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Annual *Plasmodium falciparum* entomological inoculation rates (EIR) across Africa: literature survey, internet access and review

Simon I. Hay^{1,*}, David J. Rogers¹, Jonathan F. Toomer¹, and Robert W. Snow^{2,3}

¹Trypanosomiasis and Land-use in Africa (TALA) Research Group, Department of Zoology, University of Oxford, South Parks Road, Oxford OX1 3PS, UK

²Kenya Medical Research Institute/Wellcome Trust Collaborative Programme, P.O. Box 43640, Nairobi, Kenya

³Centre for Tropical Medicine, Nuffield Department of Clinical Medicine, University of Oxford, John Radcliffe Hospital, Headington, Oxford OX3 9DS, UK

Abstract

This paper presents the results of an extensive search of the formal and informal literature on annual *Plasmodium falciparum* entomological inoculation rates (EIR) across Africa from 1980 onwards. It first describes how the annual EIR data were collated, summarized, neo-referenced and staged for public access on the internet. Problems of data standardization, reporting accuracy and the subsequent publishing of information on the internet follow. The review was conducted primarily to investigate the spatial heterogeneity of malaria exposure in Africa and supports the idea of highly heterogeneous risk at the continental, regional and country levels. The implications for malaria control of the significant spatial (and seasonal) variation in exposure to infected mosquito bites are discussed.

Keywords

malaria; *Plasmodium falciparum*; entomological inoculation rate (EIR); biting rate; sporozoite index; transmission; disease control; Africa

Introduction

Malaria continues to pose a major public-health threat to many countries in Africa (Snow *et al.*, 1999a). The launch of Roll Back Malaria (RBM) (Nabarro & Tayler, 1998; WHO, 1998) therefore was regarded as timely by many. International public health initiatives such as RBM, aimed at reducing continental burdens of malaria, require an understanding of contemporary malaria distribution, risk and burden (Snow *et al.*, 1996; Le Sueur *et al.*, 1997, Snow *et al.*, 1998a). Several attempts have been made to explore continental malaria distribution (Sutherst, 1993; Lindsay & Martens, 1998; Lindsay *et al.*, 1998; Craig *et al.*, 1999) and disease burden (Snow *et al.*, 1999a, 1999b) using climate models and malariometric data gathered from the literature. There is increasing evidence, however, that the relationship between the frequency of infection and disease outcome is complex and control options should be selected accordingly (Snow *et al.*, 1997, 1998b; Snow & Marsh, 1998; Gupta *et al.*, 1999a, 1999b).

* Author for correspondence: phone +44 (0) 1865 271243, fax +44 (0) 1865 271243, simon.hay@zoo.ox.ac.uk.

In the absence of a comprehensive reference on malaria exposure in Africa, and owing to its importance in international efforts in malaria control, an overview of the available entomological evidence describing the average annual risk across Africa of receiving a *Plasmodium falciparum* infected bite from the local vector population [the annual entomological inoculation rate (EIR)] was initiated. This review focuses particularly on the spatial heterogeneity of annual EIR within Africa and its implications for the rationalization of malaria control. A discussion of some of the methodological difficulties involved in comparing annual EIR information is also provided. There is further consideration of the limitations and benefits of data-sharing over the internet. The data described were predicted for non-surveyed areas using remotely sensed imagery from meteorological satellites (D. J. Rogers *et al.*, paper in preparation), to provide the first annual EIR surfaces for the African continent.

Materials and Methods

Annual EIR definition

The activity of the anopheline vector of malaria provides the basis for calculating the EIR, h' , the daily number of infective mosquito bites received per person (MacDonald, 1957). Algebraically $h' = mas$; where m is the anopheline density in relation to humans; a is the average number of persons bitten by 1 mosquito in a day, and s is the proportion of mosquitoes with sporozoites in their salivary glands. It is obvious that if the EIR value is to be representative of the year, the estimates of the biting rate and the sporozoite index must be repeated at a monthly (or higher) frequency, for at least a year or complete transmission season. The annual EIR is a favoured measure for assessing malaria endemicity (Burkot & Graves, 1995) and thus the suitability of vector control (Coosemans *et al.*, 1992), as well as the risk of epidemic development (Onori & Grab, 1980). Measuring the annual EIR presents several major difficulties, however, since the entomological methods used in its estimation have not been standardized (Githeko *et al.*, 1996).

Human biting rate

The most direct way to measure the human biting rate (the product of ma) is the human bait catch (WHO, 1975). This involves a team waiting in a given location, usually throughout the night, collecting all the mosquitoes that attempt to feed on exposed individuals. Despite being expensive, technically difficult to replicate and unethical in areas of drug-resistant malaria, this method is unique in that it directly samples human-biting mosquitoes (Le Goff *et al.*, 1997). Other sampling methods such as pyrethrum spray collections and light and exit traps depend on mosquito behaviours that are less directly associated with feeding on humans (Garret-Jones, 1970; Service, 1993). Fortunately, the sampling biases between the most commonly used techniques, human bait and light traps, have been investigated (Lines *et al.*, 1991; Faye *et al.*, 1992; Mbogo *et al.*, 1993a; Davis *et al.*, 1995; Smith, 1995). Correction factors have also been suggested to account for children experiencing lower biting rates than adults in the same location (Port *et al.*, 1980). Details of the protocol used for the standardization of data are presented below.

Sporozoite index

Measurements of the sporozoite index (s) require the number of infective mosquitoes (those with sporozoites in their salivary glands) in the local population to be determined (WHO, 1975). Ideally, but not always, the sporozoite index is derived from the biting rate sample. The traditional method was to dissect all sampled mosquitoes for their salivary glands and subject them to procedures designed to help reveal potential sporozoites under the microscope. More recently, the enzyme-linked immunosorbent assay (ELISA) techniques, which detect *Plasmodium*-specific circumsporozoite antigens from mosquito head and/or

thorax samples, are being increasingly used owing to their greater sensitivity and species specificity (Burkot *et al.*, 1984). No attempt was made to standardize the sporozoite index in this study because sensitivity and specificity of microscopy (Kilian *et al.*, 2000) and ELISA techniques will vary between studies.

Identification of sources of annual EIR data

Online abstracting databases (Biological Abstracts®, BIOSIS, Philadelphia, Pennsylvania, USA, MEDLINE®, US National Library of Medicine, Bethesda, Maryland, USA; CAB HEALTH, CAB International Inc., Wallingford, Oxfordshire, UK; and the Zoological Record Online®, BIOSIS, Philadelphia, Pennsylvania, USA) were searched with the following keywords (entomological inoculation rate, EIR, h' , biting rate, *ma*, sporozoite index, *s*, *Plasmodium falciparum* *Anopheles gambiae*, *Anopheles funestus*, *Anopheles*, vectorial capacity, malaria transmission, malaria control, bednets, ITBN, human bait, pyrethroid spray, light trap, exit trap, bionomics). This search resulted in a large number of references which were scrutinized for annual EIR data. From this subset of publications a 'key author list' was compiled and these names were re-entered into the abstracting databases and further relevant manuscripts were retrieved. The bibliographies of all recovered manuscripts were then checked for potential additional references. These references were collected and the searching strategies repeated until no new information was forthcoming. The list of papers found for each author was then compiled and a letter sent to each individual requesting they check that the bibliography was complete and the data were abstracted correctly. Forty-three letters were sent, to which there were 21 replies, mostly with further information from the 'grey' literature.

Recording and standardization of the annual EIR values

The values recorded in Table 1 are *P. falciparum*-infected bites per adult, per night indoors, using human biting rates averaged over a year. In most studies the author(s) had expressed their data in the above format. When adjustment was necessary, this commonly involved converting light-trap catches to their human-bait equivalent by multiplying by 1.5 (Lines *et al.*, 1991) and more rarely converting child EIR values to those of adults by multiplying by 3.57 (Port *et al.*, 1980). In addition to the annual EIR, the average annual biting rate and the sporozoite index are also presented. It should be noted, however, that owing to the approximation inherent in rounding, the product of the biting and sporozoite indices may not exactly match the recorded annual EIR. For each location an index of the length of the transmission season was expressed as the number of months in which 75% of the annual EIR was transmitted. When studies did not provide enough information for this to be calculated the length of the transmission season only was recorded. The percentage of the total annual EIR transmitted by *Anopheles gambiae* *s.l.* freshwater species, *An. funestus* and all other species was also noted. Finally, the land-use in which the study site was located was classified as dominantly rural, irrigated rice or urban.

Criteria for data exclusion

Annual EIR data measured before 1980 were excluded because it was not clear whether information collected over 20 years ago would be representative of the conditions today. In addition, the data were also extracted for comparison with contemporaneous meteorological satellite sensor data available from 1981 to date (D. J. Rogers *et al.*, paper in preparation). Moreover, data before 1980 were more difficult to search using electronic abstracting databases, although such information would make a useful addition to those compiled here. Sites were also excluded if malaria control activities, local bednet and/or insecticide usage were reported. The possibility of unreported use of bednets, insecticide and repellents in the studies remains a problem, however, so these data are best interpreted as *potential* EIR values. Finally, data were not included if the sampling frequency and duration of

observation were insufficient to record the EIR throughout the entire year or transmission season.

Methodological information

EIR sampling methods vary considerably and those used in obtaining the biting rate (human bait, pyrethroid spraying, light or exit traps) and the means of measuring the sporozoite index (dissection or ELISA) are noted in Table 1. Calculation of the sporozoite index was often complicated by the subdivision of the index into proportions due to different *Plasmodium* species. Only the sporozoite indices attributable to *P. falciparum* were used. Where the relative contribution to total transmission level for each species was not documented, the total was assumed to be due to *P. falciparum*.

Geo-referencing

Sites were geo-referenced using information from the original references, published maps and/or the GeoName™ digital gazetteer CD-ROM (GDE Systems Inc., San Diego, CA, USA). Sites for which co-ordinates were found are included in Table 1. Those sites which had conflicting latitude and longitude values from different sources were double-checked and the erroneous co-ordinates discarded. The method used to geo-reference each annual EIR value was therefore also recorded.

Data distribution

The information reviewed in this paper is available for downloading from both the Mapping malaria risk in Africa/Atlas du risque de la malaria en Afrique (MARA/ARMA URL; <http://www.mara.org.za>) and Scientists for Health And REsearch for Development (SHARED URL; <http://www.shared.de>) web sites as comma separated text files. Mechanisms for correcting existing and adding additional information will be staged in the near future. The Appendix, which provides an example of a completed data sheet used to abstract data in this study, is also available for downloading.

Results

Annual EIR data

Four hundred references were retrieved and searched for annual EIR data of which 91 satisfied the selection criteria. These papers contained 201 temporally distinct annual EIR measurements from 16 countries. Of these, 159 were spatially distinct. Table 1 contains all the 193 geo-registered sites from 15 countries with data collected after 1980. Table 2 contains annual EIR data that could not be geo-registered: 8 sites in 5 countries. The Figure shows the distribution of the study sites detailed in Table 1. The apparent disparity in the number of sites is due to the close proximity of many studies which could not be resolved on a map of Africa at the continental scale.

These studies collectively demonstrate that Africa has substantial cross-continent variability in annual EIR. The mean annual EIR value for the 159 spatially distinct sites was 121 infected bites per annum, although exposure ranged from a maximum of 884 to a minimum of 0. The local land-use also had a major effect on annual EIR. The 'rural' class had an overall mean of 146 (range 0–884) while those surrounded by irrigated rice were less exposed with a mean of 99 (range 0–601) and those in urban areas receiving significantly lower exposure with a mean of 14 (range 0–43). The variance in annual EIR expressed as the $[(\text{standard error}/\text{mean}) \times 100]$ is shown by country in Table 3. Spatially distinct rural sites only ($n = 133$) were used, to help control for major agricultural or demographic impact, and only countries with at least 10 spatially distinct study sites were included. Tanzania showed the least variance at 10.9%, and Senegal the highest at 42%. Finally, of the 133 sites

for which seasonality information could be gathered, 30% showed acute seasonal variation in annual EIR (i.e., with 75% of annual transmission occurring in 1–3 months).

Study methodology

Biting rates were determined primarily by human-bait samples ($n = 111$), followed by light-traps ($n = 31$), pyrethrum spray-catches ($n = 22$) and exit-traps ($n = 2$) measurements. Combinations of the above techniques were used in 17 studies, whilst 18 more provided no information on how the biting rate estimate was obtained. The methods used to evaluate the sporozoite index were roughly even, with 82 determined by dissection and 99 by ELISA. Three records were calculated using the average of dissection and ELISA and 17 did not record the methodology used.

