Entomological and parasitological indices of malaria transmission in Tungan-Goro and Gbaiko communities in Minna, Niger State, Nigeria

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Abstract

The occurrence of malaria in Nigeria is highly prevalent, most especially in Minna, Niger State. This study was carried out to determine the entomological and parasitological indices of malaria transmission in two communities, namely, Tungangoro and Gbaiko in Minna, Niger State, Nigeria. Collection of the mosquito was carried out using the Pyrethrum Spray Catch (PSC). The population's indoors were sampled by spreading on the floor for mosquito collection. White sheet of 5m x 5m each edge being held to the wall by a masking tape. The room was sprayed with pyrethroid insecticide (Baygon) and then left for 10 minutes, with every opening being shut. Out of the total number (742) of mosquitoes collected *Anopheles* species had a relative abundance of 456 (61.50%) with 273 (59.90%) females and 183 (40.10%) males. *Culex* species had a relative abundance of 286 (38.50%) out of which 155 (54.20%) were females and 131 (45.80%) were males. At both study locations *Anopheles* species were greater in number compared to *Culex* species. Out of the 365 female *Anopheles* mosquitoes dissected for parity, 211 (67.00%) were parous, while 104 (33.00%) were nulliparous. Out of 445 blood samples examined for malaria parasite 315 (70.80%) were positive while 130 (29.20%) were negative. There was a significant difference in the distribution of mosquito vectors and malaria parasites in the two study areas ($p<0.05$) using *chi*-square test. This study therefore will be useful as a baseline data to help in designing strategies for the control of mosquito-borne diseases in Minna and its environs.

Keywords: butterfly, diversity, abundance, Obafemi Awolowo University, Nigeria.

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Introduction

Despite advances in treatment and prevention over the past decades, malaria still threatens the lives of millions in tropical countries. Over the years, increasing use of insecticide treated nets, indoor residual spraying, and early treatment with Artemisinin-based Combination Therapies (ACT's) has led to a reduction in mobility and mortality caused by malaria in some African countries. An impediment to this progress is the ability of the parasite to develop resistance to anti-malarial drugs and increasing insecticide resistance of the mosquito vector.

Malaria is transmitted by female mosquitoes in the genus *Anopheles* because they support the sporogonic development of human malaria parasites (Beier *et al* 1998). There are over 2,500 species of *Anopheles* mosquitoes, but less than 50 are capable of transmitting malaria. In some cases, different forms are found in varying ecological regions, thus the need to identify the prevalent malaria vectors in the study locations.

According to the World Health Organization (WHO), malaria is the world's most important parasitic disease with an estimated case of 247 million resulting in 881,000 deaths most of them children under the age of five (WHO, 2008). The Federal Ministry of Health (FMOH) also reports that malaria accounts for 25 percent of infant mortality and 30 percent of childhood mortality in Nigeria (FMOH, 2009).

Malaria is endemic throughout Nigeria with a high percentage of the population at risk. It poses a major threat to over 2.4 billion people which is about 4% of the world population. Indeed malaria is a major public health problem worldwide. In Africa more than $12 billion is lost to malaria annually thus reducing the Gross Domestic Product (GDP) and contributes to a great extent to the poverty situation in Africa as it exerts a negative influence on the productivity of households in Africa. Malaria is a persistent ailment in tropical Africa especially among under five children due to their low level of resistance to the disease and mortality to it amounts to millions (WHO, 2007).

Malaria transmission in these African communities is enhanced by suitable environmental conditions such as high humidity and warmth which accelerates mosquito development. Poor housing quality also facilitate malaria transmission as the population are continually exposed to mosquito bites. In communities where the use of mosquito-treated nets is implemented, this offers protection from the mosquitoes although bites can still occur outside the house (Gulleko and Coluzzi, 1993). *Plasmodium falciparum* is responsible for most malaria related deaths worldwide and is the predominant *Plasmodium* species in sub-Saharan Africa. Transmission intensity and population at risk vary substantially between

and within countries (Abeku *et al* 2004). Of the 2.4 billion people at risk of *falciparum* malaria, 70% live in areas of unstable or low endemic risk. Almost all populations at medium and high levels of risk live in sub-Saharan Africa, where the burden of disease, death and disability from *falciparum* malaria is high (Ahmed, 2007).

