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Seasonal dynamics of anopheline species and entomological parameters involved in malaria transmission in Mokolo, Far North, Cameroon

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***Abstract*---**In order to inventory anopheline species and assess entomological parameters directly involved in the transmission of malaria to humans, an entomological study based on nocturnal captures of adult mosquitoes on human bait was carried out during the dry season (March, April and May) and the rainy season (July, August and September) of 2022 at four sites (Ouro Tada, Tasha Gawar, Tasha Koutourou and Mbikem) in the town of Mokolo, Far North Cameroon. Mosquitoes were captured on human bait using the method developed by Le Goff *et al.* (1992). This method made it possible to capture Culicidae that are aggressive towards humans and likely to transmit disease, in order to assess entomological and epidemiological factors linked to the vector. A total of 2835 adult anopheles were captured at the four sites in the town of Mokolo. *Anopheles gambiae* s.s ranked first in proportion (1705/2835), i.e. 60.14%, followed by *Anopheles arabiensis* (882/2835), i.e. 31.11%, *Anopheles funestus* (248/2835), i.e. 8.74%. The anopheles aggressiveness rate is 13.32 p/h/year. Of the 1705 female of *Anopheles gambiae* ss ovaries dissected, 1258 showed parous ovaries, giving an average share rate of TP=73.78%. More than half of the anopheline population is pare, which means that the town of Mokolo is an epidemiologically dangerous zone. The average daily vectorial capacity is 25.34 days. This means that *Anopheles gambiae* ss is potentially responsible for more than 25 new infections per day in the absence of infection, during the study period. The average annual malaria stability index in Mokolo is Ist =9. This classifies Mokolo as an area of stable transmission during the study period.

***Keywords*---**species, anopheles, entomological parameters, malaria, Mokolo, Cameroon.

1. Introduction

Mosquitoes are responsible for major public health problems through their role as excellent vectors of infectious and harmful diseases affecting humans (Service, 2004). These diseases contribute enormously to global underdevelopment, particularly in tropical countries (Lehane, 2005). During their blood meal, they can transmit agents responsible for several diseases such as malaria, dengue fever, yellow fever, encephalitis, filariasis (Das and Ansari, 2003). Malaria is an infectious disease caused by the protozoan *Plasmodium* spp. and transmitted by the infecting bite of a female mosquito of the genus *Anopheles* (Carnevale *et al.*, 2009). It is a major public health problem in tropical countries (WHO, 2012a). In 2023, countries around the world reported a total of 263 million cases of malaria, of which 95% (236 million) occurred in the WHO African Region (WHO, 2024). The global death toll from malaria reached 597,000 deaths, 97% of which occurred in the African region (WHO, 2024). In Africa, nearly 246 million cases of malaria were recorded in 2023, with almost 560,000 deaths, 76% of which involved children under the age of five (WHO, 2024). *Plasmodium falciparum* is the most widespread malaria parasite in sub-Saharan Africa, with *Anopheles gambiae* sl as the major vector (WHO, 2022). In Cameroon, 7,890,000 cases of malaria were reported in 2023, with 11,343 deaths (WHO, 2024). Despite government efforts through seasonal chemoprevention campaigns for children under five, and the distribution of long-acting mosquito nets, malaria remains a major endemic disease and the main cause of mortality and morbidity. Today, there are no data on vector typology or entomological parameters of malaria in the four sites chosen for our study. Yet people in this part of the country regularly go to hospital because of this scourge. Given this situation, it is urgent to carry out an entomological study to establish baseline data in the Mokolo locality. The aim of this research is to inventory vector types and determine the entomological parameters directly involved in the transmission of malaria to humans.

2. Materials and Methods

2.2.1. Choice of sites and duration of mosquito captures

During the survey, four sites out of six were chosen for nocturnal captures. These were: Ouro Tada, Tasha Gawar, Tasha Koutourou and Mbikem. The choice of these sites was based on a number of criteria: proximity to permanent larval breeding sites, the populous nature of the site and the willingness of heads of household to accept the captors in their homes. Anopheles were captured from February to September 2022 for a period of eight months, i.e. 4 months in the dry season (February to May) and 4 months in the rainy season (June to September), in order to obtain the human-aggressive anopheline fauna likely to transmit malaria and to assess the entomological and epidemiological factors linked to the vector.