Geo-referencing

Three of the 201 annual EIR values were published with an accurate latitude and longitude of the study area. Correspondence with authors provided co-ordinate details for a further 33 sites. The largest source of geo-referencing information was obtained from the GeoName™ digital gazetteer CD-ROM which geo-referenced 100 annual EIR values. Finally, published maps were used to uncover the co-ordinates of a further 57 sites. This left the 8 unlocated study sites shown in Table 2.

Discussion

Annual EIR heterogeneity

It has been observed that Africa can support a very wide range of EIRs (Gilles, 1993). More recently, however, variation in infection risk has been linked to very different clinical patterns and public health burdens (Snow *et al.*, 1997, 1998b; Snow & Marsh, 1998; Gupta *et al.*, 1999a, 1999b). Although this study cannot claim to have identified every study of estimated annual EIR in Africa since 1980, the results of the search do support the claim for a diverse transmission pattern for the continent. Of particular interest in this respect is the enormous apparent variation within countries such as Senegal and Kenya. If this variation reflects sub-regional ecological heterogeneity, rather than sampling biases in the distribution of studies, it has important implications for disease management.

The results demonstrate a marked demographic influence on annual EIR values. The relatively small annual EIR in urban versus rural settings was not unexpected and is exemplified in the series of studies around Brazzaville in The Congo (Trape & Zoulani, 1987b) and neighbouring Kinshasa in Zaire (Coene, 1993). The impact of irrigated rice farming on surrounding EIRs is complicated. It has been shown to increase (Coosemans, 1985), have little overall effect upon (Robert *et al.*, 1985; Githeko *et al.*, 1993; Dossou-yovo *et al.*, 1994) and also decrease (Robert *et al.*, 1985; Githeko *et al.*, 1993; Dossou-yovo *et al.*, 1994) malaria transmission depending on the location. This variation can be due to many factors, such as relative effects of irrigation on species abundance and sporozoite rate, the number of rice harvests, surrounding human population numbers and levels of breeding site contamination, the number of cattle in the locality, as well as the degree of local immunity. The data collated here are insufficient to explore any of these mechanisms in detail, but it is interesting to note that when populations near irrigated rice areas were compared to those from the sample of rural Africa as a whole they were, on average, less exposed.

Year-to-year variation in annual EIR is also very important, particularly in naturally seasonal areas. Too few investigations published data over multiple years, however, to make reliable generalizations. The following studies from Senegal should be considered when interpreting single annual EIR estimates from a site, since the annual EIR ranged from 89 to

238 in Dielmo over a 3-year monitoring period (Fontenille *et al.*, 1997b) and from 7 to 63 infected bites per year over a 4-year monitoring period in Ndiop (Fontenille *et al.*, 1997a).

The Figure shows that entomological studies are preferentially conducted where malaria is known to exist and is often a recognized local health problem. For example, the range of estimates for Burundi (Coosemans, 1985; Van Bortel *et al.*, 1996) suggests a country of intense transmission, whilst most of Burundi is at high altitude and free from malaria (Van der Stuyft *et al.*, 1993). The Figure also shows that studies are more likely to be conducted in locations where malaria research has a strong historical basis. In Kenya, for example, the sites for most data neighbour the Kenyan Medical Research Institute (KEMRI) research centres on the coast and Lake Victoria. The annual EIR statistics presented for each country must therefore be interpreted with this caveat. It would also be of value if an international network could be developed to map EIR using standardized methods in a grid-based system across Africa to record more closely the spatial distribution of malaria transmission on the continent, rather than the distribution of medical research centres and their accessible field sites.

Information technology issues

The data presented in Table 1 have been staged on the internet for public access (see Materials and Methods) along with predicted maps of annual EIR for the African continent (D. J. Rogers *et al.*, paper in preparation). This follows an objective to initiate the provision of web-based information to guide malaria control by the year 2000 (MARA/ARMA, 1998). There is a growing emphasis in many sectors on the potential benefits of the rapid internet-based supply of quality information. The greatest value of this increased information flow should be the possibility for iterative information updates with new, missed or corrected information. The most obvious problems to resolve are those of data-quality control and the provision of information in a manner accessible to a variety of users. The range of issues pertaining to data supply for malaria control planning is far from being resolved and is not appropriately addressed in this article. The authors have simply sought to make information available that might be of use to those collating data on malaria risk. Furthermore, these data are presented in such a way that those who may take issue with the protocol adopted can consult the original sources at the internet sites specified in Materials and Methods.

Data quality issues

It is evident that considerable resources have been expended by researchers, institutes and donors to provide annual EIR information across a range of sites in Africa over the past 2 decades. One of the major problems involved in comparing this information is the absence of data standardization between studies. An attempt has been made in this paper to highlight these issues.

The second major problem relates to the comprehensiveness of the reporting of annual EIR information. Most studies were incomplete in the range of information recorded. Similar problems have been experienced in parallel exercises to collate parasite rate (MARA/ARMA, 1998) and helminth infection data (Brooker *et al.*, 2000) in Africa. The following data are suggested as the minimum requirement for future peer-reviewed reporting of annual EIR. First, all methodological information should be identified including exactly how, when and for what duration biting rate and sporozoite indices were determined. It is also important that accurate names and co-ordinates are given for each of the study sites. Brief details about the nature of the surrounding land-use are useful in the determination of the extent of agricultural and demographic impacts. Where ELISA techniques are used it is helpful to record the proportion of infective bites that can be attributed to each *Plasmodium* species and the vector species by which malaria is locally transmitted. If future reporting completed

the list of information indicated in the Appendix, the foundation for a centralized, high-quality information database of annual EIR estimates across Africa would be assured.

The third problem is that, since accurate measurement of the EIR is labour intensive and thereby costly, estimates are spatially and temporally infrequent and unavailable for many settings. Another part of the study attempted to overcome this paucity of ground data by predicting annual EIR values across Africa using the information reviewed here and environmental data derived from meteorological satellite sensors (D. J. Rogers *et al.*, paper in preparation).

Reviews are becoming increasingly important within the arena of evidence-based planning for disease control and prevention (Bero & Rennie, 1995; Bero, 1996). Furthermore, improved internet access will facilitate the use of central data resources by a wider spectrum of the research and control community. It is hoped the presentation and synthesis of work here, and in the public domain, will expedite future information gathering required for rationalization of malaria control in space and time.

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Appendix

An example of a completed proforma used to abstract information from references on *P. falciparum* entomological inoculation rates (EIR) in this study, using data from Oloo *et al.*, 1996

Parameter	Unit	Value
Start date	mm-yy	June 1991
End date	mm-yy	May 1992
Sampling frequency	d-w-m-y	Monthly
Country	No units	Kenya
District	No units	Siaya
Town	No units	Kisumu (0° 06' S, 34° 45' E)
Site	No units	Kanyawegi (25 km NW of Kisumu)
Paper latitude	dd	Not reported
Paper longitude	dd	Not reported
Retrieved latitude	dd	00-9233 S (Map)
Retrieved longitude	dd	34-67328 E (Map)
Mosquito species	No units	<i>An. gambiae</i> s.l., <i>An. funestus</i>
Mosquito collection method	No units	Human bait and spray
Mean annual biting rate	b/p/night	8-42,5-05 ^a
Sporozoite rate determination method	No units	ELISA
Mean annual <i>P. falciparum</i> sporozoite infection rate	%	0-05,5-05 ^a
Mean annual EIR	b _i /p/year	166-1,93-8 (259-9) ^a
Mean annual EIR	b _i /p/night	0-455,0-257 (0-712) ^{a,b}
Transmission season	Months	NA
Ecotype (rural, urban or irrigated rice)	R/U/I	R

d, Day; w, week; m, month; y, year; dd, decimal degrees; b_i, infectious bite; p, person; NA, not available or not applicable.

^aData are presented for *An. gambiae* s.l., *An. funestus* and (total).

^bValues calculated from (b_i/p/year)/365 (and match *ma* × *s* table values product), not the rounded daily values quoted in Table 1.

References

- Akogbeto M. Étude entomologique sur la transmission du paludisme côtier lagunaire: cas d'un village construit sur un lac d'eau saumâtre. *Annales de la Société Belge de Médecine Tropicale*. 1995; 75:219–227.
- Akogbeto M, Nahum A. Impact des moustiquaires imprégnées de deltaméthrine sur la transmission du paludisme dans un milieu côtier lagunaire, Bénin. *Bulletin de la Société de Pathologie Exotique*. 1996; 89:291–298.
- Akogbeto M, Chippaux JP, Coluzzi M. Le paludisme urbain cotier à Cotonou (République du Bénin). Etude entomologique. *Revue d'Epidémiologie et Santé Publique*. 1992; 40:233–239.
- Aniedu I. Dynamics of malaria transmission near two permanent breeding sites in Baringo district, Kenya. *Indian Journal of Medical Research*. 1997; 105:206–211. [PubMed: 9183076]
- Babiker HA, Lines J, Hill WG, Walliker D. Population structure of *Plasmodium falciparum* in villages with different malaria endemicity in East Africa. *American Journal of Tropical Medicine and Hygiene*. 1997; 56:141–147. [PubMed: 9080871]
- Beier JC, Perkins PV, Onyango FK, Gargan TP, Oster CN, Whitmire RE, Koech DK, Roberts CR. Characterization of malaria transmission by *Anopheles* (Diptera: Culicidae) in western Kenya in preparation for malaria vaccine trials. *Journal of Medical Entomology*. 1990; 27:570–577. [PubMed: 2388233]
- Beier JC, Oster CN, Onyango FK, Bales JD, Sherwood JA, Perkins PV, Chumo DK, Koech DV, Whitmire RE, Roberts CR, Diggs CL, Hoffman SL. *Plasmodium falciparum* incidence relative to entomologic inoculation rates at a site proposed for testing malaria vaccines in western Kenya. *American Journal of Tropical Medicine and Hygiene*. 1994; 50:529–536. [PubMed: 7911282]
- Bero L. The Cochrane Collaboration: preparing, maintaining, and disseminating systematic reviews of the effects of health care (vol 274, pg 1935, 1995). *Journal of the American Medical Association*. 1996; 275:1403.
- Bero L, Rennie D. The Cochrane Collaboration: preparing, maintaining, and disseminating systematic reviews of the effects of health-care. *Journal of the American Medical Association*. 1995; 274:1935–1938. [PubMed: 8568988]
- Biro, S. Investigations on the bionomics of Anopheline vectors in the Ifakara Area (Kilombero District. Tanzania). University of Basel; Switzerland: 1987. DPhil Thesis
- Bockarie MJ, Service MW, Touré YT, Traoré S, Barnish G, Greenwood BM. The ecology and behaviour of the forest form of *Anopheles gambiae* s.s. *Parasitologia*. 1993; 35:5–8. [PubMed: 8233612]
- Bockarie MJ, Service MW, Barnish G, Maude GH, Greenwood BM. Malaria in a rural area of Sierra Leone. III. vector ecology and disease transmission. *Annals of Tropical Medicine and Parasitology*. 1994; 88:251–262. [PubMed: 7944670]
- Bockarie MJ, Service MW, Barnish G, Touré YT. Vectorial capacity and entomological inoculation rates of *Anopheles gambiae* in a high rainfall forested area of southern Sierra Leone. *Tropical Medicine and Parasitology*. 1995; 46:164–171. [PubMed: 8533019]
- Boudin C, Robert V, Verhave JP, Carnevale P, Ambroise-Thomas P. *Plasmodium falciparum* and *P. malariae* epidemiology in a West African village. *Bulletin of the World Health Organization*. 1991; 69:199–205. [PubMed: 1677615]
- Brooker S, Rowlands M, Haller L, Savioli L, Bundy D. Towards an atlas of helminth infection in sub-Saharan Africa: the use of geographical information systems (GIS). *Parasitology Today*. 2000 in press.
- Burkot TR, Graves PM. The value of vector-based estimates of malaria transmission. *Annals of Tropical Medicine and Parasitology*. 1995; 89:125–134. [PubMed: 7605122]
- Burkot TR, Williams JL, Schneider I. Identification of *Plasmodium falciparum*-infected mosquitoes by a double antibody enzyme-linked immunosorbent assay. *American Journal of Tropical Medicine and Hygiene*. 1984; 33:783–788. [PubMed: 6385740]
- Carnevale, P.; Robert, V. Effects of Agricultural Development on Vector-borne Diseases. Food and Agriculture Organization of the United Nations; Rome: 1987. Introduction of irrigation in Burkina Faso and its effect on malaria transmission; p. 57-67.