Nigeria accounts for a quarter of all malaria cases in Africa (WHO, 2008). In the southern part of the country, transmission occurs all year round while in the north it is more seasonal. Almost all malaria cases in the country are caused by *P. falciparum*, considered to be the leading cause of death worldwide in 2004, from a single infections agent (WHO, 2008). Malaria is the most common disease in Nigeria and according to the Federal Ministry of Health (FMOH, 2005), half of its population will have one or more malaria attacks annually.

Presently, there is dearth of knowledge of the drivers of malaria transmission in Minna, North Central Nigeria (Olayemi *et al* 2009), thus the results of this study will generate data to be applied for effective control measures of malaria in the areas of study. The aim of this study is to generate adequate information and data on the indices of malaria transmission in the study areas.

Material and methods

Study area

This study was carried out in two selected communities i.e. Tungan-Goro and Gbaiko in Minna due to the their ecological setup and the settlement of the inhabitants in Niger State, North Central Nigeria, which lies within Longitude $6^0$33F and $9^0$37N on a land area of 88 km^2 and having an estimated population of 1.2 million inhabitants. The area has a tropical climate with mean annual temperature, relative humidity and rainfall of 30.20^{0}C, 61.00% and 1,334.00 mm, respectively. The study-areas were surrounded with some streams that are few kilometres away from their habitats which serve as larval breeding pools for mosquito species and other insects. The surrounding of the habitat sometimes or always remains permanently bushy with thick and tall grasses. Mosquitoes move easily into houses through the corridors which are permanently open at both ends of their buildings and the drainage systems are very poor. Stagnant pools are also common around the houses. Water supply remains a major problem, pond, hand dug wells are used as a source of water supply. The climate in north-central Nigeria is that of a tropical continental region which is characterized by a relatively wide annual temperature range and a restricted rainfall. The mean annual temperature range from 27 to 30^{0}C and the mean annual relative humidity is higher in the former at (76.00%) than the latter (61.00%) while the mean annual rainfall ranges from 1,334.00mm and the estimate of the area is marked by two distinct weather seasons, i.e. rainy and dry seasons.

Ethical clearance and advocacy

Before the implementation and commencement of this research, extensive consultation was undertaken between the researcher and the communities involved, as well as careful liaison with village, district heads as well as the parents of the children. During the pilot study, before the collection of blood samples, all stakeholders namely, health director, village heads and parents of the children were consulted for their consent. The village health workers provided participants with information regarding the reasons for the research during routine visits to the community heads. Less argument ensued following previous studies with free administration of anti malarial drugs to pupils and the ability of the researcher to communicate freely and fluently in Hausa language. It was however regrettable that some villagers as well as the parents whose wards were involved in the research exercise were angry, alleging that their wards samples would be used for rituals. The project was approved by the Ethical Committee of the State Ministry of Health, followed by a local ethical approval for each study site in Niger State, Nigeria.

Mosquito collection, preservation and identification

Collections of the mosquitoes were carried out using the spread sheet Pyrethrum Spray Catches (PSC) (El-Badry and Al-Ali, 2010). The populations indoors were sampled by spreading the floor with a white sheet of 5m x 5m with each edge being held to the wall by a masking tape. The room was sprayed with pyrethroid insecticide (Baygon) and then left for 10 minutes, with every opening being shut. After the period the mosquitoes knocked down on the sheet were gathered and handpicked with a forcep into petri dishes and they were conveyed to the laboratory for identification using keys of Gullies and De Meillon (Gillies and De-Meillon, 1968), Gullies and (Coetzee *et al* 2000) was used for separation into sexes separated by physiological state, un blood fed and blood fed.

Blood samples and anopheline mosquitoes collection, processing and dissection

Blood samples and anopheline mosquitoes were collected weekly using Pyrethrum spray catch method between 06:00hrs-07:00hrs from August to October, 2011 and 2012 respectively. Mosquito collection were carried out in two sampling sites representing the general ecotype of the area. Captured mosquitoes were sorted according to the sites of collection, and were then conveyed to laboratory for further identification using the keys of Gilles and De Meillon (Gillies and De-Meillon, 1968). Also dissection of the salivary glands for sporozoites and ovary for parity was carried out according to the techniques of WHO (WHO, 2002) and Service (Service, 1993).