2.2.2. Inventory of anopheline species

2.2.2.1. Frequency of captures

In each of the four sites, 4 capture houses were selected, also corresponding to 4 man-nights. Capture frequency was 1 trip per month, for a total of 6 trips. So: 4 houses x 4 sites (=16 catchers) x 8 months x 1 outing = 128 man-nights. The capture houses remained fixed and unchangeable until the end of the work. Capture was carried out from 8 p.m. to 6 a.m., with a shift change at 1 a.m. to avoid staff dozing off.

2.2.2.2. Human captures

The capturer, equipped with flashlight, capture tubes, pens and small bags labeled in hourly time slots, sits inside the capture house in breeches or rolled-up pants. He shines the flashlight on his legs every two to three minutes to see if a mosquito has landed to take a blood meal. Ideally, the mosquito should be captured as soon as it lands, before it bites. The mosquito resting on the skin is captured by carefully approaching the tube (Figure 1). The mosquito is wedged into the tube with the thumb, then the tube is sealed with absorbent cotton. It is then placed in the time bag corresponding to the time slot.

Figure 1: nocturnal capture of adult mosquitoes on human bait

2.2.2.3. Morphological identification of anopheline species

Morphological identification is carried out under binocular magnifying glass, using identification keys established by Gillies and De Meillon (1968) and Gillies and Coetzee (1987). The most frequently examined characters, particularly for species identification keys, were the pale bands on the posterior tarsomeres, which are narrow and only apical, the wing length, which is around 3mm (*Anopheles funestus*), maxillary palps with 3 pale bands (*Anopheles arabiensis*); maxillary palps with 4 pale bands (*Anopheles gambiae* ss).

2.2.3. Evaluation of entomological transmission parameters

2.2.3.1. Dissection of female anopheles caught on human bait

After identification, living, bloodless female anopheles were separated from the others for dissection. These were carried out in the early hours of the morning, using the method of Russel *et al.* (1963). The mosquito, stunned immediately after capture, was placed dorsally on a slide, with the abdominal part placed on the edge of a drop of tap water. A section is made between sternites 6 and 7. Using the left hand, hold the anopheles at trunk level, and pull out the terminal part with the right hand. The ovaries are then placed in a drop of tap water. The whole unit is left to air-dry. Drying results in air entering the trachea and the entire tracheal system serving the ovaries. The dried ovaries are examined under the microscope, using the 10X objective and, if necessary, the system is confirmed at the 40X objective.

2.2.3.2. Calculation of entomological parameters

- **Aggression rate (m.a):** The aggressiveness rate, also known as aggressiveness density, is the number of mosquito bites a man receives per unit of time (day, month, year) (MacDonald, 1957). It is obtained by capturing mosquitoes coming to bite man and dividing the number of Culicidae captured by the number of subjects used, per unit of time. It is expressed in bites per man per night (p/h/n) and is calculated using the formula below:

$$m.a = \frac{Number\ of\ mosquitoes\ caught\ per\ time\ unit}{Total\ number\ of\ overnight\ men}(p/m/n)$$

- **Sporozoite index (Is):** The sporozoite index represents the percentage of anopheles of a given species in which salivary glands dissected within 24 hours of capture contain sporozoites.

$$Is = \frac{number\ of\ positive\ salivary\ glands}{Total\ number\ of\ salivary\ glands\ dissected}\ (\%)$$

- **Parturition rate (TP):** The parturition rate is the ratio of parous females to the total number of dissected females and is expressed as a percentage (Denitova, 1963).

$$TP = \frac{P}{P+NP}\,x100$$

P= parous females; NP= nulliparous females.

- **Entomological inoculation rate (h):** The entomological inoculation rate (Ross, 1911) is the number of infected bites a man receives in a given period.

(h) = m.a.Is Is= sporozoic index.

- **Survival rate (p):** The survival rate is the daily probability of survival of female mosquitoes. It is obtained by the formula of Davidson (1954):

$$P = \sqrt[l]{\frac{P}{P+NP}}\quad ;$$

l being the length of the gonotrophic cycle ($l \cong 3$).

- **Life expectancy (E):** Life expectancy is calculated using MacDonald's (1957) formula as follows:

$$E=\frac{l}{-ln\,p}$$

p being the daily survival rate.

- **Infectious life expectancy (Ei):** Infecting life expectancy is estimated by Moskovsky's formula as follows (Détinova, 1963):

$$Ei = \frac{p^n}{-\,ln\,p}$$

n the value of the *Plasmodium falciparum* sporogonic cycle.