- Carnevale P, Robert V, Boudin C, Halna J-M, Pazart L, Gazin P, Richard A, Mouchet J. La lutte contre le paludisme par des moustiquaires imprégnées de pyréthrinoides au Burkina Faso. *Bulletin de la Société de Pathologie Exotique*. 1988; 81:832–846.
- Carnevale P, le Goff G, Toto J-C, Robert V. *Anopheles nili* as the main vector of human malaria in villages of southern Cameroon. *Medical and Veterinary Entomology*. 1992; 6:135–138. [PubMed: 1421483]
- Charlwood JD, Smith D, Lyimo E, Kitua AY, Masanja H, Booth M, Alonso PL, Tanner M. Incidence of *Plasmodium falciparum* infection in infants in relation to exposure to sporozoite-infected anophelines. *Tropical Medicine*. 1998; 59:243–251.
- Coene J. Malaria in urban and rural Kinshasa: the entomological input. *Medical and Veterinary Entomology*. 1993; 7:127–137. [PubMed: 8481529]
- Coosemans MH. Comparaison de l'endémie malarienne dans une zone de riziculture et dans une zone de culture de coton dans la Plaine de la Rusizi, Burundi. *Annales de la Société Belge de Médecine Tropicale*. 1985; 65:187–200.
- Coosemans M, Wery M, Mouchet J, Carnevale P. Transmission factors in malaria epidemiology and control in Africa. *Memorias do Instituto Oswaldo Cruz*. 1992; 87:385–391. [PubMed: 1343718]
- Craig MH, Snow RW, le Sueur D. A climate-based distribution model of malaria transmission in sub-Saharan Africa. *Parasitology Today*. 1999; 15:105–111. [PubMed: 10322323]
- Davis JR, Hall T, Chee EM, Majala A, Minjas J, Shiff CJ. Comparison of sampling anopheline mosquitoes by light-trap and human-bait collection indoors at Baramoyo, Tanzania. *Medical and Veterinary Entomology*. 1995; 9:249–255. [PubMed: 7548941]
- Dossou-yovo J, Doannio J, Rivière F, Duval J. Rice cultivation and malaria transmission in Bouaké city (Côte d'Ivoire). *Acta Tropica*. 1994; 57:91–94. [PubMed: 7942359]
- Dossou-yovo J, Doannio JMC, Rivière F, Chauvancy G. Malaria in Côte d'Ivoire wet Savannah region: the entomological input. *Tropical Medicine and Parasitology*. 1995; 46:263–269. [PubMed: 8826108]
- El Said S, Beier JC, Kenawy MA, Morsy ZS, Merdan AI. *Anopheles* population dynamics in two malaria endemic villages in Faiyum Governorate, Egypt. *Journal of the American Mosquito Control Association*. 1986; 2:158–163. [PubMed: 3333790]
- Faye O. Evaluation de l'efficacité du fénitrothion (Sumithion PM40) sur la densité du vecteur et la prévalence du paludisme à Pout (Thiès, Sénégal). *Annales de la Société Belge de Médecine Tropicale*. 1992; 72:103–112.
- Faye O, Diallo S, Gaye O, Ndir O, Faye O. Efficacité Comparée de l'utilisation des pièges lumineux du type CDC et des sujets humains pour l'échantillonnage des Populations anophéliennes. Resultats obtenus dans la zone de Bignona (Sénégal). *Annales de la Société Belge de Médecine Tropicale*. 1992; 85:185–189.
- Faye O, Fontenille D, Herve JP, Diack PA, Diallo S, Mouchet J. Le paludisme en zone Sahélienne du Sénégal. 1. Données entomologiques sur la transmission. *Annales de la Société Belge de Médecine Tropicale*. 1993; 73:21–30.
- Faye O, Gaye O, Faye O, Diallo S. La transmission du paludisme dans des villages éloignés ou situés en bordure de la mangrove au Sénégal. *Bulletin de la Société de Pathologie Exotique*. 1994; 87:157–163.
- Faye O, Gaye O, Fontenille D, Hébrard G, Konaté L, Sy N, Hervé J-P, Touré Y, Diallo S, Molez J-F, Mouchet J. La sécheresse et la baisse du paludisme dans les Niayes du Sénégal. *Cahiers Santé*. 1995a; 5:299–305.
- Faye O, Fontenille D, Gaye O, Sy N, Molez JF, Konaté L, Hebrard G, Herve JP, Trouillet J, Diallo S, Mouchet J. Paludisme et riziculture dans le delta du fleuve Sénégal (Sénégal). *Annales de la Société Belge de Médecine Tropicale*. 1995b; 75:179–189.
- Fondjo E, Robert V, le Goff G, Toto JC, Carnevale P. Le paludisme urbain à Yaoundé (cameroun). 2. Etude entomologique dans deux quartiers peu urbanisés. *Bulletin de la Société de Pathologie Exotique*. 1992; 85:57–63.
- Fontenille D, Lepers J-P, Campbell GH, Coluzzi M, Rakotoarivony I, Coulanges P. Malaria transmission and vector biology in Manarintsoa, high plateaux of Madagascar. *American Journal of Tropical Medicine and Hygiene*. 1990; 43:107–115. [PubMed: 2202220]

- Fontenille D, Lepers J-P, Coluzzi M, Campbell GH, Rakotoarivony I, Coulanges P. Malaria transmission and vector biology on Sainte Marie Island, Madagascar. *Journal of Medical Entomology*. 1992; 29:197–202. [PubMed: 1495029]
- Fontenille D, Lochouart L, Diatta M, Sokhna C, Dia I, Diagne N, Lemasson J-J, Ba K, Tall A, Rogier C, Trape J-F. Four years' entomological study of the transmission of seasonal malaria in Senegal and the bionomics of *Anopheles gambiae* and *A. arabiensis*. *Transactions of the Royal Society of Tropical Medicine and Hygiene*. 1997a; 91:647–652. [PubMed: 9509170]
- Fontenille D, Lochouart L, Diagne N, Sokhna C, Lemasson J-J, Diatta M, Konaté L, Faye F, Rogier C, Trape J-F. High annual and seasonal variations in malaria transmission by anophelines and vector species composition in Dielmo, a holoendemic area in Senegal. *American Journal of Tropical Medicine and Hygiene*. 1997b; 56:247–253. [PubMed: 9129525]
- Garret-Jones C. Problems of epidemiological entomology as applied to malaria. *Miscellaneous Publications of the Entomological Society of America*. 1970; 7:168–177.
- Gazin P, Robert V, Cot M, Carnevale P. *Plasmodium falciparum* incidence and Patency in a high seasonal transmission area of Burkina Faso. *Transactions of the Royal Society of Tropical Medicine and Hygiene*. 1988; 82:50–55. [PubMed: 3051549]
- Gazin P, Gonçalves K, Koné B, Lochouart L. Incidence des accès palustres dans un quartier de la ville de Bobo-Dioulasso (Burkina-Faso). *Bulletin de la Société de Pathologie Exotique*. 1996; 89:200–203.
- Gilles, HM. Epidemiology of malaria. In: Gilles, HM.; Warrell, DA., editors. *Bruce-Chwatt's Essential Malariaology*. 3rd edition. Oxford University Press; Oxford: 1993. p. 124–163.
- Githeko AK, Service MW, Mbogo CM, Atieli FK, Juma FO. *Plasmodium falciparum* sporozoite and entomological inoculation rates at the Ahero rice irrigation scheme and the Miwani sugar-belt in western Kenya. *Annals of Tropical Medicine and Parasitology*. 1993; 87:379–391. [PubMed: 8250629]
- Githeko AK, Mbogo CNM, Curtis CF, Lines J, Lengeler C. Entomological monitoring of large-scale vector-control interventions. *Parasitology Today*. 1996; 12:127–128.
- Gupta S, Snow RW, Donnelly C, Marsh K, Newbold C. Immunity to non-cerebral severe malaria is acquired after one or two infections. *Nature Medicine*. 1999a; 5:340–343.
- Gupta S, Snow RW, Donnelly C, Newbold C. Acquired immunity and postnatal clinical protection in child-hood cerebral malaria. *Proceedings of the Royal Society of London Series B*. 1999b; 266:33–38. [PubMed: 10081156]
- Ijumba JN, Mwangi RW, Beier JC. Malaria transmission potential of *Anopheles* mosquitoes in the Mwea-Tebere irrigation scheme, Kenya. *Medical and Veterinary Entomology*. 1990; 4:425–432. [PubMed: 2133010]
- Karch S, Asidi N, Manzambi ZM, Salaun JJ. La faune anophélienne et la transmission du paludisme humain à Kinshasa (Zaire). *Bulletin de la Société de Pathologie Exotique*. 1992; 85:304–309.
- Karch S, Garin B, Asidi N, Manzambi Z, Salaun JJ, Mouchet J. Moustiquaires imprégnées contre le paludisme au Zaïre. *Annales de la Société Belge de Médecine Tropicale*. 1993; 73:37–53.
- Kilian AHD, Metzger WG, Mutschelknauss EJ, Kabagambe G, Langi P, Korte R, von Sonnenburg F. Reliability of malaria microscopy in epidemiological studies: results of quality control. *Tropical Medicine and International Health*. 2000; 5:3–8. [PubMed: 10672199]
- Konaté L, Diagne N, Brahimi K, Faye O, Legros F, Rogier C, Petrarca V, Trape J-F. Biologie des vecteurs et transmission de *Plasmodium falciparum*, *P. malariae* and *P. ovale* dans un village de savane d'Afrique de l'ouest (Dielmo, Sénégal). *Parasite*. 1994; 1:325–333. [PubMed: 9235206]
- Le Goff G, Robert V, Fondjo E, Carnevale P. Efficacy of insecticide impregnated bed-nets to control malaria in a rural forested area in southern Cameroon. *Memorias do Instituto Oswaldo Cruz*. 1992; 87:355–359.
- Le Goff G, Carnevale P, Fondjo E, Robert V. Comparison of three sampling methods of man-biting anophelines in order to estimate the malaria transmission in a village of south Cameroon. *Parasite*. 1997; 4:75–80. [PubMed: 9208033]
- Le Masson JJ, Fontenille D, Lochouart L, Dia I, Simard F, Ba K, Diop A, Diatta M, Molez J-F. Comparison of behavior and vector efficiency of *Anopheles gambiae* and *An. arabiensis* (Diptera:

