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# Does Variation in Malaria Vector Collection Methods Significantly Affect Entomologic Inoculation Rates?

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**Abstract** **Background:** Entomologic Inoculation Rate (EIR), the product of vector biting rate and the sporozoites rate or the proportion of mosquitoes with sporozoites in the salivary glands has been strongly correlated with malaria prevalence. This study was undertaken to determine whether mosquito collection method significantly affected EIR estimates. **Method:** Study was conducted in 7 local Government Areas (LGAs) of Bayelsa State, across 3 eco-vegetational zones (fresh water forest, brackish water swamp forest, mangrove coastal water forest). Three methods were used for mosquito collections: Pyrethrum Spray Catch (SPC), Human Bait Catch (HBC) (Indoor), Human Bait Catch (Outdoor). EIR was calculated as per standard method. **Results:** EIR means obtained by PSC and HBC (Outdoor) methods were not significantly different ($F=4.989$; $df=2$; $p<0.05$), but significant differences were obtained between PSC and HBC (Indoor) estimates. These differences were also significantly influenced by eco-vegetational zones ($F=3.92$; $df=2$' $p<0.05$). **Conclusions:** It is advisable to compare EIRs obtained by the same mosquito collection methods as indices of malaria prevalence.

**Keywords** Vector Collection Methods, Entomological Inoculation Rates (EIRs), Malaria, Indoor/Outdoor, Ecovegetational zones

## 1. Introduction

Malaria transmission intensity is often assessed by the entomologic inoculation rate (EIR), the product of the vector biting rate and the sporozoites rate (sr); which is the proportion of mosquitoes with sporozoites in the salivary glands [1]. EIR estimates the number of infective bites a person receives per unit time and thus the level of exposure of an individual to malaria parasites studies have shown strong correlation between EIR and malaria prevalence [2-4]; May *et al.* [5] reviewed EIRs across Africa.

Unlike most other parts of the world where it is difficult to determine EIRs because of exceedingly low sporozoite rates, many valuable studies of transmission have been conducted in Africa, where sporozoite generally range from 1% to 20% [6]. The EIRs in ebdemic areas of Africa range from <1>1000 infective bites per year [7].

Establishing the relationship between transmission intensity and health outcomes is crucial for the planning of long-term malaria control programmes. Unfortunately, this is fraught with methodologic difficulties. Smith *et al.* [8] noted that one of the important considerations is that the incidence of infection for *Plasmodium falciparum* malaria is much lower than entomologic inoculation rates (EIRs), especially at higher transmission levels. Moreover, biting rates of malaria vectors per host depend on his or her biomass and thus age. Smith *et al.* [8] proposed an algorithm for estimating human infection rates from the EIR with allowance for these two factors.

To compare EIR and Malaria prevalence data collected simultaneously at the same sites; Beier *et al*. [4] undertook literature searches to identify relevant studies that met *a priori* a set of inclusion criteria. Studies conducted over at least one year; frequency of mosquito sampling at least monthly throughout the year or during periods of transmission for sites with seasonal patterns of transmission; standard methods such as human-biting catches, pyrethrum sparay catches, or Center for Disease Control light traps used for estimating biting rates; dissection or ELISA methods used for determining proportion of sporozoite-infected mosquitoes; and studies were conducted during periods when no mosquito control operations were in effect.

Studies on the estimation of EIRs across the continent have involved different mosquito collection methods. These have been either singly: Bigoga *et al.* [9, 10] by the Human Landing Collection (HLC) indoors and outdoors in Cameroon and Amek *et al.* [11] by the Light Trap Collection (LTC) in Kenya; jointly : Overgaard *et al.* [12] by HLC and LTC in Equatorial Guinea and Wanji *et al.* [13] by HLC and Pyrethrum Spray Collection (PSC) in Cameroon. The thrust of most of these studies was on the comparison of seasonal EIRs and variation with location, except Overgaard *et al.* [12] who observed that EIRs were higher outdoors and

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mosquitoes obtained by HLC yielded higher EIRs than those by LTC. Studies were undertaken over a 12-month period to compare Entomologic Inoculation Rate data obtained using HBC and PSC methods simultaneously at the same location.