- Vectorial capacity (VC): Vectorial capacity (Garret-Jones and Schidrawi, 1969) represents the rate of potentially infecting contact (or daily malaria propagation rate) between individuals via the anopheline vector. It expresses the reproduction rate of the parasite in a given region, enabling us to assess the risk of transmission and the impact of insecticide treatments (Mouchet *et al.*, 1991).

$$VC = \frac{m.a^2 \times p^n}{-\ln\ p}$$

m: vector density relative to man;
a: number of blood meals taken from man by a vector in one day (= % of meals taken from man multiplied by 0.5, assuming a two-day gonotrophic cycle);
p: daily survival rate (or proportion of vectors surviving per day);
n: duration of the sporogonic cycle for the plasmodial species considered (or incubation period in the vector in days).

- **Stability index (ISt):** The stability index takes into account two main factors: life expectancy (1/-lnP), and the anthropophilic index (h) (Mac Donald, 1957).

$$Ist = \frac{h}{-\ln p}$$

h = anthropophilia index; p = daily survival rate

- If Ist< 0.5, malaria is unstable and may cause epidemics;
- If 0.5 = Ist = 2.5 malaria is of intermediate stability;
- If Ist> 2.5 malaria is stable.

2.2.4. Statistical analysis of results

Data were entered and analyzed using R software (i3864.1.0for Windows GUI front-end). The Chi-square test was used to compare the entomological parameters calculated, with the exception of anopheline density, between the two seasons (dry and rainy) and between capture sites. The Kruskal-Wallis H-test was used to compare more than two mean entomological parameters between capture sites simultaneously. The seasonal variation of these quantitative variables was assessed by Student's t test.

P<0,05 statistically significant

3. Results

3.1 Anopheles species identified

Anopheles captured when blood samples were taken were distributed over the four sites in the town of Mokolo (Table I). *Anopheles gambiae* ss occupied first place in proportion (1705/2835, i.e. 60.14%), followed by *Anopheles arabiensis* (882/2835, i.e. 31.11%) and *Anopheles funestus* (248/2835, i.e. 8.74%). A non-significant difference (x^2= 0.28571, *df* = 2, p-value = 0.3679) was observed between the proportions of these four species. This observation is similar to that made in most West African cities, where *Anopheles gambiae* s.l. is recognized as the main malaria vector (Carnevale and Mouchet, 1990). The dominance of the *Anopheles gambiae* ss species is also linked to three major factors: firstly, the rice-growing activities practised in Mokolo, which create numerous larval breeding grounds, most often favorable to the development of Anopheles larvae; secondly, the existence of permanent pools of water, offering favorable conditions (sunshine, little vegetation) for the development of Anopheles. This corroborates the observation made by Bouba *et al.* (2017) in three districts of Maga, where they realized that the dominance of the species *Anopheles gambiae* s.l. and the permanent aggressiveness observed are linked to the agricultural activities practiced in the study area and to the existence of a lake offering favorable conditions for its development. Finally, this high rate of *Anopheles gambiae* s.l. can also be explained by the fact that anopheles disperse very little from densely populated houses intended for capture. Studies on Anopheles dispersal have indeed shown that they spread very little in areas of high human population density (Saotoing, 2017). The results of the seasonal dynamics of the anopheline species inventoried showed that the number of anopheles captured was high in the rainy season (2407) compared with the dry season (428). However, a non-significant difference (t = 1.6768, *df* = 4, p-value = 0.1689) was observed between the numbers of the three species in the two seasons. This situation could be explained by the presence of water in all seasons all around the study area due to the existence of the small water retention dam. According to Saotoing (2017), the rainy season offers the different culicidian species a choice of breeding sites in terms of quality and quantity. The results of the present work are also similar to those of Abdousalam *et al.* (2019), who worked on the prevalence and risk factors associated with malaria in Abéché (Chad) and showed that the permanence of water favours mosquito breeding. In addition, the work of Akono *et al.* (2015) in Cameroon and Klinkenberg *et al.* (2008) in Ghana established that the arrival of the rains leads to the appearance of breeding grounds conducive to the development of mosquito larvae. Another study by Atangana *et al.* (2012) on the epidemiology of malaria in the Sudano-Sahelian zone of Cameroon (Mokolo) showed that *Anopheles gambiae* s.s, *Anopheles arabiensis* and *Anopheles funestus* were the vectors frequently identified in the area, and that the association of these vectors would have an impact on malaria transmission around the small Mokolo dam. According to these authors, the coexistence of *Anopheles gambiae* s.s, *Anopheles arabiensis* and *Anopheles funestus* makes the town of Mokolo a huge, uninterrupted focus of malaria, increasing the duration of transmission (Atangana *et al.*, 2012). This anopheline fauna has previously been observed in different regions of Cameroon and in the dry savannah regions of West Africa (Nkondjio *et al.*, 2008).