- Culicidae) in Barkedji, a Sahelian area of Senegal. *Journal of Medical Entomology*. 1997; 34:196–403.
- Le Sueur D, Binka F, Lengeler C, de Savigny D, Snow RW, Teuscher T, Toure YT. An atlas of malaria in Africa. *Africa Health*. 1997; 19:23–24. [PubMed: 12292303]
- Lepers JP, Fontenille D, Rason MD, Chougnnet C, Astagneau P, Coulanges P, Deloron P. Transmission and epidemiology of newly transmitted falciparum-malaria in the central highland plateaux of Madagascar. *Annals of Tropical Medicine and Parasitology*. 1991; 85:297–304. [PubMed: 1746977]
- Lindsay SW, Martens WJM. Malaria in the African highlands: past, present and future. *Bulletin of the World Health Organization*. 1998; 76:33–45. [PubMed: 9615495]
- Lindsay SW, Shenton FC, Snow RW, Greenwood BM. Responses of *Anopheles gambiae* complex mosquitoes to the use of untreated bednets in The Gambia. *Medical and Veterinary Entomology*. 1989; 3:253–262. [PubMed: 2519670]
- Lindsay SW, Campbell H, Adiamah JH, Greenwood AM, Bangali JE, Greenwood BM. Malaria in a peri-urban area of The Gambia. *Annals of Tropical Medicine and Parasitology*. 1990; 84:553–562.
- Lindsay SW, Wilkins HA, Zieler HA, Daly RJ, Petrarca V, Byass P. Ability of *Anopheles gambiae* mosquitoes to transmit malaria during the dry and wet seasons in an area of irrigated rice cultivation in The Gambia. *Journal of Tropical Medicine and Hygiene*. 1991; 94:313–324. [PubMed: 1942209]
- Lindsay SW, Alonso PL, Armstrong-Schellenberg JRM, Hemingway J, Adiamah JH, Shenton FC, Jawara M, Greenwood BM. A malaria control trial using insecticide-treated bed nets and targeted chemoprophylaxis in a rural area of The Gambia, West Africa. 7. Impact of permethrin-impregnated bed nets on malaria vectors. *Transactions of the Royal Society of Tropical Medicine and Hygiene*. 1993; 87(supplement 2):S2/45–S2/51.
- Lindsay SW, Parson L, Thomas CJ. Mapping the ranges and relative abundance of the two principal African malaria vectors, *Anopheles gambiae sensu stricto* and *An. arabiensis*, using climate data. *Proceedings of the Royal Society of London Series B*. 1998; 265:847–854. [PubMed: 9633110]
- Lines JD, Curtis CF, Wilkes TJ, Njunwa KJ. Monitoring human-biting mosquitos (Diptera: Culicidae) in Tanzania with light-traps hung beside mosquito nets. *Bulletin of Entomological Research*. 1991; 81:77–84.
- Lochouart L, Gazin P. La transmission du paludisme dans la ville de Bobo-Dioulasso (Burkina Faso). *Annales de la Société Belge de Médecine Tropicale*. 1993; 73:287–290.
- Lyimo, E. Some aspects of the adult bionomics of *Anopheles gambiae s.l.* in relation to malaria transmission in southeastern Tanzania. Wageningen Agricultural University; The Netherlands: 1993. PhD Thesis
- MacDonald, G. The Epidemiology and Control of Malaria. Oxford University Press; London: 1957.
- Magbity EB, Marbiah NT, Maude G, Curtis CF, Bradley DJ, Greenwood BM, Petersen E, Lines JD. Effects of community-wide use of lambda-cyhalothrin-impregnated bednets on malaria vectors in rural Sierra Leone. *Medical and Veterinary Entomology*. 1997; 11:79–86. [PubMed: 9061681]
- Magbity EB, Marbiah NT, David K, Bradley DJ, Petersen E, Lines JD. Reduction of malaria transmission by *Anopheles gambiae* mosquitoes from continual use of lambda-cyhalothrin impregnated bednets in southern Sierra Leone. 1999 in press.
- Magesa SM, Wilkes TJ, Mnzava AEP, Njunwa KJ, Myamba J, Kivuyo MDP, Hill N, Lines JD, Curtis CF. Trial of pyrethroid impregnated bednets in an area of Tanzania holoendemic for malaria. Part 2. Effects on the malaria vector population. *Acta Tropica*. 1991; 49:97–108. [PubMed: 1680284]
- Manga L, Fondjo E, Carnevale P, Robert V. Importance of low dispersion of *Anopheles gambiae* (Diptera: Culicidae) on malaria transmission in hilly towns in south Cameroon. *Journal of Medical Entomology*. 1993; 30:936–938. [PubMed: 8254644]
- Manga L, Toto JC, Carnevale P. Malaria vectors and transmission in an area deforested for a new international airport in southern Cameroon. *Annales de la Société Belge de Médecine Tropicale*. 1995; 75:43–49.
- Manga L, Bouchite B, Toto JC, Froment A. La faune anophélienne et la transmission du paludisme dans une zone de transition forêt/savane au centre de Cameroun. *Bulletin de la Société de Pathologie Exotique*. 1997a; 90:128–130.

- Manga L, Toto JC, Le Goff G, Brunhes J. The bionomics of *Anopheles funestus* and its role in malaria transmission in a forested area of southern Cameroon. *Transactions of the Royal Society of Tropical Medicine and Hygiene*. 1997b; 91:387–388. [PubMed: 9373627]
- MARA/ARMA. Towards an atlas of malaria risk in Africa. Mapping malaria risk in Africa/Atlas du risque de la malaria en Afrique; Durban: 1998. First technical report
- Mbogo CNM, Glass GE, Forster D, Kabiru EW, Githure JI, Ouma JH, Beier JC. Evaluation of light traps from sampling anopheline mosquitoes in Kilifi, Kenya. *Journal of the American Mosquito Control Association*. 1993a; 9:260–263. [PubMed: 8245934]
- Mbogo CNM, Snow RW, Kabiru EW, Ouma JH, Githure JI, Marsh K, Beier JC. Low-level *Plasmodium falciparum* transmission and the incidence of severe malaria infections on the Kenyan coast. *American Journal of Tropical Medicine and Hygiene*. 1993b; 49:245–253. [PubMed: 8357087]
- Mbogo CNM, Snow RW, Khamala CPM, Kabiru E, Ouma JH, Githure JI, Marsh K, Beier JC. Relationships between *Plasmodium falciparum* transmission by vector populations and the incidence of severe disease at nine sites on the Kenyan coast. *American Journal of Tropical Medicine and Hygiene*. 1995; 52:201–206. [PubMed: 7694959]
- Mnzava, AP. Epidemiology and control of malaria transmission by residual house spraying with DDT and lambdacyhalothrin in two populations of the *Anopheles gambiae* complex in Tanga region, Tanzania. University of Basel; Switzerland: 1991. DPhil Thesis
- Modiano D, Petrarca V, Sirima BS, Nebié I, Diallo D, Esposito F, Coluzzi M. Different response to *Plasmodium falciparum* malaria in West African sympatric ethnic groups. *Proceedings of the National Academy of Sciences of the United States of America*. 1996; 93:13206–13211. [PubMed: 8917569]
- Nabarro DN, Tayler EM. The ‘roll back malaria’ campaign. *Science*. 1998; 280:2067–2068. [PubMed: 9669961]
- Njan Nloga A, Robert V, Toto JC, Carnevale P. *Anopheles moucheti*, vecteur principal du paludisme au sud Cameroun. *Bulletin de Liaison Doc. OCEAC*. 1993; 26:63–67.
- Oloo A, Githeko A, Adungo D, Karanja J, Vulule J, Kisia-Abok I, Seroney I, Ayisi J, Ondijo S, Koech DK, Abdullah MS. Field trial of permethrin impregnated sisal curtains in malaria control in western Kenya. *East African Medical Journal*. 1996; 73:735–740. [PubMed: 8997865]
- Onori E, Grab B. Indicators for the forecasting of malaria epidemics. *Bulletin of the World Health Organization*. 1980; 58:91–98.
- Port GR, Boreham PFL, Bryan JH. The relationship of host size to feeding by mosquitoes of the *Anopheles gambiae* Giles complex (Diptera: Culicidae). *Bulletin of Entomological Research*. 1980; 70:133–144.
- Richard A, Zoulani A, Lallemand M, Trape JF, Carnevale P, Mouchet J. Le paludisme dans la région forestière du Mayombe, République Populaire du Congo. I. Présentation de la région et données entomologiques. *Annales de la Société Belge de Médecine Tropicale*. 1988; 68:293–303.
- Robert V, Carnevale P. Influence of deltamethrin treatment of bed nets on malaria transmission in the Kou valley, Burkina Faso. *Bulletin of the World Health Organization*. 1991; 69:735–740. [PubMed: 1786622]
- Robert V, Gazin P, Boudin C, Molez JF, Ouédraogo V, Carnevale P. La transmission du paludisme en zone de savane arborée et en zone rizicole des environs de Bobo-Dioulasso (Burkina Faso). *Annales de la Société Belge de Médecine Tropicale*. 1985; 65:201–214.
- Robert V, Gazin P, Ouédraogo V, Carnevale P. Le paludisme urbain à Bobo-Dioulasso (Burkina Faso). 1. Etude entomologique de la transmission. *Cahiers O.R.S.T.O.M. Série Entomologie Médicale et Parasitologie*. 1986; 24:121–128.
- Robert V, Carnevale P, Ouédraogo V, Petrarca V, Coluzzi M. La transmission du paludisme humain dans un village de savane du sud-ouest du Burkina Faso. *Annales de la Société Belge de Médecine Tropicale*. 1988; 68:107–121.
- Robert V, le Goff G, Toto J-C, Mulder L, Fondjo E, Manga L, Carnevale P. Anthropophilic mosquitos and malaria transmission at Edea, Cameroon. *Tropical Medicine and Parasitology*. 1993; 44:14–18. [PubMed: 8100084]

- Robert V, Dieng H, Lochouart L, Traoré SF, Trape J-F, Simondon F, Fontenille D. La transmission du paludisme dans la zone de Niakhar, Sénégal. *Tropical Medicine and International Health*. 1998; 3:667–677. [PubMed: 9735937]
- Rogier C, Trape J-F. Malaria attacks in children exposed to high transmission: who is protected? *Transactions of the Royal Society of Tropical Medicine and Hygiene*. 1993; 87:245–246. [PubMed: 8236379]
- Rossi P, Belli A, Mancini L, Sabatinelli G. Enquête entomologique longitudinale sur la transmission du paludisme à Ouagadougou (Burkina Faso). *Parassitologia*. 1986; 28:1–15. [PubMed: 3455529]
- Service, MW. *Mosquito Ecology: Field Sampling Methods*. Elsevier's Applied Science; London: 1993.
- Shiff CJ, Minjas JN, Hall T, Hunt RH, Lyimo S, Davis JR. Malaria infection potential of anopheline mosquitos sampled by light trapping indoors in coastal Tanzanian villages. *Medical and Veterinary Entomology*. 1995; 9:256–262. [PubMed: 7548942]
- Shililu JL, Maier WA, Seitz HM, Orago AS. Seasonal density, sporozoite rates and entomological inoculation rates of *Anopheles gambiae* and *Anopheles funestus* complex in a high-altitude sugarcane growing zone in western Kenya. *Tropical Medicine and International Health*. 1998; 3:706–710. [PubMed: 9754665]
- Smith T. Proportionality between light trap catches and biting densities of malaria vectors. *Journal of the American Mosquito Control Association*. 1995; 11:377–378. [PubMed: 8551314]
- Smith T, Charlwood JD, Kihonda J, Mwankusye S, Billingsley P, Meuwissen J, Lyimo E, Takken W, Teuscher T, Tanner M. Absence of seasonal variation in malaria parasitaemia in an area of intense seasonal transmission. *Acta Tropica*. 1993; 54:55–72. [PubMed: 8103627]
- Snow RW, Marsh K. The epidemiology of clinical malaria among African children. *Bulletin de l'Institut Pasteur*. 1998; 96:15–23.
- Snow RW, Marsh K, le Sueur D. The need for maps of transmission intensity to guide malaria control in Africa. *Parasitology Today*. 1996; 12:455–457.
- Snow RW, Omumbo JA, Lowe B, Molyneux CS, Obiero JO, Palmer A, Weber MW, Pinder M, Nahlen B, Obonyo C, Newbold C, Gupta S, Marsh K. Relation between severe malaria morbidity in children and level of *Plasmodium falciparum* transmission in Africa. *Lancet*. 1997; 349:1650–1654. [PubMed: 9186382]
- Snow RW, Gouws E, Omumbo J, Rapuoda B, Craig MH, Tanser FC, le Sueur D, Ouma J. Models to predict the intensity of *Plasmodium falciparum* transmission: applications to the burden of disease in Kenya. *Transactions of the Royal Society of Tropical Medicine and Hygiene*. 1998a; 92:601–606. [PubMed: 10326100]
- Snow RW, Nahlen B, Palmer A, Donnelly CA, Gupta S, Marsh K. Risk of severe malaria among African infants: direct evidence of clinical protection during early infancy. *Journal of Infectious Diseases*. 1998b; 177:819–822. [PubMed: 9498474]
- Snow RW, Craig M, Deichmann U, Marsh K. Estimating mortality, morbidity and disability due to malaria among Africa's non-pregnant population. *Bulletin of the World Health Organization*. 1999a; 77:624–640. [PubMed: 10516785]
- Snow RW, Craig MH, Deichmann U, le Sueur D. A preliminary continental risk map for malaria mortality among African children. *Parasitology Today*. 1999b; 15:99–104. [PubMed: 10322322]
- Sutherst, RW. Arthropods as disease vectors in a changing environment. In: Lake, JV.; Bock, GR.; Ackrill, K., editors. *Environmental Change and Human Health*. John Wiley and Sons; Chichester: 1993. p. 124–145.
- Temu EA, Minjas JN, Coetzee M, Hunt RH, Shiff CJ. The role of four anopheline species (Diptera: Culicidae) in malaria transmission in coastal Tanzania. *Transactions of the Royal Society of Tropical Medicine and Hygiene*. 1998; 92:152–158. [PubMed: 9764318]
- Thompson R, Begtrup K, Cuamba N, Dgedge M, Mendis C, Gamage-Mendis A, Enosse SM, Barreto J, Sinden RE, Hogg B. The Matola malaria project: a temporal and spatial study of malaria transmission and disease in a suburban area of Maputo, Mozambique. *American Journal of Tropical Medicine and Hygiene*. 1997; 57:550–559. [PubMed: 9392594]
- Thomson MC, D'Alessandro U, Bennett S, Connor SJ, Langerock P, Jawara M, Todd J, Greenwood BM. Malaria prevalence is inversely related to vector density in The Gambia, West Africa.