The mosquitoes were examined for *Plasmodium* sporozoites by observing the salivary glands following the techniques of WHO (2002) and Service (1993). Briefly, the ovaries were dissected out of the abdomen at the region of 6th and 7th Selerite under a dissecting microscope using x40 and x200 objectives of Zeiss light microscope in the department of Biology Laboratory,

Federal University of technology, Minna, and for further confirmation at the National Veterinary Research Institute Laboratory, Vom. According to Holstein (Holstein, 1954), these ovaries which the terminal skeins of the tracheoles were found to be uncoiled were considered as parous while ones with coiled skein were considered nulliparous.

Parasitological analysis

Blood sample that were collected from children of 0-5 years old by pricking gently of their thumb and the blood droplet was examined using a direct thin and thick blood smear slide preparation stained with Giemsa as demonstrated by Mnuga *et al* (2006) for the presence of the ring form stages of the parasites in the blood of the individuals in the laboratory.

Plasmodium sporozoite infection rate

This is the number of sporozoites found in the salivary gland of dissected Anopheline mosquitoes, and it was calculated by dividing the number of sporozoites positive mosquitoes by the number of mosquitoes dissected.

$$S.R. = \frac{\text{Number of sporozoites positive mosquito}}{\text{Number of dissected mosquitoes}}$$

Parous rate

This was determined by the dissection of the ovary of the collected specimen and was calculated by dividing the number of parous females by the number of dissected mosquitoes.

$$P.R = \frac{\text{Number of parous females mosquitoes}}{\text{Number of dissected mosquitoes}}$$

Probability of daily survival

This was estimated as the square root of the proportion of parous rate of the mosquitoes, and it gives an indication as to how long the parasites will survive in the ovary/body of the female mosquitoes.

$$D.S = \sqrt{P.R}$$

Life expectancy (I.E.)

This gives an indication to the number of days the mosquitoes are expected to live to be able to transmit the sporozoites; it is calculated using the formula:

$$L.E. = 1/-\log_e p$$

Where p = probability of daily survival.

Results

Survey of mosquito population for Tungan-Goro and Gbaiko

The relative abundance of mosquito species within the study areas is shown in Table 1. A total number of 742 mosquitoes were collected at the two study-areas. Four hundred and thirty mosquitoes were collected at Tungan-Goro and 312 mosquitoes collected at Gbaiko. Out of the 430 mosquitoes collected at Tungan-Goro, 232 were identified as *Anopheles* species while 198 were *Culex* species. Out of the 232 *Anopheles* species collected at Tungan-Goro, 97 were males with 41.8% abundance while 135 were females with 58.2% abundance. Also out of the 198 *Culex* species from Tungan-Goro, 96 (48.5%) were males, while 102 (51.5%) were females. At Gbaiko, 224 *Anopheles* species were collected, 86 (38.4%) were males, while 138 (61.1%) were females. Also out of the 88 *Culex* species collected at Gbaiko, 35 (39.8%) were males, while 53 (60.2%) were females. Comparism of the population between the mosquito collected from Tungan-Goro and Gbaiko shows a significant different at $p< 0.05$ using *chi*-square test.

Table 1. Relative abundance of mosquito species in Tungan-Goro and Gbaiko in Minna, Niger.

Collection sites	Mosquito population examined	*Anopheles gambiae*		*Culex pipiens pipiens*	
		Males No. (%)	Females No. (%)	Males No. (%)	Females No. (%)
Tungan-Goro	430	97 (41.8)	135 (58.2)	96 (48.5)	102 (51.5)
Gbaiko	312	86 (38.4)	138 (61.1)	35 (39.8)	53 (60.2)
Total	**742**	**183 (40.1)**	**273 (59.9)**	**131 (45.8)**	**155 (54.2)**

x^2 Cal (157.78) is greater than x^2 tab (3.84) ($p<0.05$).

Sporozoites prevalence rate

For prevalence of sporozoites rate found in the *Anopheles gambiae* mosquitoes in the study areas, a total of 365 *Anopheles gambiae* mosquitoes were dissected from a total sum of 456 that were collected. From the dissected population, 191 (52.3%) were positive, sporozoite was found in their salivary glands while, 174 (47.7%) were negative. For Tungan-Goro a total number of 168 mosquitoes were dissected for the presence of sporozoites out of the 232 mosquitoes that were collected and 87 were positive making 51.8%, while 81 (48.2%) were negative. For Gbaiko out of 224 *Anopheles* mosquitoes that were collected, 197 were dissected for the presence of sporozoites and 104 (52.8%) were positive and remaining 93 (47.2%) were negative. Using the *chi*-square test it was shown that there was a significant difference at $p<0.05$ in the sporozoite rates in the mosquitoes collected from Tungan-Goro and Gbaiko (Table 2).