Table I: Seasonal distribution of anopheles captured at the four sites in the town of Mokolo

	Rainy season		**Dry season**		Total	
	n	%	n	%	n	%
Anopheles gambiae s.s	1506	88.32	199	11.68	1705	60.14
Anophèles arabiensis	751	85.15	131	14.85	882	31.11
Anopheles funestus	150	60.48	98	39.5	248	8.74
Total	2407	84.90	428	15.10	2835	100

n: number of employees; %: percentage

3.2. Entomological parameters of transmission of Plasmodium spp by *Anopheles gambiae* ss

3.2.1. Aggressiveness rate

A total of 1,705 *Anopheles gambiae* ss were caught on human subjects at the four capture sites, giving an aggressiveness rate (ma) of 13.32 p/h/year (Figure 2). A monthly variation in *Anopheles gambiae* ss aggressiveness rates was observed at each of these sites. The highest rates were observed in July, August and

September. In all four localities, the peak in aggressiveness rates was observed in August for the Ouro Tada, Tasha Koutourou and Mbikem sites. The Tasha Gawar site saw its peak aggressiveness in September. The lowest rates were obtained in February, March, April and May. Rates were highest at Ouro Tada (30.75 bites/man/night) and lowest at Tasha Gawar (13.25 bites/man/night). A very highly significant difference was observed between Anopheles aggressiveness rates across all four capture sites (x^2=15.726, *df* = 3, p-value = 0.00038).This leads to the conclusion thus that the aggressive density of *Anopheles gambiae* ss varies with locality. An entomological study carried out in Maga by Bouba *et al.* (2017) revealed a fairly low rate of Anopheles aggressiveness, with the highest in August (m.a = 18.22 p/h/n) and the lowest at the end of the dry season (April and May) and June, with 0.77 p/h/n, 1.61 p/h/n and 0.77p/h/n respectively.

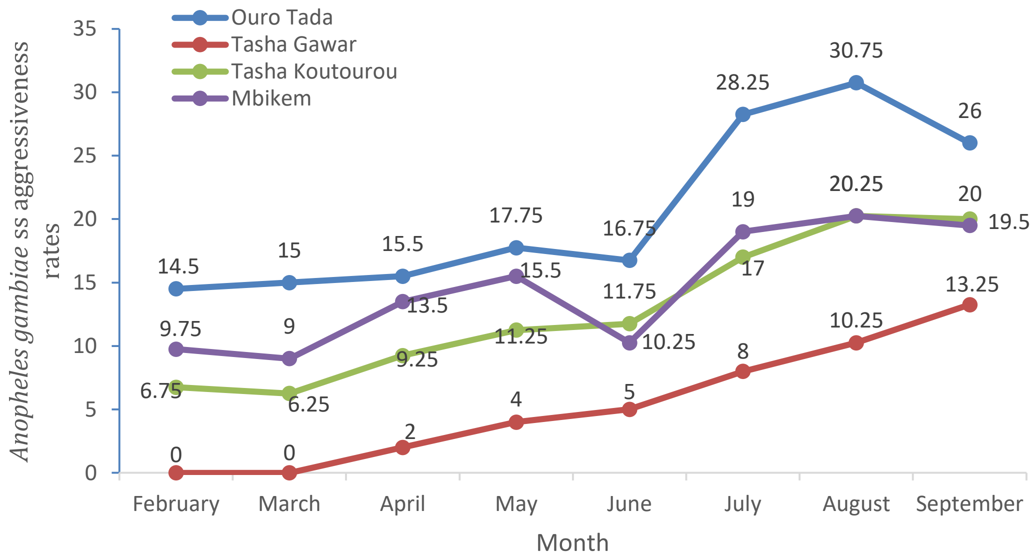

Figure 2: Variation in *Anopheles gambiae* ss aggressiveness rates at each capture site

3.2.2. Sporozoite index

Of 1705 female *Anopheles gambiae* ss salivary glands dissected, only 951 showed *Plasmodium* sporozoites, giving a sporozoite index of 55.77% (Table II). Akogbeto *et al.* (1992) conducted an entomological study of urban malaria in Cotonou, Benin, and found an average sporozoite count of 1.7%. In Yaoundé, Manga *et al.* (1992) found a sporozoite index of 5.2%. In Maroua, Saotoing (2017) conducted a study on *Plasmodium* transmission and found a sporozoite index of 9.9%. The difference between these different indices would depend on ecological factors (limited human/vector contact) and the mosquito's vectorial capacity. Considering the number of female anopheles captured and dissected positive in Mokolo, it would appear that female anopheles in this locality are highly dynamic in the transmission of Plasmodium to humans. The existence of sporozoites in the salivary glands of Mokolo mosquitoes indicates permanent contact between humans and Anopheles in this town, and that Plasmodium transmission is real.