- Transactions of the Royal Society of Tropical Medicine and Hygiene. 1994; 88:638–643. [PubMed: 7886754]
- Thomson MC, Adiamah JH, Connor SJ, Jawara M, Bennett S, D'Alessandro U, Quinões M, Langerock P, Greenwood BM. Entomological evaluation of The Gambia's national impregnated bednet programme. *Annals of Tropical Medicine and Parasitology*. 1995; 89:229–241. [PubMed: 7668914]
- Trape JF, Zoulani A. Etudes sur le paludisme dans une zone de mosaïque forêt-savane d'Afrique centrale, la région de Brazzaville. I. Résultats des enquêtes entomologiques. *Bulletin de la Société de Pathologie Exotique*. 1987a; 80:84–99.
- Trape JF, Zoulani A. Malaria and urbanization in Central Africa: the example of Brazzaville. Part II: Results of entomological surveys and epidemiological analysis. *Transactions of the Royal Society of Tropical Medicine and Hygiene*. 1987b; 81(supplement 2):10–18. [PubMed: 2901796]
- Trape JF, Zoulani A, Quinet MC. Assessment of the incidence and prevalence of clinical malaria in semi-immune children exposed to intense and perennial transmission. *American Journal of Epidemiology*. 1987; 126:193–201. [PubMed: 3605048]
- Trape JF, Lefebvre-Zante E, Legros F, Ndiaye G, Bouganali H, Druilhe P, Salem G. Vector density gradients and the epidemiology of urban malaria in Dakar, Senegal. *American Journal of Tropical Medicine and Hygiene*. 1992; 47:181–189. [PubMed: 1354414]
- Trape JF, Rogier C, Konaté L, Diagne N, Bouganali H, Canque B, Legros F, Badji A, Ndiaye G, Ndiaye P, Brahimi K, Faye O, Druilhe P, Pereira da Silva L. The Dielmo Project: a longitudinal study of natural malaria infection and the mechanisms of protective immunity in a community living in a holoendemic area of Senegal. *American Journal of Tropical Medicine and Hygiene*. 1994; 51:123–137. [PubMed: 8074247]
- Van Bortel W, Delacollette C, Barutwanayo M, Coosemans M. Deltamethrin-impregnated bednets as an operational tool for malaria control in a hyper-endemic region of Burundi: impact on vector population and malaria morbidity. *Tropical Medicine and International Health*. 1996; 1:824–835. [PubMed: 8980597]
- Van der Stuyt P, Manirankunda L, Delacollette C. The risk approach in diagnosing malaria in high-altitude regions. *Annales de la Société Belge de Médecine Tropicale*. 1993; 73:81–89.
- Vercruysse J. Étude entomologique sur la transmission du paludisme humain dans le bassin du fleuve Sénégal (Sénégal). *Annales de la Société Belge de Médecine Tropicale*. 1985; 65:171–179.
- Vercruysse J, Jancloes M. Étude entomologique sur la transmission du paludisme humain dans la zone urbaine de Pikine (Sénégal). *Cahiers O.R.S. T.O.M. Série Entomologie Médicale et Parasitologie*. 1981; 19:165–178.
- WHO. Manual on Practical Entomology. Part II. Methods and Techniques. World Health Organization; Geneva: 1975.
- WHO. Roll Back Malaria. World Health Organization; Geneva: 1998. Fact Sheet, no. 203

Figure.

A map showing the geo-referenced locations in Africa for which annual EIR data were published. The top left corner is 40°N, 20°W. Each grid square is 5 × 5 degrees and north is to the top of the page.

Table 1
Geo-referenced locations in Africa for which annual *P. falciparum* EIR data were published

Country and site	Location ¹ (Long., Lat.)	Land-use ²	Study date	Sporozoite index ³ (%)	Biting rate ⁴ (<i>mf</i> annual)	EIR ⁵ (annual)	Seasonality ⁶ (months)	Relative EIR transmission by species ⁷ (%)	Citation
Benin									
Cotonou, Ghégamé quarter	2.45, 6.36 ^d	U	Jan 1987–Dec 1987	2.80 ^e	1179 ^g	33.0	1	100:0:0	Akogbeto <i>et al.</i> , 1992
Cotonou, Ladji quarter	2.43, 6.38 ^d	R	Jan 1987–Dec 1987	1.60 ^e	3666 ^g	58.0	4	100:0:0	Akogbeto <i>et al.</i> , 1992
Cotonou, Sainte-Rita Nord quarter	2.42, 6.37 ^d	R	Jan 1987–Dec 1987	1.40 ^e	3363 ^g	47.0	4	100:0:0	Akogbeto <i>et al.</i> , 1992
Ganvié	2.42, 6.47 ^b	R	Jan 1993–Dec 1993	0.43 ^e	2555 ^g	11.0	6	P:A:P	Akogbeto, 1995
Ganvié, near lake Nokoué	2.42, 6.42 ^a	R	Jan 1993–Dec 1995	0.37 ^e	2917 ^g	10.8	6	100:0:0	Akogbeto & Nahum, 1996
Burkina Faso									
Barna	-4.42, 11.38 ^b	R	Jan 1981–Dec 1981	NA ^{NA}	NA ^{NA}	175.2	3	57:35:8	Carnevale & Robert, 1987
Baré	-4.10, 11.08 ^b	R	Jan 1981–Dec 1981	NA ^{NA}	NA ^{NA}	91.3	3	57:35:8	Carnevale & Robert, 1987
Barkoumbien and Barkoundouba	-1.23, 12.67 ^b	R	Aug 1994–Jun 1995	NA ^f	NA ^h	140.0	4-5	P:P:A	Modiano <i>et al.</i> , 1996
Bobo-Dioulasso	-4.30, 11.20 ^b	U	Nov 1991–Jan 1993	0.10 ^e	2150 ^g	2.2	NA	100:0:0	Lochouam & Gazin, 1993
Bobo-Dioulasso, Colma- Nord quarter	-4.30, 11.21 ^a	U/R	Jan 1985–Dec 1985	0.19 ^e	2421 ^g	4.6	NA	100:0:0	Robert <i>et al.</i> , 1986
Bobo-Dioulasso, Diariadougou quarter	-4.29, 11.18 ^a	U	Jan 1985–Dec 1985	0.19 ^e	74 ^g	0.1	NA	100:0:0	Robert <i>et al.</i> , 1986
Bobo-Dioulasso, Dioulassoba quarter	-4.30, 11.19 ^a	U	Jan 1985–Dec 1985	0.19 ^e	289 ^g	0.6	NA	100:0:0	Robert <i>et al.</i> , 1986
Bobo-Dioulasso, Sarfalao quarter	-4.30, 11.20 ^b	U	Jun 1993–Sep 1993	0.50 ^e	800 ^g	4.0	NA	100:0:0	Gazin <i>et al.</i> , 1996
Dandé and Tago	-4.55, 11.59 ^a	R	Jan 1983–Dec 1984	3.99 ^e	1380 ^g	55.0	3	69:31:0	Robert <i>et al.</i> , 1985
Desso	-4.28, 11.35 ^b	R	Jan 1981–Dec 1981	NA ^{NA}	NA ^{NA}	208.1	3	57:35:8	Carnevale & Robert, 1987
Gounguin Nord	-1.55, 12.37 ^a	U	Jul 1984–Dec 1984	NA ^e	NA ^h	0.0	0	0:0:0	Rossi <i>et al.</i> , 1986
Karangasso	-4.63, 11.22 ^b	R	Jan 1985–Feb 1986	4.13 ^f	6360 ^g	262.8	4	57:41:2*	Boudin <i>et al.</i> , 1991
Karangasso, Koko suburb	-4.65, 11.22 ^a	R	Feb 1985–Feb 1986	NA ^e	NA ^g	116.0	4	P:P:P	Robert <i>et al.</i> , 1988
Karangasso, Koko suburb	-4.65, 11.22 ^a	R	May 1985–Apr 1986	2.60 ^e	4548 ^g	116.1	5	51:49:0	Carnevale <i>et al.</i> , 1988
Karangasso, Koko suburb	-4.65, 11.22 ^a	R	May 1986–Apr 1987	4.56 ^e	4913 ^g	223.8	4	59:41:0	Carnevale <i>et al.</i> , 1988
Karangasso, Massasso suburb	-4.64, 11.21 ^a	R	Feb 1985–Feb 1986	NA ^e	NA ^g	370.0	4	P:P:P	Robert <i>et al.</i> , 1988

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Karangasso, Massasso suburb	-4.64, 11.21 ^a	R	May 1985–Apr 1986	5.75 ^e	701.2 ^g	403.3	4	60:37:3	Carnevale <i>et al.</i> , 1988
Kongodjan	-4.45, 11.58 ^a	R	Jan 1983–Dec 1984	1.78 ^e	7480 ^g	133.0	4	52:48:0	Robert <i>et al.</i> , 1985
Kongodjan	-4.45, 11.58 ^a	R	Jan 1983–Dec 1983	NA ^e	NA ^g	133.0	3	P:P-A	Gazin <i>et al.</i> , 1988
Koro	-4.20, 11.15 ^b	R	Jan 1981–Dec 1981	NA ^{NA}	NA ^{NA}	171.6	3	57:35:8	Carnevale & Robert, 1987
Koubri	-1.38, 12.15 ^a	R	Jul 1984–Dec 1984	NA ^e	NA ^h	441.6	3	P:P-A	Rossi <i>et al.</i> , 1986
Ouagadougou, Kologh Naba suburb	-1.54, 12.39 ^a	U	Jul 1984–Dec 1984	NA ^e	NA ^h	1.5	3	P:P-A	Rossi <i>et al.</i> , 1986
Ouagadougou, Nongrenassm suburb	-1.51, 12.40 ^a	U	Jul 1984–Dec 1984	NA ^c	NA ^h	7.7	3	P:P-A	Rossi <i>et al.</i> , 1986
Ouagadougou, Saint Camille suburb	-1.52, 12.36 ^a	U	Jul 1984–Dec 1984	NA ^e	NA ^h	5.6	1	P:P-A	Rossi <i>et al.</i> , 1986
Ouagadougou, Saint Léon suburb	-1.52, 12.37 ^a	U	Jul 1984–Dec 1984	NA ^e	NA ^h	0.0	0	0:0:0	Rossi <i>et al.</i> , 1986
Pabré	-1.58, 12.50 ^a	R	Jul 1984–Dec 1984	NA ^e	NA ^h	113.0	3	P:P-A	Rossi <i>et al.</i> , 1986
Soumouso	-4.05, 11.02 ^a	R	Jan 1981–Dec 1981	NA ^{NA}	NA ^{NA}	200.8	3	57:35:8	Carnevale & Robert, 1987
Tago	-4.38, 11.67 ^a	R	Jan 1983–Dec 1983	NA ^e	NA ^g	82.0	3	P:P-A	Gazin <i>et al.</i> , 1988
Toukoro	-4.25, 11.43 ^b	R	Jan 1981–Dec 1981	NA ^{NA}	NA ^{NA}	76.7	3	57:35:8	Carnevale & Robert, 1987
VK1	-4.41, 11.35 ^a	I	Jan 1981–Dec 1981	NA ^{NA}	NA ^{NA}	0	3	72:25:3	Carnevale & Robert, 1987
VK2	-4.41, 11.37 ^a	I	Jan 1981–Dec 1981	NA ^{NA}	NA ^{NA}	21.9	3	72:25:3	Carnevale & Robert, 1987
VK3	-4.41, 11.38 ^a	I	Jan 1981–Dec 1981	NA ^{NA}	NA ^{NA}	62.1	3	72:25:3	Carnevale & Robert, 1987
VK4	-4.42, 11.37 ^a	I	Jan 1981–Dec 1981	NA ^{NA}	NA ^{NA}	20.1	3	72:25:3	Carnevale & Robert, 1987
VK4	-4.42, 11.37 ^a	I	Jan 1983–Dec 1984	0.36 ^e	14000 ^g	50.0	4	100:0:0	Robert <i>et al.</i> , 1985
VK4	-4.42, 11.37 ^a	I	May 1985–Apr 1986	0.21 ^e	25857 ^g	54.9	4	90:10:0	Robert & Carnevale, 1991
VK5	-4.43, 11.38 ^a	I	Jan 1981–Dec 1981	NA ^{NA}	NA ^{NA}	36.5	3	72:25:3	Carnevale & Robert, 1987
VK6	-4.44, 11.37 ^a	I	Jan 1981–Dec 1981	NA ^{NA}	NA ^{NA}	54.8	3	72:25:3	Carnevale & Robert, 1987
VK6	-4.44, 11.37 ^a	I	Jan 1983–Dec 1984	0.43 ^e	13900 ^g	60.0	2	90:10:0	Robert <i>et al.</i> , 1985
Zaglouli	-1.63, 12.33 ^a	R/I	Jul 1984–Dec 1984	NA ^e	NA ^h	82	2	P:P-A	Rossi <i>et al.</i> , 1986
Burundi									
Gasange	29.60, -4, 32 ^a	NA	Nov 1992–Oct 1993	3.14 ^e	8503 ^g	267.0	6	P:P-A	Van Bortel <i>et al.</i> , 1996
Gihanga Mulira	29.29, -3.19 ^b	I	Jan 1983–Dec 1983	0.48 ^e	21499 ^g	103.2	12	96:4:0	Coosemans, 1985