Table 2. Prevalence of sporozoites in *Anopheles gambiae* mosquitoes in Tungangoro and Gbaiko in Minna, Niger State.

Collection sites	No of mosquitoes collected	No of mosquitoes dissected	No. positive (%)	No. negative (%)
Tungangoro	232	168	87 (51.8)	81 (48.2)
Gbaiko	224	197	104 (52.8)	93 (47.2)
Total	**456**	**365**	**191 (52.3)**	**174 (47.7)**

x^2 cal = 53.66, x^2 tab = 3.84 at ($p>0.05$).

Parous and nulliparous rate determination

Parous and nulliparous rates determination of the *Anopheles* mosquitoes in the study-area can be seen on table 3. A total of 315 mosquitoes were dissected out of 456 collected. At Tungangoro out of 159 mosquitoes dissected, 103 (64.8%) were parous while 56 (35.2%) were nulliparous. At Gbaiko, out of 156 mosquitoes that were dissected, 108 (69.2%) were parous while 48 (30.8%) were nulliparous Using the *chi*-square test it was established that there was a significant at $p<0.05$ difference in the rate of parous mosquitoes in Tungan-Goro and Gbaiko.

Table 3. Parous rate of *Anopheles gambiae* mosquitoes in Tungan-Goro and Gbaiko in Minna, Niger State.

Collection sites	Number of mosquitoes population collected	Number of mosquitoes population dissected	Number of positive parous population (%)	Number of negative parous population (%)
Tungangoro	232	159	103 (64.8)	56 (35.2)
Gbaiko	224	158	108 (69.2)	48 (30.8)
Grand Total	**456**	**315**	**211 (67.0)**	**104 (33.0)**

x^2 tab = 3.84, x^2 cal = 158.52 at ($p>0.05$).

Table 4 showed the prevalence of malaria parasite infection among children (0-5) years at Tungan-Goro and Gbaiko in Minna, Niger State. A total of 445 children were sampled and examined comprising 226 from Tungan-Goro and 219 from Gbaiko. At Tungan-Goro 178 of the children sampled (78.8%) were positive of malaria parasite while 48 (21.2%) were negative. At Gbaiko 137 of the children sampled (62.6%) were positive while 82 (37.4%) were negative. From the 445 blood analysed for the malaria parasite, 315 were positive with malaria parasite and then account for about 70.8% rate of malaria infection in both study sites while 130 were negative accounting for about 29.2% of the total population sampled. The *chi*-square statistical analysis shows that there was a significant difference at $p<0.05$ in the rate of malaria infection in Tungan-Goro and Gbaiko.

Table 4. Prevalence of malaria parasite among under five children in Tungan-Goro and Gbaiko.

Collection sites	No of children examined for malaria parasites	No of children positive (%) (Malaria Infection)	No of children negative (%) (Not infected with malaria)
Tungangoro	226	178 (78.8%)	48 (21.2%)
Gbaiko	219	137 (62.6%)	82 (37.4%)
Total	**445**	**315 (70.8%)**	**130 (29.2%)**

x^2 tab = 79.06 is greater than x^2 tab = 3.84 at ($p>0.05$).

Discussion

This study showed high abundance of mosquito species and the prevalence of malaria parasites among the under five children within the study areas as indicators of transmission.

Anopheles mosquito's relative abundance was very high though the use of some insecticides and the usage of long lasting insecticide treated nets can reduce vector infectivity as well as vector survival rate and increasing the length of the sporogonic cycle (Anonymous, 1991). Both Tungangoro and Gbaiko had high *Anopheles* mosquitoes which may be due to the environmental management of breeding sites as reported by Angerilli (Angerilli, 1980) and some of the environmental practices within the study areas which include the reduction and management of breeding sites at the locations that has to do with disposing of containers receptacles, water storage jars, unused tyres, abandoned cans etc., also the *Anopheles* species found in these study areas were also reported by (Coluzzi *et al* 2002) which was the most important vector of the malaria parasites in the sub-Saharan Africa which was in connection with certain climatic factors most especially the annual precipitation which appears to influence the range and the relative abundance of the mosquito species.