Table II: Sporozoītic indices of *Anopheles gambiae* ss captured at the four sites in the town of Mokolo

Sites	Parameters	February	March	April	May	June	July	August	september	Global results
Ouro Tada	gl diss	58	60	62	71	67	113	123	104	658
	gl+	2	5	43	21	31	49	107	32	290
	Is	0.03	0.08	0.69	0.29	0.46	0.43	0.86	0.3	**0.44**
Tasha Gawar	gl diss	0	0	8	16	20	32	41	53	170
	gl+	0	0	4	2	11	28	23	8	76
	Is	0	0	0.5	0.12	0.55	0.87	0.56	0.15	**0.18**
Tasha Koutourou	gl diss	27	25	37	45	47	68	81	80	410
	gl+	6	3	23	19	41	53	72	67	284
	Is	0.22	0.12	0.62	0.42	0.87	0.77	0.88	0.83	**0.69**
Mbikem	gl diss	39	36	54	62	41	76	81	78	467
	gl+	21	17	15	23	37	57	78	53	301
	Is	0.53	0.47	0.27	0.37	0.9	0.75	0.96	0.67	**0.64**
Global results	gl diss	124	121	161	194	175	289	326	315	1705
	gl+	29	25	85	65	120	187	280	160	951
	Is	**0.23**	**0.2**	**0.52**	**0.33**	**0.68**	**0.33**	**0.85**	**0.5**	**0.55**

3.2.3. Entomological inoculation rate (EIR or h)

Figure 2 shows that the highest entomological inoculation rate was obtained during the month of August at Ouro Tada (26.44 p/h/n) and the lowest in the months of February (0.43 p/h/n) and March (1.2 p/h/n). At Tasha Gawar in July, the highest rate was observed (6.96 p/h/n) and the lowest in February, March, April and May. At Tasha Koutourou, the highest EIR was observed in August (17.82 p/h/n) and the lowest in February (1.48 p/h/n) and March (0.75 p/h/n). In Mbikem, a higher EIR was obtained in August (19.44 p/h/n) and the lowest (3.64 p/h/n) in April. Overall, transmission was lower in the dry season, with very low entomological inoculation rates. These results are in line with those obtained by Mamou (2025) in Mali, who found that transmission was low during dry seasons, with entomological inoculation rates to *P. falciparum* of less than one infecting bite per man per month. Transmission was mainly observed during the months of July, August and September. The results corroborate those of Dolo *et al.* (2004) who found that transmission was only observed during two months (August and September) despite the long rainy season.

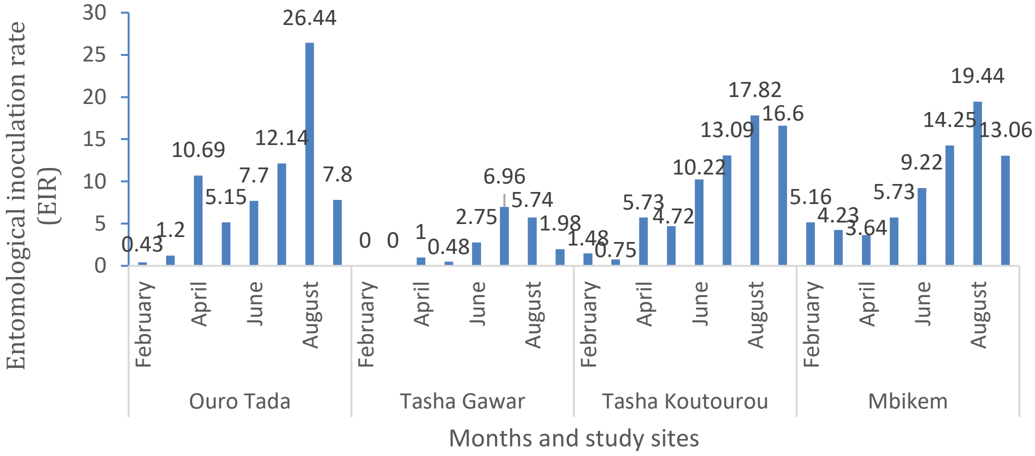

Figure 2: Entomological inoculation rate (EIR) for *Plasmodium* spp at the four sites