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Gisenga	29-67, -4, 44 ^d	NA	Nov 1992–May 1994	3-85 <i>e</i>	6534 <i>g</i>	251-7	5	P-P-A	Van Bortel <i>et al.</i> , 1996
Kazirabageni	29-63, -4-23 ^d	R	Nov 1992–May 1994	2-02 <i>e</i>	1753 <i>g</i>	35-4	5	P-P-A	Van Bortel <i>et al.</i> , 1996
Mugere	29-66, -4, 37 ^d	I	Nov 1992–Oct 1993	1-02 <i>e</i>	59021 <i>g</i>	600-9	7	P-P-A	Van Bortel <i>et al.</i> , 1996
Cameroon									
Ebogo	11-47, 3-40 ^b	R	Apr 1991–Mar 1992	0-93 <i>e</i>	38189 <i>g</i>	355-0	6	14:0-86	Njan Nloga <i>et al.</i> , 1993
Edea, Bililang suburb	10-13, 3-80 ^d	U	Jan 1990–Dec 1990	1-20 ^e	319 <i>g</i>	3-8	NA	100:0:0	Robert <i>et al.</i> , 1993
Edea, Pongo suburb	10-13, 3-80 ^d	U	Jan 1990–Dec 1990	8-21 <i>e</i>	368 <i>g</i>	30-2	NA	100:0:0	Manga <i>et al.</i> , 1993
Etoa	11-48, 3-77 ^b	R	Feb 1996–May 1996	4-10 <i>e</i>	11571 <i>g</i>	474-5	NA	P-55:45	Manga <i>et al.</i> , 1997b
Mbébé	11-00, 4-15 ^d	R	Apr 1989–Mar 1990	1-93 NA	10330 <i>g</i>	200-0	5	36-9:55	Le Goff <i>et al.</i> , 1992
Nditam	11-26, 5-36 ^d	R	May 1995–Mar 1996	9-40 ^e	876 <i>g</i>	82-1	1	100:0:0	Manga <i>et al.</i> , 1997a
Nsimalen, Ekoko	12-12, 3-82 ^d	R	Apr 1991–Mar 1992	1-22 <i>e</i>	8724 <i>g</i>	106-0	5-6	13:0-87	Manga <i>et al.</i> , 1995
Nsimalen, Nkol Mefou	11-57, 3-70 ^d	R	Apr 1991–Mar 1993	2-33 <i>e</i>	2920 <i>g</i>	68-0	6	100:0:0	Manga <i>et al.</i> , 1995
Sanaga river villages	11-00, 4-15 ^d	R	Apr 1989–Mar 1990	1-77 <i>e</i>	10303 <i>g</i>	182-1	6	43:0-57	Carnevale <i>et al.</i> , 1992
Yaoundé, Essos	11-00, 3-00 ^d	U	Mar 1989–Feb 1990	20-3 <i>e</i>	64 <i>g</i>	13-0	NA	100:0:0	Manga <i>et al.</i> , 1993
Yaoundé, Nkol Bikok quarter	11-52, 3-87 ^d	U	Mar 1989–Mar 1990	5-00 ^e	284-7 <i>g</i>	14-2	1	100:0:0	Fondjo <i>et al.</i> , 1992
Congo, Democratic Republic of									
Kinkolé	15-51, -4-36 ^d	R	Feb 1990–Dec 1991	3-24 <i>e</i>	1241 <i>g</i>	40-2	12	100:0:0	Karch <i>et al.</i> , 1993
Kinshasa, Kimbangu 3 district	15-31, -4, 35, <i>c</i>	U	Sep 1988–Dec 1989	1-86 ^f	1862 <i>g</i>	29-2	5-6	100:0:0	Coene, 1993
Kinshasa, Kwamuthu district	15-27, -4, 46 ^c	R	Sep 1988–Dec 1989	7-41 <i>f</i>	6132 <i>g</i>	454-4	5-6	86:2:12	Coene, 1993
Kinshasa, rural area	15-30, -4-44 ^d	R	Apr 1989–Oct 1990	NA ^e	NA <i>g</i>	61-2-0	NA	100:0:0	Karch <i>et al.</i> , 1992
Kinshasa, semi-rural area	15-35, -4-36 ^d	R/U	Apr 1989–Oct 1990	NA ^e	NA <i>g</i>	198-7	NA	100:0:0	Karch <i>et al.</i> , 1992
Kinshasa, urban area	15-31, -4-31 ^d	U	Apr 1989–Oct 1990	0-3 <i>e</i>	953 <i>g</i>	2-8	NA	100:0:0	Karch <i>et al.</i> , 1992
Congo, Republic of									
Brazzaville	15-28, -4-26 ^b	U	Oct 1982–May 1984	3-47 ^e	650 <i>g</i>	22-5	NA	100:0:0	Trape & Zoulani, 1987b
Kulla	12-43, -4-17 ^d	R	Oct 1981–Oct 1982	4-91 <i>e</i>	8103 <i>g</i>	397-9	5	97:3:0	Richard <i>et al.</i> , 1988
Linzolo	15-11, -4-41 <i>b</i>	R	Oct 1981–Jan 1984	2-11 <i>e</i>	11673 <i>g</i>	246-0	9	NA	Trape & Zoulani, 1987a

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Linzolo	15-11, -4-41 ^b	R	Oct 1983–Sep 1984	NA ^a	NN ^g	234.6	9	96:4:0	Trape <i>et al.</i> , 1987
Makaba	12-38, -4-14 ^b	R	Oct 1981–Oct 1982	6.85 ^e	1168 ^g	80.0	6	89:11:0	Richard <i>et al.</i> , 1988
Côte d'Ivoire									
Alloukoukro	-5-08, 7-80 ^a	R	Jan 1991–Dec 1991	3.13 ^e	8507 ^g	266.5	6	77:23:0	Dossou-yovo <i>et al.</i> , 1995
Alloukoukro	-5-08, 7-80 ^a	R	Jan 1992–Dec 1992	3.39 ^e	5792 ^g	196.5	5	81:19:0	Dossou-yovo <i>et al.</i> , 1995
Egypt									
El Zawya	30-85, 29-42 ^a	R	Feb 1983–Feb 1984	0.00 ^e	128 ^g	0.0	0	0:0:0	El Said <i>et al.</i> , 1986
Gambia, The									
Bakau	-16-68, 13-48 ^b	U	Jun 1988–May 1989	0.98 ^f	128 ^g	140 ^k	NA	100:0:0	Lindsay <i>et al.</i> , 1990
Barokunda	-15-32, 13-65 ^b	R	NA 1988–NA 1988	2.97 ^f	3701 ⁱ	110.0	5	100:0:0	Lindsay <i>et al.</i> , 1993
Biran Giado Ya	-15-85, 13-59 ^a	R	Jun 1986–Dec 1986	2.67 ^e	412 ^j	11.0	3	100:0:0	Lindsay <i>et al.</i> , 1989
Bwiam	-16-09, 13-23 ^c	R	Jan 1991–Dec 1991	2.47 ^f	37 ^h	0.9	5	P:A:P	Thomson <i>et al.</i> , 1994
Dasilami ^a	-14-27, 13-41 ^c	R	Jan 1991–Dec 1991	2.23 ^f	54 ^h	1.2	5	P:A:P	Thomson <i>et al.</i> , 1994
Dasilami ^b	-15-23, 13-48 ^b	R	NA 1988–NA 1988	1.29 ^f	1160 ⁱ	15.0	5	100:0:0	Lindsay <i>et al.</i> , 1993
Dongoro Ba	-15-28, 13-38 ^b	R	NA 1988–NA 1988	17.86 ^f	448 ^j	80.0	5	100:0:0	Lindsay <i>et al.</i> , 1993
Jahally	-14-97, 13-55 ^c	R	Jan 1991–Dec 1991	0.95 ^f	443 ^h	4.2	5	P:A:P	Thomson <i>et al.</i> , 1995
Jalangbereh	-15-40, 13-38 ^b	R	NA 1988–NA 1988	9.10 ^f	769 ⁱ	70.0	5	100:0:0	Lindsay <i>et al.</i> , 1993
Jessadi	-15-30, 13-63 ^b	R	NA 1988–NA 1988	2.69 ^f	2380 ^j	64.0	5	100:0:0	Lindsay <i>et al.</i> , 1993
Katamina	-15-28, 13-55 ^b	R	NA 1988–NA 1988	0.37 ^f	1076 ^j	4.0	5	100:0:0	Lindsay <i>et al.</i> , 1993
Kerewan	-16-09, 13-49 ^c	R	Jan 1991–Dec 1991	0.23 ^f	211 ^h	0.4	5	P:A:P	Thomson <i>et al.</i> , 1995
Kulari	-14-08, 13-40 ^c	R	Jan 1991–Dec 1991	7.65 ^f	0.28 ^h	7.8	5	P:A:P	Thomson <i>et al.</i> , 1995
Madina	-15-25, 13-52 ^a	R	NA 1988–NA 1988	7.45 ^f	2376 ^j	177.0	5	100:0:0	Lindsay <i>et al.</i> , 1993
Male Kunda	-15-30, 13-55 ^b	R	NA 1988–NA 1988	2.60 ^f	2692 ^j	70.0	5	100:0:0	Lindsay <i>et al.</i> , 1993
Niwodunlung	-15-22, 13-46 ^a	R	NA 1988–NA 1988	0.00 ^f	1481 ⁱ	0.0	5	100:0:0	Lindsay <i>et al.</i> , 1993
Pakali Ba	-15-25, 13-50 ^b	R	NA 1988–NA 1988	3.04 ^f	3253 ^j	99.0	5	100:0:0	Lindsay <i>et al.</i> , 1993
Salikene	-15-97, 13-48 ^c	R	Jan 1991–Dec 1991	0.55 ^f	360 ^h	1.9	5	P:A:P	Thomson <i>et al.</i> , 1995
Sare Alpha	-13-98, 13-37 ^b	R	Jan 1991–Dec 1991	6.07 ^f	187 ^h	11.2	5	P:A:P	Thomson <i>et al.</i> , 1995