Malaria parasites prevalence was high indicating a high rate of *Plasmodium* parasitaemia among the under five children which was in line with the high relative abundance *Anopheles* vectors sampled within the study areas which agrees with the previous work reported by Molta *et al* (2004) and Munga *et al* (2006) in Jos, north-central Nigeria and Ralph [23] in the malaria endemic village of Erunmu in south-west Nigeria. For the sporozoites and parity rates determination of 55% is relatively high compare to the work and findings of Olayemi and Ande [24] in Ilorin, which was also similar to the findings of Fradin (1998) in Senegal with 25% prevalence of sporozoites and parity rates determination and higher than the 7.1% reported in Ghana by Appawu *et al* (2004), also in south west Nigeria by Awolola *et al* (2003) that reported the prevalence of sporozoites rates of *Anopheles* mosquitoes as 5.6%, 2.9% and 1.8% respectively.

The results obtained from the parasitological examination of blood samples of the under five children is in line with the presence and relative abundance of the adult female *Anopheles* mosquitoes as the principal vector of malaria transmission (WHO, 2002), the relative abundance of the *Anopheles* mosquito species within the study-areas also agrees with the findings of Bockarie *et al* (1994) who reported that *Anopheles* species tends to occur regularly throughout the wet and dry seasons in West Africa mostly with the peak at the rainy seasons which is in line with the period the study was carried out. The relative abundance of the mosquito species within the study areas was also associated with the availability of suitable breeding habitats within the locations as described by Minakawa and Jam (2005). The breeding sites ranges across the various types of

water bodies such as temporary ground pools to large permanent water bodies found within the study areas. More so the high rate of malaria infection within the study-area could be attributed to the fact that the infection is already a looming endemic problem in Nigeria, including Niger State as the sampling and surveying period coincided with the peak of raining season when mosquitoes are breeding due to the amount of rainfall from July to September. Moreover Minna and its environs including the study-areas are relatively water logged and poorly drained areas, gutters and other drainages are also routinely clogged with wastes as a result of an inefficient public waste disposal system. All these provide good breeding sites for mosquitoes which help to fuel stable and continuous malaria transmission, even beyond the peak rainy season in the months of November and December respectively.

The findings of this study indicates that both the entomological and parasitological indices of malaria transmission which includes the sporozoites found in the salivary glands of the female *Anopheles* as well as their parous nature and the *Plasmodium* parasites found in the blood samples of the under five children are well-established in the study-areas, thus explaining the endemicity of malaria in Minna and its environment.

References

Abeku, T. A., Hay, S. I., Oshola, S., Langi, B. B., Devlas, S. J. and Cox, J. 2004. Malaria epidemic war and detection in Africa highlands. *Trends in Parasitology, 20:* 400-405.

Ahmed, A. M. 2007. A dual effect for the black seed oil on the malaria vector *Anopheles gambiae*. Enhances immunity and reduce the concomitants reproductive cost. *Journal of Entomolology*, *4*, 1-19.

Angerilli, N. D. P. 1980. Influences of extracts of vegetation on the survival and oviposition by *Aedes aegypti* (Diptera: Culicidae) *Can. Entomology, 112,* 1249; 1252.

Anonymous 1991. Malaria: prospects and obstacles. A report of the committee for the study on malaria prevention and control: Status preview and alternative strategies. Division of International Health Institute of Medicine. National Academic Press, Washington D.C. 157-179.

Appawu, M. S., Owusu-Agyesi, S., Dadzie, V., Asoala, F. and Anto, F. 2004. Malaria Transmission Dynamics at a site in northern Ghana proposed for testing malaria vaccines. *Trop. Med. Int. Health*, 9, 164-170.

Awolola, S.T., Ibrahim, K., Okorie, T., Koekemoer, L. L., Hunt, R. H. and Coetzee, M. 2003. Species composition and biting activities of anthropophagic *Anopheles* mosquitoes and their role in malaria transmission in a holo-endemic area of south western Nigeria. *African Entomology, 11*, 227-232.