3.2.4. Parturition rate

Examination of the physiological age of the imaginal population of *Anopheles gambiae* ss captured at the four study sites shows that this population varied considerably over the study period from February to September 2022 (Table III). In fact, at all sites, average maturity rates varied from 60.03% in the dry season to 81.59% in the rainy season, with an annual average of 73.78%. A non-significant difference (x^2=0.3267, *df* = 3, p-value = 0.9549) was observed between the maturity rates of the two seasons. However, a predominance of the parting rate in the rainy season was noted. A similar fluctuation was observed in the forest zone of southern Cameroon by Njan Nlôga (1994), who found parturition rates ranging from 45.3% at the start of the short rainy season to 72.8% at the end of the rainy seasons. Saotoing (2017) reports that parturition rates are higher in humid zones than in savannah regions. The results also show that the highest maturity rates are observed at the beginning of the rainy seasons. This can be explained by the stability of larval breeding sites and the absence of leaching, since rainfall is irregular at the beginning and end of the rainy season, giving mosquito larvae the time they need to develop normally. This corroborates the observation of Saotoing *et al.* (2011b) who conclude in their work that in the absence of leaching, mosquito larvae develop normally.

Table III: Variation in Anopheles parturition rates at the four sites in the town of Mokolo

Sites	Parameters	February	March	April	May	June	July	August	September	Global results
Ouro Tada	Dissected ovary	58	60	62	71	67	113	123	104	658
	Parous ovary	23	32	37	42	53	79	93	81	440
	PR	0.39	0.53	0.59	0.59	0.79	0.69	0.75	0.77	**0.66**
Tasha Gawar	Dissected ovary	0	0	8	16	20	32	41	53	170
	Parous ovary	0	0	3	8	16	22	37	41	127
	PR	0	0	0.37	0.5	0.8	0.68	0.9	0.77	**0.74**
Tasha Koutourou	Dissected ovary	27	25	37	45	47	68	81	80	410
	Parous ovary	17	19	28	16	35	52	67	58	292
	PR	0.62	0.76	0.75	0.35	0.74	0.76	0.82	0.72	**0.71**

Sites	Parameters	February	March	April	May	June	July	August	September	Global results
Mbikem	Dissected ovary	39	36	54	62	41	76	81	78	467
	Parous ovary	36	31	43	51	37	57	69	75	399
	PR	0.92	0.86	0.79	0.82	0.9	0.75	0.85	0.96	**0.85**
Global results	Dissected ovary	124	121	161	194	175	289	326	315	1705
	Parous ovary	76	82	111	117	141	210	266	255	1258
	PR	**0.61**	**0.67**	**0.68**	**0.6**	**0.8**	**0.72**	**0.81**	**0.8**	**0.73**

3.2.5. Survival rate

In general, the daily survival rate of the adult population of *Anopheles gambiae* ss calculated according to the formula of Davidson (1954) is p= 0.9. In the different sites, this rate varied from 0.87, 0.9, 0.89 and 0.94 respectively for Ouro Tada, Tasha Gawar, Tasha Koutourou and Mbikem (Figure 3). A non-significant difference (x^2= 5.1012, *df* = 3, p-value = 0.4159) was noted between the daily survival rates of the four sites. This would mean that malaria transmission in the town of Mokolo was continuous throughout the study period. The average daily survival rate of *Anopheles gambiae* ss being 0.9 and therefore close to the number 1 is then high enough to keep the anopheles alive to encounter the preferred host, which is man. The present results confirm those obtained in Maroua by Saotoing *et al.* (2011a) where they obtain, p=0.79 and p=0.82 respectively in the dry and rainy seasons. Bouba *et al.* (2017) also obtained annual survival rates of 0.85, i.e. 0.84 and 0.86 in the dry and rainy seasons respectively.