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Suruja	-14.90, 13.55 ^c	I	Jan 1991–Dec 1991	2.17 ^f	231 ^h	5.0	5	P:A:P	Thomson <i>et al.</i> , 1995
Suruja	-14.90, 13.55 ^c	I	Mar 1987–Jun 1988	NA ^f	NA ⁱ	3.0 ^k	NA	100:0:0	Lindsay <i>et al.</i> , 1991
Sibanor	-16.20, 13.21 ^b	R	Jan 1991–Dec 1991	2.88 ^f	113 ^h	3.2	5	P:A:P	Thomson <i>et al.</i> , 1994
Stahuma	-15.40, 13.43 ^d	R	NA 1988–NA 1988	2.23 ^f	3366 ^j	75.0	5	100:0:0	Lindsay <i>et al.</i> , 1993
Sutukoba	-14.02, 13.50 ^c	R	Jan 1991–Dec 1991	2.94 ^f	34 ^h	1.0	5	P:A:P	Thomson <i>et al.</i> , 1994
Turan	-15.72, 13.58 ^d	R	Jun 1986–Dec 1986	2.70 ^e	890 ^j	23.8	3	100:0:0	Lindsay <i>et al.</i> , 1989
Wellingara Ba	-15.26, 13.41 ^d	R	NA 1988–NA 1988	2.19 ^f	1553 ^j	34.0	5	100:0:0	Lindsay <i>et al.</i> , 1993
Kenya									
Ahero	34.92, -0.17 ^c	I	May 1989–Jun 1990	NA ^f	NA ^g	416.0	7	15:85:0	Githeko <i>et al.</i> , 1993
Fumbini	39.84, -3.61 ^c	NA	Jan 1992–May 1993	2.30 ^f	131 ^g	3.0	1	95:5:0	Mbogo <i>et al.</i> , 1995
Kambi ya Wari	39.84, -3.52 ^c	U/R	Jan 1992–May 1993	10.54 ^f	37 ^g	3.6	2	95:5:0	Mbogo <i>et al.</i> , 1995
Kaoiyeni	39.90, -3.46 ^c	NA	Jan 1992–May 1993	4.08 ^f	61 ^g	2.5	1	95:5:0	Mbogo <i>et al.</i> , 1995
Kanyawegi	34.67, -0.92 ^c	R	Jun 1991–May 1992	5.29 ^f	4917 ^{gh}	259.9	NA	64:36:0	Oloo <i>et al.</i> , 1996
Karima	37.32, -0.69 ^c	NA	Oct 1986–Jun 1987	2.65 ^f	657 ^g	17.4	NA	80:10:10	Ijumba <i>et al.</i> , 1990
Kibarani	39.85, -3.58 ^c	NA	Jan 1992–May 1993	11.31 ^f	156 ^g	18.0	4	95:5:0	Mbogo <i>et al.</i> , 1995
Kilifi Town	39.85, -3.63 ^b	U	Dec 1990–Nov 1991	2.17 ^f	69 ^{gh}	1.5	2	100:0:0	Mbogo <i>et al.</i> , 1993b
Kisian	34.67, -0.07 ^b	R	Oct 1985–Jun 1988	5.98 ^{e f}	5001 ^g	299.3	5–6	76:24:0	Beier <i>et al.</i> , 1990
Loboi swamp	36.06, 0.36 ^d	R	NA	2.55 ^e	915 ^h	23.4	2	84:16:0	Aniedu, 1997
Mikongirini	39.87, -3.56 ^c	NA	Jun 1992–May 1993	0.40 ^f	46 ^g	0.0	0	0:0:0	Mbogo <i>et al.</i> , 1995
Miwani	35.01, -0.59 ^c	R	May 1989–Jun 1990	NA ^f	NA ^g	91.0	3	80:20:0	Githeko <i>et al.</i> , 1993
Mtondia	39.90, -3.57 ^c	NA	Jun 1992–May 1993	2.49 ^f	2844 ^g	59.6	2	95:5:0	Mbogo <i>et al.</i> , 1995
Mukombe	39.86, -3.52 ^c	NA	Jun 1992–May 1993	7.25 ^f	52 ^g	3.8	2	95:5:0	Mbogo <i>et al.</i> , 1995
Mumias	34.49, 0.18 ^c	R	May 1995–Mar 1996	7.22 ^f	647 ^h	46.7	7	63:37:0	Shililu <i>et al.</i> , 1998
Perkerra irrigation scheme	35.97, 0.47 ^d	I	NA	3.48 ^e	533 ^h	16.4	2	100:0:0	Aniedu, 1997
Saradidi	34.38, -0.12 ^d	R	Feb 1986–Oct 1987	NA ^{ef}	NA ^g	273.8	5	90:10:0	Beier <i>et al.</i> , 1994
Saradidi	34.38, -0.12 ^d	R	Oct 1985–Jun 1988	17.1 ^{e f}	1387 ^g	237.3	5	90:10:0	Beier <i>et al.</i> , 1990
Sokoke	39.82, -3.53 ^b	NA	Dec 1990–Nov 1991	4.23 ^f	189 ^{gh}	8.0	4	100:0:0	Mbogo <i>et al.</i> , 1993b

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Ufui	39-93, -3-46 ^c	NA	Jun 1992–May 1993	0-01 <i>f</i>	19 ^g	0-0	<i>I</i>	95:5:0	Mbogo <i>et al.</i> , 1995
Zowerani	39-92, -3-51 ^c	NA	Jun 1992–May 1993	2-35 <i>f</i>	68 ^g	1-6	<i>I</i>	95:5:0	Mbogo <i>et al.</i> , 1995
Madagascar									
Ambohitratra, St Joseph, Maromandia	49-90, -17-00 ^b	R	Nov 1988–Oct 1989	0-59 <i>f</i>	13761 <i>g</i>	82-0	12	P:P:P	Fontenille <i>et al.</i> , 1992
Manarintsoa	47-42, -18-92 ^c	R	Oct 1987–Jul 1988	0-71 <i>f</i>	212 <i>g</i>	1-5	4-5	97-3-0	Lepers <i>et al.</i> , 1991
Manarintsoa	47-42, -18-92 ^c	R	Oct 1988–Feb 1990	0-14 <i>f</i>	657 <i>g</i>	0-9	NA	NA	Fontenille <i>et al.</i> , 1990
Mozambique									
Matola	32-93, -25-94 ^d	U/R	Jan 1994–Jun 1995	NA <i>f</i>	NA ^g	12	NA	P:P:A	Thompson <i>et al.</i> , 1997
Senegal									
Aéré Lao	-14-30, 16-40 ^d	R	May 1982–Aug 1983	0-24 <i>e</i>	1600 ^g	3-8	3-4	100-0-0	Vercruysse, 1985
Afiniam, Diagobel, Tendimane	-16-30, 12-70 ^d	R	Jan 1985–Nov 1985	0-03 <i>e</i>	22490 <i>g</i>	7-0	5	100:0:0	Faye <i>et al.</i> , 1994
Barkedji	-14-87, 15-28 ^d	R	Jul 1994–Mar 1996	NA <i>f</i>	NA ^g	111-1	2-3	100:0:0	Le Masson <i>et al.</i> , 1997
Boké Diallobé	-14-00, 16-10 ^d	R	May 1982–Aug 1983	1-2 <i>e</i>	200 ^g	2-4	3-4	100-0-0	Vercruysse, 1985
Dakar, around Grande Naye marsh	-17-42, 14-75 ^d	NA	Jan 1988–Dec 1988	NA <i>e</i>	NA ^g	0-1	NA	100-0-0	Trape <i>et al.</i> , 1992
Dielmo	-16-42, 13-72 ^d	R	Apr 1990–Mar 1992	1-29 <i>f</i>	14790 ^g	191-5	5	69:31:0	Konaté <i>et al.</i> , 1994
Dielmo	-16-42, 13-72 ^b	R	Apr 1992–Mar 1993	NA <i>f</i>	NA ^g	222-8	6	23:77:0	Fontenille <i>et al.</i> , 1997b
Dielmo	-16-42, 13-72 ^b	R	Apr 1993–Mar 1994	NA <i>f</i>	NA ^g	78-5	4-5	74:26:0	Fontenille <i>et al.</i> , 1997b
Dielmo	-16-42, 13-72 ^b	R	Apr 1994–Mar 1995	NA <i>f</i>	NA ^g	135-2	4	66:34:0	Fontenille <i>et al.</i> , 1997b
Dielmo	-16-42, 13-72 ^b	R	Jan 1990–Dec 1990	NA ^{NA?}	NA ^{NA?}	115-0	4	100:0:0	Rogier & Trape, 1993
Dielmo	-16-42, 13-72 ^b	R	Jun 1990–May 1991	1-04 ^e	9731 <i>g</i>	101-2	4	P:P:A	Trape <i>et al.</i> , 1994
Dielmo	-16-42, 13-72 ^b	R	Jun 1991–May 1992	1-57 ^e	17357 <i>g</i>	272-5	6	P:P:A	Trape <i>et al.</i> , 1994
Diohine	-16-52, 14-50 ^b	R	Jan 1995–Dec 1995	1-95 <i>f</i>	680 ^g	13-3	5	100-0-0	Robert <i>et al.</i> , 1998
Diomandou Dieri	-14-44, 16-50 ^d	I	Jun 1990–Nov 1991	0-00 <i>e</i>	2665 ^g	0-0	0	0:0:0	Faye <i>et al.</i> , 1993
Diomandou Walo	-14-43, 16-51 ^d	I	Jun 1990–Nov 1991	0-09 <i>e</i>	5913 ^g	5-2	<i>I</i>	100:0:0	Faye <i>et al.</i> , 1993
Kassack-Nord	-16-03, 16-40 ^d	R	Sep 1992–Nov 1994	0-00 ^f	NA ^g	0-0	0	0:0:0	Faye <i>et al.</i> , 1995b
Kotikh	-16-58, 14-48 ^d	R	Jan 1995–Dec 1995	1-75 <i>f</i>	1558 ^g	27-3	8	100-0-0	Robert <i>et al.</i> , 1998

Country and site	Location ¹ (Long., Lat.)	Land-use ²	Study date	Sporozoite index ³ (%)	Biting rate ⁴ (<i>ma</i> annual)	EIR ⁵ (annual)	Seasonality ⁶ (months)	Relative EIR transmission by species ⁷ (%)	Citation
Maka-Diana	-16-40, 16-20 ^d	R	Sep 1992–Nov 1994	0.00 ^f	NA ^g	0-0	0	0:0-0	Faye <i>et al.</i> , 1995b
Ndiop	-16-42, 13-75 ^b	R	Jan 1993–Dec 1993	NA ^f	NA ^g	63-0	2	100:0-0	Fontenille <i>et al.</i> , 1997a
Ndiop	-16-42, 13-75 ^b	R	Jan 1994–Dec 1994	NA ^f	NA ^g	17-0	2	100:0-0	Fontenille <i>et al.</i> , 1997a
Ndiop	-16-42, 13-75 ^b	R	Jan 1995–Dec 1995	NA ^f	NA ^g	37-0	2	93:7-0*	Fontenille <i>et al.</i> , 1997a
Ndiop	-16-42, 13-75 ^b	R	Jan 1996–Dec 1996	NA ^f	NA ^g	7-0	1	100:0-0	Fontenille <i>et al.</i> , 1997a
Ndiop	-16-42, 13-75 ^b	R	May 1993–Dec 1996	NA ^f	NA ^g	31-0	2	98:2-0	Fontenille <i>et al.</i> , 1997a
Ngayokheme	-16-43, 14-53 ^b	R	Jan 1995–Dec 1995	1-80 ^f	512 ^g	9-2	NA	100:0-0	Robert <i>et al.</i> , 1998
Pout region	-17-07, 14-77 ^d	NA	Aug 1988–Jul 1989	0.00 ^e	23908 ^g	0-0	0	0:0-0	Faye, 1992
Pikine	-17-40, 14-75 ^b	U	Oct 1979–Dec 1980	0.55 ^e	7818 ^g	43-0	4	100:0-0	Vercruysse & Jancloes, 1981
Thiaye, Ngadiaga, Dianballo	-17-05, 14-95 ^d	R	Jul 1991–Jun 1992	0.48 ^f	2305 ^g	11-0	4	100:0-0	Faye <i>et al.</i> , 1995a
Takème and Ousseuk	-16-20, 12-80 ^d	NA	Jan 1985–Nov 1985	0-36 ^e	15123 ^g	55-0	5	100:0-0	Faye <i>et al.</i> , 1994
Toulde Galle	-14-60, 16-53 ^d	I	Jun 1990–Nov 1991	0-00 ^e	438 ^g	0-0	0	0:0-0	Faye <i>et al.</i> , 1993
Sierra Leone									
Bayama	-11-77, 8-00 ^d	R	Nov 1990–Oct 1991	4-36 ^f	20294 ^g	88-2	7	100:0-0	Bockarie <i>et al.</i> , 1995
Bayama	-11-77, 8-00 ^d	R	Nov 1990–Oct 1991	3-90 ^f	20732 ^g	80-5	12	100:0-0	Bockarie <i>et al.</i> , 1993
Bayama	-11-77, 8-00 ^d	R	Aug 1993–Nov 1994	6-82 ^f	6125 ^g	41-6	NA	NA	E. B. Magbity, 1999, pers. com.; Magbity <i>et al.</i> , 1999
Baoma	-11-73, 8-04 ^d	R	Aug 1993–Nov 1994	2-16 ^f	3924 ^g	84-8	NA	NA	E. B. Magbity, 1999, pers. com.; Magbity <i>et al.</i> , 1999
Dandabu	-11-64, 8-15 ^d	R	Aug 1993–Nov 1994	5-38 ^f	1507 ^g	81-1	NA	NA	E. B. Magbity, 1999, pers. com.; Magbity <i>et al.</i> , 1999
Gumahun	-11-50, 8-18 ^d	R	Jun 1992–Jul 1993	6-94 ^f	175 ^g	12-1	NA	100:0-0	Magbity <i>et al.</i> , 1997; E. B. Magbity, 1999, pers. com.
Jaiama	-11-69, 8-16 ^d	R	Aug 1993–Nov 1994	8-72 ^f	2602 ^g	22-9	NA	NA	E. B. Magbity, 1999, pers. com.; Magbity <i>et al.</i> , 1999
Konjodorma	-11-50, 8-15 ^d	R	Jun 1992–Jul 1993	3-96 ^f	818 ^g	32-4	NA	100:0-0	Magbity <i>et al.</i> , 1997; E. B. Magbity, 1999, pers. com.
Kpetema	-11-50, 8-13 ^d	R	Jun 1992–Jul 1993	8-81 ^f	1551 ^g	13-7	NA	100:0-0	Magbity <i>et al.</i> , 1997; E. B. Magbity, 1999, pers. com.
Manjama	-11-74, 8-02 ^d	R	Aug 1993–Nov 1994	12-13 ^f	2340 ^g	28-7	NA	NA	E. B. Magbity, 1999, pers. com.; Magbity <i>et al.</i> , 1999