Beier, J. C., Perkins, P. V., Onyango, F. K., Gargan, T. P., Oster, C. N., Whitmire, R. E. and Roberts, C. R. 1998. Characterization of malaria transmission by *Anopheles* (Diptera: Culicidae) in western Kenya in preparation for malaria vaccine trials. *Journal of Medical Entomology, 27*, 570-577.

Bockarie, M. J., Service, M. W., Barnish, G., Maude, G. H. and Greenwood, B. M. 1994. Malaria in a rural area of Sierra Leone. III. Vector ecology and disease transmission. *Annals of Tropical Medicine and Parasitology*, 88 (3), 251-62.

Coetzee, M., Craig, M. and Le-Seuur, D. 2000. Distribution of Africa malaria mosquitoes belonging to the *Anopheles gambiae* complex. *Parasitology Today, 16,* 74-77.

Coluzzi, M., Sabbatini, A., Della-Tore, DiDeco, M. A., Petrarca, V. Apolythene. 2002. Chromosome Analysis of the *Anopheles gambiae* species complex. *Parasitologia, 35,* 23-9.

El-Badry, A. A. and Al-Ali, K. H. 2010. Prevalence and seasonal distribution of deuque mosquito *Aedes aegypti*. (Diptera.Culicidae) in Al-Madinah Al-Munawwarah. *Saudi Arabia Journal of Entomology*, *7*, 80-88.

Federal Ministry of Health, Federal Republic of Nigeria. 2005. *National Anti-malarial Treatment Policy.* Abuja: Federal Ministry of Health, National Malaria and Vector Control Division.

Federal Ministry of Health, Nigeria (FMOH). 2009. *A road map for malaria control in Nigeria.* Strategic Plan, 12.

Fradin, M. S. 1998. Mosquitoes and mosquito repellents: A clinician's guide. *Annals of Internal Medicine, 128 (11),* 931-940.

Gillies, M. T. and De Meillon, B. 1968. The Anophelinae of Africa south of the Sahara (Ethiopian Zoogeographical Region). *Publications of the South African Institute for Medical Research, 54.*

Gulleko, C. H. and Coluzzi, M. 1993. Advances in the study of Afro-typical malaria vectors. *Parasitologia, 35,* 23-9.

Holstein, M. H. 1954. Biology of *Anopheles gambiae*: Research in Western Africa. WHO. Geneva, Swiss.

Minakawa, N. G. and Jam, G. 2005. Relationship between occurrence of Anopheles S.I. (Diptera: Cullicidae) and size and stability of larvae habitat *Medical journal of Entomology, 42,* 295-300.

Molta, N. B., Omalu, I. C. J., Oguche, S., Pam, S. D., Afolabi, B. M. and Mosanya, M. E. 2004. Declining efficacies of chloroquine and sulfadoxine-pyrimethamine combination against *Plasmodium falciparum* in the north-central Plateau, Nigeria: Parasitological performance of the drugs. *Nigerian Journal of Parasitology, 25*, 57-63.

Munga, S., Minakawa, N., Zhou, G., Mushinzimana, E., Barrack, O., Gilheko, A. K. and Yam, G. 2006. Association between land cover and habitat productivity of malaria vectors in western Kenya in highlands. *American Journal of Tropical Medicine and Hygiene, 7A,* 67-75.

Olayemi, I. K. and Ande, A. T. 2008. Species composition and larval habitats of mosquitoes (Diptera: Culicidae) in Borin, Nigeria. *The Zoologist*, 6: 7-15.

Olayemi, I. K., Ande, A. T., Isah, B. and Idris, A. R. 2009. Epidemiology of malaria in relation to climatic variables in Minna, Nigeria. *African Journal of Medical Sciences, 2(1):* 5-10.

Ralph, H. 2008. "Family Culicidae Meigen, 1818". *Mosquito Taxonomic Inventory.*

Service, M. W. 1993. *Mosquito Ecology: field Sampling methods, 2nd ed.* Chapman and Hall, London, United Kingdom.

World Health Organization (WHO). 2007. *The Africa Malaria Report,* 125-130.

World Health Organization (WHO). 2002. *Malaria entomology and vector control. Learner's Guide.* Social mobilization and training control, prevention and eradication department, communicable diseases cluster, World Health Organization, Geneva.

World Health Organization (WHO). 2008. *World Malaria Report.* Geneva.

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