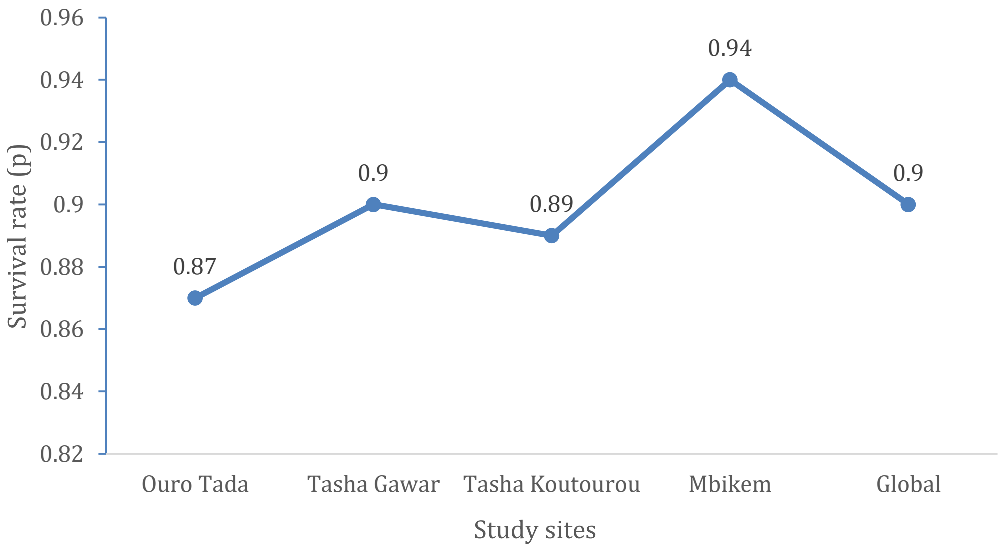

Figure 3: Variation in the survival rate of *Anopheles gambiae* ss in the different study sites

3.2.6. Life expectancy

In the study area, *Anopheles gambiae* ss has a long life expectancy of between 23.07 and 50 days (Figure 4). This increases the vector's chance of encountering its preferred human host. These results are in contrast to those obtained in the far north of Cameroon by Saotoing (2005), where he found that *Anopheles gambiae* sl had a life expectancy of between 4 and 5 days. This relatively short lifespan is not conducive to good transmission. As noted in the work of Bouba *et* *al.* (2017), this difference in life expectancy is linked to climatic conditions, which may favor mosquito outbreaks at the time of the study period. Depending on the site, life expectancies were 23.07, 30, 27.27 and 50 days respectively for the Ouro Tada, Tasha Gawar, Tasha Koutourou and Mbikem sites. A significant difference (x^2= 38.323; *df* = 3) was observed between the life expectancies of the four sites. The average life expectancy of anopheles found was much higher (13.04 days) than that found by Karch *et al.* (1993) in Kinshasa (8.5 days) and that found by Mulumba in Kinshasa (12.8 days), but lower than that obtained by Emery *et al.* (2015), which was 16.4 days. This difference is probably due to climatic and ecological conditions that are highly favorable to the development of anopheles (Karch *et al.*, 1993; Mulumba *et al.*, 2004). In southern Cameroon, Njan Nlôga (1994) carried out a study along similar lines, finding that *Anopheles moucheti* life expectancy was high at the start of the rainy season (9.4 days) and lower in the dry season (3.8 days). For this author, female Anopheles tend to live longer in the rainy season than in the dry season.