Country and site	Location ¹ (Long., Lat.)	Land-use ²	Study date	Sporozoite index ³ (%)	Biting rate ⁴ (<i>ma</i> annual)	EIR ⁵ (annual)	Seasonality ⁶ (months)	Relative EIR transmission by species ⁷ (%)	Citation
Mendewa	-11.48, 8.16 ^a	R	Jun 1992-Jul 1993	4.74 ^f	128 ^g / <i>g</i>	6.1	NA	100:0:0	Magbity <i>et al.</i> , 1997; E. B. Magbity, 1999, pers. com.
Mendewa	-11.48, 8.16 ^b	R	Jan 1990-Apr 1991	NA ^f	NA ^{NA}	21.9	4-5	58:42:0	Bockarie <i>et al.</i> , 1994
Nengbema	-11.68, 8.13 ^a	R	Jun 1992-Jul 1993	4.42 ^f	471 ^g / <i>g</i>	20.8	NA	100:0:0	Magbity <i>et al.</i> , 1997; E. B. Magbity, 1999, pers. com.
Nengbema	-11.68, 8.13 ^a	R	Jan 1990-Apr 1991	NN	NA ^{NA}	21.5	4-5	97:3:0	Bockarie <i>et al.</i> , 1994
Ngulu	-11.56, 8.11 ^a	R	Jun 1992-Jul 1993	6.08 ^f	712 ^g / <i>g</i>	43.3	NA	100:0:0	Magbity <i>et al.</i> , 1997; E. B. Magbity, 1999, pers. com.
Njala-Komboya	-11.54, 8.20 ^a	R	Jan 1990-Apr 1991	NA ^f	NA ^{NA}	26.7	4-5	96:4:0	Bockarie <i>et al.</i> , 1994
Nyaudeyama	-11.66, 8.12 ^a	R	Jun 1992-Jul 1993	4.05 ^f	993 ^g / <i>g</i>	40.2	NA	100:0:0	Magbity <i>et al.</i> , 1997; E. B. Magbity, 1999, pers. com.
Nyaudeyama	-11.66, 8.12 ^a	R	Jan 1990-Apr 1991	NA ^f	NA ^{NA}	35.5	4-5	97:3:0	Bockarie <i>et al.</i> , 1994
Tondoya	-11.64, 8.13 ^a	R	Jun 1992-Jul 1993	7.30 ^f	1424 ^g / <i>g</i>	102.0	NA	100:0:0	Magbity <i>et al.</i> , 1997; E. B. Magbity, 1999, pers. com.
Tanzania									
Chasimba	38.82, -6.58 ^c	R	Jan 1992-Dec 1992	NA ^f	NA ⁱ	217.7	9	87:13:0	Shiff <i>et al.</i> , 1995
Idete	36.48, -8.10 ^b	R	Jan 1992-Dec 1994	NA ^f	NA ⁱ	584.0	12	P:P:A	Charlwood <i>et al.</i> , 1998
Kongo	38.83, -6.53 ^b	R	Jan 1992-Dec 1992	NA ^f	NA ⁱ	576.7	12	81:19:0	Shiff <i>et al.</i> , 1995
Kaole	38.93, -6.45 ^c	R	Jan 1996-Dec 1996	NA ^f	NA ⁱ	124.3	12	66:34:0	Temu <i>et al.</i> , 1998
Kerege	39.03, -6.57 ^b	R	Jan 1992-Dec 1992	NA ^f	NA ⁱ	271.6	11	88:12:0	Shiff <i>et al.</i> , 1995
Kikawila	36.75, -8.08 ^a	R	Dec 1983-Aug 1984	2.49 ^e	11427 ^{NA}	284.0	3	69:31:0	Biro, 1987
Kikwazu	38.82, -5.40 ^d	R	Apr 1988-Dec 1989	NA ^e	NA ⁱ	667.0	3	100:0:0	Mnzava, 1991
Kongo	38.83, -6.53 ^c	R	Jan 1996-Dec 1996	NA ^f	NA ⁱ	306.3	12	83:17:0	Temu <i>et al.</i> , 1998
Kumbamtoni	38.76, -5.10 ^d	R	Jan 1987-Dec 1988	7.14 ^f	6004 ⁱ	428.8	NA	P:P:P	Magesa <i>et al.</i> , 1991
Kumbamtoni	38.82, -5.31 ^a	R	Apr 1987-Mar 1989	NA ^e	NA ⁱ	420.0	6	100:0:0	Mnzava, 1991
Mapinga	39.07, -6.60 ^b	R	Jan 1992-Dec 1992	NA ^f	NA ⁱ	235.6	9	83:17:0	Shiff <i>et al.</i> , 1995
Matimbwa	38.87, -6.50 ^b	R	Jan 1992-Dec 1992	NA ^f	NA ⁱ	702.6	12	90:10:0	Shiff <i>et al.</i> , 1995
Matimbwa	38.87, -6.50 ^c	R	Jan 1996-Dec 1996	NA ^f	NA ⁱ	122.1	12	51:49:0	Temu <i>et al.</i> , 1998

Country and site	Location ¹ (Long., Lat.)	Land-use ²	Study date	Sporozoite index ³ (%)	Biting rate ⁴ (<i>ma</i> annual)	EIR ⁵ (annual)	Seasonality ⁶ (months)	Relative EIR transmission by species ⁷ (%)	Citation
Michenga	36-63, -8-12 ^a	R	Jan 1990–Dec 1990	NA ^e	NA ^j	547.5	4	100:NA:NA	Babiker <i>et al.</i> , 1997
Michenga	36-63, -8-12 ^a	R	Jan 1990–Dec 1991	NA ^f	NA ^j	548.0	4	100:NA:NA	Lyimo, 1993
Namawala	36-40, -8-15 ^e	R	Mar 1990–Jul 1991	1.37 ^f	24090 ^j	329.0	6	P:P:A	Smith <i>et al.</i> , 1993
Temgini and Enzi	38-76, -5-18 ^c	NA	NA 1995–NA 1996	NA ^f	NA ^{gi}	405.0	NA	NA	C. F. Curtis, 1998, pers. com.
Umba	38-87, -5-17 ^a	R	Jan 1987–Dec 1988	4.68 ^f	11899 ^j	556 ⁷	NA	P:P:P	Magesa <i>et al.</i> , 1991
Yombo	38-85, -6-57 ^b	R	Jan 1992–Dec 1992	NA ^f	NA ^j	220.6	10	79:21:0	Shiff <i>et al.</i> , 1995
Zinga	38-98, -6-52 ^b	R	Jan 1992–Dec 1992	NA ^f	NA ^j	93.7	7	88:12:0	Shiff <i>et al.</i> , 1995

¹ Sources of latitude/longitude:

^a published maps

^b GeoName™ digital gazetteer CD-ROM;

^c correspondence with authors;

^d cited in the reference.

² R, rural; U, urban; I, irrigated rice.

³ Sporozoite detection method:

^e dissection;

^f ELISA.

⁴ *ma* sampling technique:

^g human bait;

^h insecticide spray;

ⁱ light traps;

^j exit traps.

⁵ EIR values:

^k converted using (Port *et al.*, 1980) average child-to-adult conversion factor, *f*, of 3.57.

⁶ Values in *italics* record the number of months in which 75% of transmission occurs. Other values record the length of the entire transmission season.

⁷ For *Anopheles gambiae* s.l.: *An. funestus*; any other locally important vector. Where absolute values are unavailable P indicates presence only and A absence. NA refers to data that were not available, or not applicable. Values in **bold** refer to calculated values.

Table 2
Locations in Africa for which annual EIR data were published that could not be geo-referenced

Country and site	Location ^f (Long., Lat.)	Land-use ²	Study date	Sporozoite index ³ (%)	Biting rate ⁴ (<i>ma</i> annual)	EIR ⁵ (annual)	Seasonality ⁶ (months)	Relative EIR transmission by species ⁷ (%)	Citation
Cameroon									
Yaoundé, Nikol Bissou	NA, NA	R	Mar 1989–Mar 1990	1.67 ^e	1814 ^g	30.3	3	100:0:0	Fondjo <i>et al.</i> , 1992
Congo, Democratic Republic of									
Mbangi-mbangu	NA, NA	R	Feb 1990–Nov 1990	2.50 ^e	17.3 ^g	157.0	12	100:0:0	Karch <i>et al.</i> , 1993
Mbansale	NA, NA	R	Feb 1990–Nov 1990	3.50 ^e	5001 ^g	175.2	12	100:0:0	Karch <i>et al.</i> , 1993
Mbansalé	NA, NA	R	Feb 1991–Nov 1991	4.80 ^e	6826 ^g	324.9	12	100:0:0	Karch <i>et al.</i> , 1993
Côte d'Ivoire									
Bouaké, market garden districts	NA, NA	R	Jan 1992–Dec 1992	2.01 ^e	4380 ^g	88	8	100:0:0	Dossou-yovo <i>et al.</i> , 1994
Bouaké, rice fields district	NA, NA	I	Jan 1992–Dec 1992	0.68 ^e	18615 ^g	126	9	100:0:0	Dossou-yovo <i>et al.</i> , 1994
Egypt									
Abheet village	NA, NA	R	Feb 1983–Feb 1984	0.59 ^e	308 ^g	1.8	1	0:0:100	El Said <i>et al.</i> , 1986
Sudan									
Asar	NA, NA	R	Oct 1990–Dec 1990	2.06 ^e	NA ^h	0.6	NA	100:0:0	Babiker <i>et al.</i> , 1997

^f Sources of latitude/longitude:

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k converted using (Port *et al.*, 1980) average child-to-adult conversion factor, f , of 3.57.

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7 For *Anopheles gambiae* s.l.: *An. funestus*; any other locally important vector. Where absolute values are unavailable P indicates presence only and A absence. NA refers to data that were not available, or not applicable. Values in **bold** refer to calculated values

Table 3

Variance in EIR values within countries for all spatially unique rural sites (133 sites total with temporal duplicates averaged)

	Burkina Faso	Kenya	Senegal	Sierra Leone	Tanzania	Gambia, The	All Africa
Mean I	156.8	64.3	28.7	129.0	367.0	42.1	134.2
Median	133	17.4	9.2	62.2	405	11	76.7
Maximum	441.6	299.3	159.5	703.4	667	177	703.4
Minimum	55	0	0	12.1	93.7	0	0
Range	386.6	299.3	159.5	691.3	573.3	177	703.4
Standard deviation	96.5	102.3	46.8	184.5	164.6	52.3	162.2
Standard error of mean	24.9	24.8	12.1	49.3	39.9	12.7	14.1
Variation	15.9	38.6	42.0	38.2	10.9	30.1	10.5
Number of sites	15	17	15	14	17	17	133

I The arithmetic mean is used as a measure of central tendency in the data (Dossou-Yovo *et al.*, 1994). Median values are also presented as they are less sensitive to non-normal distributions.