## 2. Methods

### 2.1. Study Area

The study was conducted in 7 Local Government Areas (LGAs), Bayelsa State, Nigeria. The vegetation comprises three eco-vegetational zones: freshwater swamp forest, brackish water swamp forest and mangrove coastal water forest. The topography of study area is characterized by a maze of creeks and swamps criss-crossing the low-lying plain. The study LGAs were Yenagoa, Sagbama and Kolokuma-Opokuma in the freshwater swamp forest; Ogbia, southern Ijaw, Ekeremor in the brackish water swamp forest and Nembe in the Mangrove coastal water forest. All LGAs were rural, with the exception of semi-urban Yenagoa, the State capital.

### 2.2. Mosquito collections

Details on PSC collections have been extensively described [14, 15]. Simultaneously, human bait catches were made by consenting trained individuals in each town/village. Mosquitoes were caught indoors and outdoors by two individuals at each location. Mosquitoes that landed to bite were spotted and caught immediately with a mouth aspirator. Collections were made on two consecutive nights in each quarter over 4 quarters (12 months). PSC and HBC collections were undertaken in the same compound.

## 3. Results

The results of the human biting, sporozoites and Entomologic Inoculation rates obtained by the three methods (PSC, HBC-Indoors, HBC-Outdoors) appear in Tables 1-7. EIR means obtained by PSC and HBC (Outdoor) methods were not significantly different; however, both were significantly different from EIR obtained by the HBC (Indoor) method ($F=4.99$; $df=2$; $p<0.05$). These differences were significantly affected by eco-vegetational zones ($F=3.92$; $df=2$; $p<0.05$) and location ($F=9.24$; $df=4$; $p<0.05$). Tests for significant differences in EIRs among collection methods and locations showed that there were significant differences; similar results were obtained among collection methods and zones ($p<0.05$).

**Table 1.** Entomologic Inoculation Rates of *Anopheles gambiae* s.l. collected by different methods

| **Eco-Vegetational zones/Location** | **Methods** | | |
|---|---|---|---|
| FRESH WATER | HBC (Indoors) | HBC (Outdoors) | PSC |
| Yenagoa | 0.31 | 0.81 | 0.38 |
| Sagbama | 1.19 | 1.06 | 1.47 |
| Kolokuma | 1.88 | 1.87 | 2.09 |
| BRACKISH WATER | | | |
| Ogbia | 0.50 | 1.15 | 1.02 |
| Southern Ijaw | 0.31 | 0.31 | 0.71 |
| Ekeremor | 0.87 | 1.15 | 1.37 |
| MANGROVE FOREST | | | |
| Nembe | 0.97 | 2.60 | 1.99 |

HBC= Human Bait Catches PSC= Pyrethrum Spray Catches

**Table 2.** Man-Biting Rates of PSC-Collected *Anopheles gambiae* s.l. across Locations

| **Eco-Vegetational Zones/Location** | **No of Rooms Visited** | **No of Occupants** | **No of Nights** | **Man-Nights** | **No of Fed *An. gambiae*** | **Biting Rate / Person/Night** |
|---|---|---|---|---|---|---|
| FRESH WATER | | | | | | |
| Yenagoa | 8 | 14 | 8 | 22 | 43 | 1.96 |
| Sagbama | 7 | 11 | 8 | 19 | 176 | 9.26 |
| Kolokuma | 8 | 17 | 8 | 25 | 319 | 12.76 |
| BRACKISH WATER | | | | | | |
| Ogbia | 8 | 12 | 8 | 20 | 144 | 7.20 |
| Southern Ijaw | 7 | 12 | 8 | 20 | 77 | 3.85 |
| Ekeremor | 7 | 14 | 8 | 22 | 144 | 6.55 |
| MANGROVE FOREST | | | | | | |
| Nembe | 9 | 19 | 8 | 27 | 287 | 10.63 |

**Table 3.** Man-Biting Rates of HBC-Collected (Indoors) *Anopheles gambiae* s.l. across Locations

| **Eco-Vegetational Zones/Location** FRESH WATER | **No of Catches** | **No of Nights** | **Man-Nights** | **No Collected** | **Biting Rate / Person / Night** (bites/person/night) |
|---|---|---|---|---|---|
| Yenagoa | 8 | 8 | 16 | 37 | 2.31 |
| Sagbama | 8 | 8 | 16 | 79 | 4.94 |
| Kolokuma | 8 | 8 | 16 | 176 | 11.00 |
| BRACKISH WATER | | | | | |
| Ogbia | 8 | 8 | 16 | 66 | 4.13 |
| Southern Ijaw | 8 | 8 | 16 | 53 | 3.31 |
| Ekeremor | 8 | 8 | 16 | 45 | 2.81 |
| MANGROVEFOREST | | | | | |
| Nembe | 8 | 8 | 16 | 124 | 7.75 |

