested area near Yaounde, while we found an average of 24 bites/man/night in 1989. These comparisons show the stability of anopheline populations in villages where no vector control operations have been carried out.

People of these villages receive more than 10,000 bites of *Anopheles* annually, of which almost 200 are infective, due to *An.nili* acting as the principal and perennial vector, plus *An.gambiae* with seasonal peaks. Such a high level of biting and inoculation justifies a vector control programme.

These studies underline the need for entomological evaluation of every malariological situation in relation to the concept of stratification in malariology (W.H.O., 1986).

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