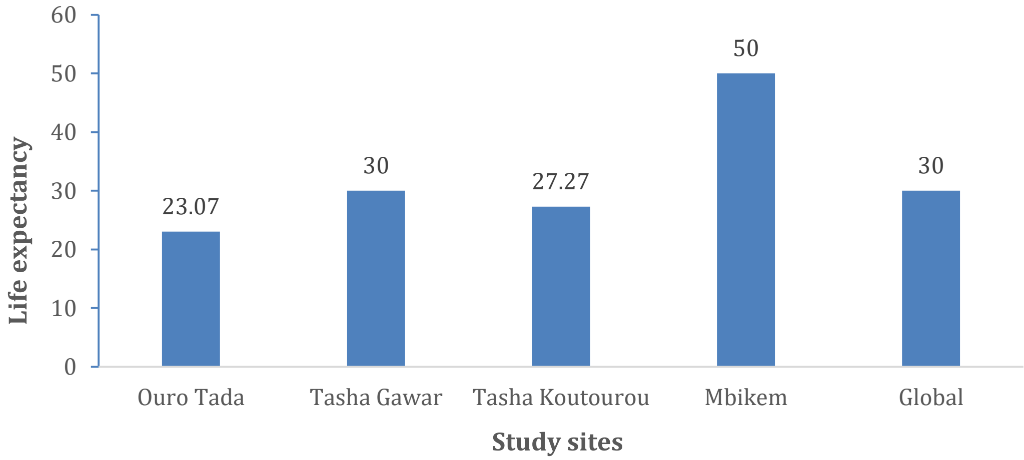

Figure 4: Variation in life expectancy of *Anopheles gambiae* ss

3.2.7. Infection life expectancy

In the study area, the average annual infection life expectancy calculated according to the formula of MacDonald (1957) and Moskovsky (Détinova, 1963) was 7.2 days (Table III). The variations observed are thought to be due to the vector agents involved. The shorter the duration of the sporogonic cycle, the faster the infected Anopheles will infect. The greater the longevity of the Anopheles, the greater the probability of transmitting the parasite to a greater number of people (Saotoing, 2017). The mean annual values for infecting life expectancy are 5; 7.2; 6.36; and 13.83 days respectively for the Ouro Tada, Tasha Gawar, Tasha Koutourou and Mbikem sites. These values are an indication or proof of the existence of contact between the vector and man. Mulumba *et al.* (2004) carried out a study on the estimation of survival parameters of *Anopheles gambiae* in the Kinshasa environment and found that the life expectancy of the infectant was between 3.0 and 5.9 days. The actual existence of the pathogen is revealed mainly by the presence of sporozoites in the salivary glands of female Anopheles.

Table III: Variation in infestation life expectancy of *Anopheles gambiae* ss

	Ouro Tada	Tasha Gawar	Tasha Koutourou	Mbikem	Global
p	0.87	0.9	0.89	0.94	0.9
p^n	0.65	0.72	0.7	0.83	0.72
-lnp	0.13	0.1	0.11	0.06	0.1
Ei	**5**	**7.2**	**6.36**	**13.83**	**7.2**

3.2.8. Vector capacity

Across all sites, the daily vector capacity was 25.34 (Table IV). This means that *Anopheles gambiae* ss could theoretically be responsible for 25 new cases of infection every day in the absence of protection, i.e. an average annual capacity of 9249.1 new cases of malaria infection. This value (25.34) is far higher than that obtained by Bouba *et al.* (2017), which is 14.9 new cases per day in the Maga rice-growing zone. Njan Nlôga (1994) carried out an entomological study in the forest region of southern Cameroon and obtained a vectorial capacity of 7 new cases of infection per day. *Plasmodium* transmission thus appears to be higher in irrigated areas than in dry savannah or sahel zones, or in humid forest zones. Bouba (2017) justifies this situation by the fact that, in rice-growing zones, the presence of a lake or water retention dam is responsible for the proliferation of anopheles through the drainage of water in irrigation canals.

Table IV: Vectorial capacity of *Anopheles gambiae* ss

	Ouro Tada	Tasha Gawar	Tasha Koutourou	Mbikem	Global
Ei	5	7.2	6.36	13,.83	7.2
m	658	170	410	467	1705
m (mean/day)	0.34	0.08	0.21	0.24	0.22
a^2	16	16	16	16	16
$m.a^2$	5.44	1.22	3.36	3.84	3.52
VC	**27.2**	**8.78**	**21.36**	**53.1**	**25.34**

3.2.9. Stability index (ISt)

The present work was carried out on the residual fauna, which revealed that mosquitoes bite humans inside dwellings. To this end, the anthropophilicity index can be considered equal to 99%. The average annual malaria stability index for Mokolo during the study period was 9, well above the standard value of 2.5 (Table VI). This classifies the town of Mokolo as a zone of stable transmission. In the Democratic Republic of Congo, Emery *et al.* (2015), in their work on determining the bioecological and entomological parameters of *Anopheles gambiae* sl in malaria transmission in Bandundu-ville, found a stability index of 6.512 in Bandundu-ville, higher than that observed in Brazzaville (5.04) in the Republic of Congo (Carnevale *et al.* 1985) and Kinshasa (3.50) (Karch *et al.* 1993). According to Emery *et al.* (2015), malaria is a loco-regional disease that must integrate the dynamics of environment/vector/parasite/disease relationships.

Table VI: Malaria stability index in the different study sites

	Ouro Tada	Tasha Gawar	Tasha Koutourou	Mbikem	Global
h	0.9	0.9	0.9	0.9	0.9
(-ln p)	0.13	0.1	0.11	0.06	0.1
Ist	**6.6**	**9**	**8.18**	**15**	**9**

h: anthropophilia index; p: survival rate; Ist: statability index.

Conclusion

Nocturnal captures of adult mosquitoes on human bait at the four sites in the study area confirmed the existence of three anopheline vector species: *Anopheles gambiae* ss, *Anopheles arabiensis* and *Anopheles funestus*, with prevalences differing from site to site. This diversity, the predominance of *Anopheles gambiae* ss and the entomological parameters of *Plasmodium* spp transmission place the town of Mokolo in a stable endemic zone. This study on the seasonal dynamics of anopheline species and the entomological parameters involved in malaria transmission in Mokolo therefore provides a set of data on the natural history of malaria in this locality, which was to be selected as a sentinel site for the National Malaria Control Program.

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