**Table 4.** Man-Biting Rates of HBC-Collected (Outdoors) *Anopheles gambiae* s.l. across Locations

| **Eco-Vegetational Zones/Location** FRESH WATER | **No of Catches** | **No of Nights** | **Man-Nights** | **No Collected** | **Biting Rate / Person / Night** (bites/person/night) |
|---|---|---|---|---|---|
| Yenagoa | 8 | 8 | 16 | 109 | 6.81 |
| Sagbama | 8 | 8 | 16 | 196 | 12.25 |
| Kolokuma | 8 | 8 | 16 | 401 | 25.06 |
| BRACKISH WATER | | | | | |
| Ogbia | 8 | 8 | 16 | 151 | 9.44 |
| Southern Ijaw | 8 | 8 | 16 | 147 | 9.19 |
| Ekeremor | 8 | 8 | 16 | 125 | 7.81 |
| MANGROVEFOREST | | | | | |
| Nembe | 8 | 8 | 16 | 351 | 21.94 |

**Table 5.** Sporozoite Rates of PSC- Collected *Anopheles gambiae* s.l. across Locations

| **Eco-Vegetational Zones/Location** | **No Examined** | **No (%) Positive** |
|---|---|---|
| FRESH WATER | | |
| Yenagoa | 68 | 12 (17.6) |
| Sagbama | 201 | 32 (15.92) |
| Kolokuma | 360 | 59 (16.39) |
| BRACKISH WATER | | |
| Ogbia | 170 | 24 (14.12) |
| Southern Ijaw | 103 | 19 (18.45) |
| Ekeremor | 167 | 35 (20.96) |
| MANGROVE FOREST | | |
| Nembe | 251 | 47 (18. 73) |

**Table 6.** Sporozoite Rates of HBC-Collected (Indoors) *Anopheles gambiae* s.l. across locations

| **Eco-Vegetational Zones / Location** | **No Examined** | **No (%) Positive** |
|---|---|---|
| FRESH WATER | | |
| Yenagoa | 37 | 5 (13.51) |
| Sagbama | 79 | 19 (24.05) |
| Kolokuma | 176 | 30 (17.05) |
| BRACKISH WATER | | |
| Ogbia | 66 | 8 (12.12) |
| Southern Ijaw | 53 | 5 (9.43) |
| Ekeremor | 45 | 14 (31.11) |
| MANGROVEFOREST | | |
| Nembe | 88 | 11 (12.50) |

**Table 7.** Man-Biting Rates of HBC-Collected (Outdoors) *Anopheles gambiae* s.l. across Locations

| Eco-Vegetational Zones/ Locations | No Examined | No (%) Positive |
|---|---|---|
| FRESH WATER | | |
| Yenagoa | 109 | 3 (2.70) |
| Sagbama | 196 | 17 (8.67) |
| Kolokuma | 401 | 30 (7.48) |
| BRACKISH WATER | | |
| Ogbia | 127 | 15 (11.81) |
| Southern Ijaw | 147 | 5 (3.40) |
| Ekeremor | 122 | 18(14.75) |
| MANGROVEFOREST | | |
| Nembe | 279 | 33 (11.83) |

# 4. Discussion

The higher HBRs and EIRs recorded outdoors from HBC in this study were also observed by Overgaard *et al.* [12] in Equatorial Guinea. The significant impact of location on EIR obtained in this study was also recorded by Bigoga *et al.* [10] in Cameroon. The significant differences in EIR means between HLC (outdoors)/ PSC and HLC (Indoors) indicate that collection method probably has an impact on EIR values. Overgaard *et al.* [12] also observed significant differences between EIRS obtained by HLC and LTC. Longterm studies are planned. It is advisable to compare EIRs obtained by the same collection methods as indices of malaria prevalence.

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