

Short Research Communications

Variations in species composition and infection rates in *Anopheles gambiae s.l.* across eco-vegetational zones in Nigeria and Cameroon

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Significant variations in vector biology within and between countries have been reported in malaria epidemiological studies¹. It is now generally agreed that a clear understanding of the detailed epidemiology of the disease is a pre-requisite to effective malaria control in the African sub-region². *Anopheles gambiae* complex (Diptera: Culicidae) is one of the most efficient vectors of *Plasmodium falciparum* in the African sub-region; it is a complex of sibling taxa³. Two of these sibling species, *An. gambiae sensu stricto* and *An. arabiensis* are the major vectors⁴. Relative abundance of the sibling species varies across eco-vegetational zones^{5–8}. Vector competence among sibling species is dependent on the degree of anthropophily, endophily and ability to recover after the dry season⁵. Consequently, variations occur in infection rates among sibling species^{9–10}. Two of the problems of malaria vector control in Nigeria are the diversity of anopheline vectors and large size of the country. Infection rates varied across ecological zones in Nigeria¹¹ and Cameroon¹². This report focuses on species composition and infection rates from investigations conducted to obtain key entomological indices of *An. gambiae s.l.* in four villages across eco-vegetational zones in Nigeria (Igbo-Ora and Bama) and Cameroon (Fokoué and Mora). Malaria is perennial and endemic at Igbo-Ora, Bama, Mora and Fokoué, with transmission reaching its peak in August; the density and activity of *An. gambiae s.l.* in these villages follow the rainfall patterns¹³.

Bama (13.68° E, 11.16° N) and Mora (14.68° E, 11.05° N), villages in the Lake Chad Basin are in the Sudan savanna; Igbo-Ora (3.28° E, 7.43° N) in the Savanna woodland ecotone, between the forested south and the Savanna, while Fokoué (10.12° E, 5.35° N) is located in the hilly savanna woodland of central Cameroon. There are two overlapping seasons in the forest and savanna woodland: November–April (dry), May–October (rainy); the Sudan savanna is characterized by three seasons: hot-dry (February–May); rainy (June–September) and dry humid (October–January). Detailed description of Igbo-Ora has been documented elsewhere¹⁴.

The four villages were surveyed and marked into quarters containing groups of houses. The rivers and streams that traverse the villages served as key landmarks for the selection of collection sites. Mosquitoes were collected weekly from May 2004–October 2005 to cover the dry and rainy seasons. Mosquitoes were caught using an aspirator from residual fauna of indoor resting mosquitoes during the periods: 0800–1100 hrs and 1600–1900 hrs. Sample processing, analyses and data acquisition for the identification of sibling species and determination of infection rates were done. Sibling species were identified using PCR¹⁵ and infection obtained by the circumsporozoite (CSP) antigen by sandwich ELISA¹⁶. The Chi-square and Student's *t*-test were used for statistical analyses.

Table 1. Numbers of mosquitoes collected from study villages of Nigeria and Cameroon

Village	Species	No. collected (%)	
		2004	2005
Bama	<i>An. arabiensis</i>	25 (58.1)	136 (100)
	<i>An. gambiae s.s.</i>	18 (41.9)	0 (0)
Igbo-Ora	<i>An. arabiensis</i>	216 (55.4)	68 (49.3)
	<i>An. gambiae s.s.</i>	174 (44.6)	70 (50.7)
Mora	<i>An. arabiensis</i>	1 (100)	11 (91.7)
	<i>An. gambiae s.s.</i>	0 (0)	1 (8.3)
Fokoué	<i>An. arabiensis</i>	0 (0)	0 (0)
	<i>An. gambiae s.s.</i>	0 (0)	5 (100)

In the arid Sudan savanna, Bama (Nigeria) and Mora (Cameroon), *An. arabiensis* was more abundant than *An. gambiae s.s.*, constituting 58.1–100% (Table 1). When the data from both villages were used, the difference in abundance was significant in both years: 2004 ($\chi^2 = 0.708$; $p < 0.05$) and 2005 ($\chi^2 = 11.41$; $p < 0.05$). Pooling of the 2004 and 2005 data for each village showed that the differences were also significant: Bama ($\chi^2 = 63.30$; $p < 0.05$) and Mora ($\chi^2 = 0.07$; $p < 0.05$). In the savanna-woodland, Igbo-Ora (Nigeria) and Fokoué (Cameroon), annual differences in species abundance of the pooled data from both villages were significant: 2004 ($\chi^2 = 390$; $p < 0.05$), 2005 ($\chi^2 = 4.97$; $p < 0.05$). When the 2004 and 2005 data were pooled in each village, the differences were also significant: Igbo-Ora ($\chi^2 = 1.53$; $p < 0.05$) and Fokoué ($t = 1$; $p < 0.05$).

At Bama, in the arid Sudan savanna, the infection rate in *An. arabiensis* was higher in 2004, but the difference was not significant ($t = 1$; $p > 0.05$). In 2005, no infective mosquito was recorded in both species (Table 2). At Igbo-Ora in the savanna woodland, the infection rate in *An. arabiensis* was higher in 2004, but in 2005, the infection rate in *An. gambiae s.s.* was higher. However, the pooled 2004 and 2005 data did not reveal any significant difference in infection rates between species ($\chi^2 = 0.48$; $p > 0.05$). The significantly higher number of *An. arabiensis* in the Sudan savannah of Cameroon and Nigeria is in agreement with the conclusions of earlier studies that *An. arabiensis* is more adapted to drier habitats^{12,17}. However, the higher number of *An. arabiensis* at Igbo-Ora, approximately 70 km from coastal Lagos¹⁸ was evidence of an advance of the species to more humid areas in West Africa. This southward advance of *An. arabiensis* had also been observed in Cameroon where Domfang *et al*¹⁹ recorded *An. gambiae s.s.*, *An. arabiensis* and *An. funestus* at Tibati, a village in the savanna woodland zone. The observed southward advance of *An. arabiensis* highlights the limitation in the exclusive reliance on climate and distributional data or the use of spatial imaging to predict species occurrence^{6,17}.

The higher infection rate of *An. arabiensis* in the Sudan savanna was not surprising because it had been reported as contributing a large proportion of the infectious mosquito bites on the African continent^{10,20–21}. The northward advance of *An. gambiae*

Table 2. Infection rates of *Anopheles gambiae s.s.* and *An. arabiensis* at villages in the Sudan savanna and savanna woodland, Nigeria

Village	Species	Periods					
		2004			2005		
		No. examined	No. positive	Infection rate	No. examined	No. positive	Infection rate
Bama	<i>An. arabiensis</i>	25	1	4	0	0	0
	<i>An. gambiae s.s.</i>	18	0	0	0	0	0
Igbo-Ora	<i>An. arabiensis</i>	216	5	2.31	68	1	1.47
	<i>An. gambiae s.s.</i>	174	2	1.15	70	2	2.85

s.s. into the arid north at Bama in 2004, reflected the plasticity of the species, which was highlighted by White⁵. The extremely low mosquito numbers at Mora might have been due to local behavioural peculiarities, such as exophily after a blood meal. The low numbers recorded at Fokoué was probably associated with low temperatures in the hilly terrain. The non-significant difference in the infection rates recorded in *An. gambiae* s.s. and *An. arabiensis* from the combined data of 2004 and 2005, indicates the importance of both species of the *An. gambiae* complex in malaria transmission in the arid north or humid south of West Africa, although *An. gambiae* s.s. had often been considered a more competent vector⁴.

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