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SHORT REPORT: INFLUENCE OF CENTERS FOR DISEASE CONTROL LIGHT TRAP POSITION, RELATIVE TO A HUMAN-BAITED BED NET, ON CATCHES OF *ANOPHELES GAMBIAE* AND *CULEX QUINQUEFASCIATUS* IN TANZANIA

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Abstract. The best position for Centers for Disease Control (Atlanta, GA) light traps, in relation to human-occupied bed nets for trapping of host-seeking *Anopheles gambiae* Giles and *Culex quinquefasciatus* Say mosquitoes, was determined in Tanzania. Significantly higher catches were recorded for both species when the trap was positioned at the foot end of the bed, near the top of the net. Parity rates were significantly higher near the top of the net than at the level of the host. Since trap position affects the catch size and the proportion of infectious mosquitoes therein, standardized use of this sampling technique for estimating entomologic inoculation rates (i.e., the number of potentially infectious bites received over a certain period of time) is recommended.

Various designs and applications of light traps have been proposed and evaluated for sampling anthropophilic mosquito populations to indirectly estimate human biting rates.[1] Of all light traps, the standard Centers for Disease Control (CDC) (Atlanta, GA) miniature light trap[2] has been found to be an efficient device for sampling endophagic malaria and filariasis vectors in Africa.[3] The optimum location of the light trap for sampling house-visiting mosquitoes has been reported to be as close to the host(s) as possible, and its catching efficiency is greatly improved when the human bait is protected by a bed net.[4] The correlation between light-trap and human-biting catches for *Anopheles gambiae, An. funestus* Giles, and *Culex quinquefasciatus* has been described,[5] and this trap-bed net system is now widely used to monitor vector populations and evaluate vector control interventions.[6,7] However, it has been reported that light traps are biased towards sampling 2–2.3 times as many *Plasmodium falciparum*–infected females than human-biting catches.[8,9] Therefore, they may not provide a reliable cross-section of the host-seeking population. Also, the influence of the location of the trap in relation to an occupied bed net has not been investigated in detail. Since mosquitoes have been shown to be attracted to different sites of the human body,[10] we tested the hypothesis that the sensitivity of the trapping system would differ according to the location of the trap in relation to the position of the human host under the bed net.

Research clearance was obtained from and approved by the Tanzania Commission for Science and Technology. Trapping of *An. gambiae* was done at Njage village, about 80 km from Ifakara in southeastern Tanzania. Previous investigations showed that this area harbors a population of *An. gambiae sensu stricto* only. Experiments with *Cx. quinquefasciatus* were done at Muheza, 40 km from Tanga in northeastern Tanzania. At both field sites four traditional style houses (mud walls with thatched roofs), occupied by one male adult only, were selected. The average age of the occupants was 34 years (range = 19–48) in Njage and 29 years (range = 27–30) in Muheza. Each occupant was provided with an unimpregnated rectangular (110 × 185 ×178 cm) bed net. The average height of the bed above floor level was 42 cm (range = 34–52) in Njage and 46 cm (range = 42–55) in Muheza. A standard miniature CDC light trap with an incandescent light bulb (Model 512; John W. Hock Company, Gainesville, FL) was hung beside the bed net with the shield of the trap touching the side of the net and the trap entrance in one of four positions: the head end or foot end of the bed, at either 70 cm or 150 cm from the floor (approximately 25 cm or 105 cm above the bed, respectively). Using a two-way analysis of variance (ANOVA) incomplete factorial design, we randomized trap positions and alternated them each night for every house for eight or 12 nights (for *An. gambiae* and *Cx. quinquefasciatus,* respectively). Traps were operated between 9:00 PM and 6:00 AM for Cx. *quinquefasciatus* and between 8:00 PM and 6:00 AM for *An. gambiae.* We ascertained that all volunteers had retired at the beginning of the night and that their traps were operating properly, and we checked their presence periodically during the experimental period. Female catches were subjected to log (x + 1) transformation and subjected to Latin square ANOVA[11] after a satisfactory check for normality of the distribution. An F test significant at $P < 0.05$ was followed by a Least Significant Difference test for comparison of treatment means. Subsamples of the catches were dissected in 0.75% phosphate buffer solution and their parity was determined by coiling or uncoiling of their ovarian tracheoles.[12] Parity rates for the different trap positions were compared using chi-square tests for independence.

A total of 13,402 *An. gambiae* and 4,051 *Cx. quinquefasciatus* were caught during the eight- and 12-day experiments, respectively, of which the vast majority (> 90%) were unfed specimens, presumably host-seeking while caught. Results of the ANOVA are shown in Table 1A. For both species significant house and trap position effects were observed, with the former probably reflecting variations in spatial mosquito densities, house design, or host-attractiveness, and the latter indicating differences in catch size among the four trap positions. Further analysis of trap position effects (Table 1B) showed that the feet-high position resulted in 1.3–2.1 times higher catches ($P < 0.05$) for *An. gambiae* and 2.3–3.1 times higher catches ($P < 0.001$) for *Cx. quinquefasciatus* when compared with the other positions. Pooled data analysis (top versus bottom, head versus feet side of the bed) showed significantly ($P < 0.05$) higher catches for traps near the top of the net but no difference between head/feet side of the

TABLE 1

A, Analysis of variance tables for catches of *Anopheles gambiae* and *Culex quinquefasciatus*; **B**, Catches for different CDC light trap positions in relation to a human-baited bed net*

Source	*An. gambiae* df	*An. gambiae* MS	*An. gambiae* F value	*Cx. quinquefasciatus* df	*Cx. quinquefasciatus* MS	*Cx. quinquefasciatus* F value
A						
Day	7	0.115	2.906 NS	11	0.245	1.261 NS
House	3	0.673	17.02 $P < 0.001$	3	0.251	12.94 $P < 0.001$
Trap position	3	0.152	3.844 $P < 0.05$	3	0.565	29.09 $P < 0.001$
Error	18	0.040		30	0.019	

B

Trap position†	*An. gambiae* N	*An. gambiae* log (x + 1)	*An. gambiae* Mean	*An. gambiae* Parity rate‡	*Cx. quinquefasciatus* N	*Cx. quinquefasciatus* log (x + 1)	*Cx. quinquefasciatus* Mean	*Cx. quinquefasciatus* Parity rate§
Head-low	3,060	2.55	353.1 ab	0.52 (218) a	653	1.68	47.4 a	0.27 (112) ab
Head-high	3,602	2.46	287.6 ab	0.57 (188) a	787	1.81	63.2 a	0.37 (183) ac
Feet-low	2,700	2.32	209.8 a	0.49 (107) a	770	1.76	56.0 a	0.24 (170) b
Feet-high	4,040	2.65	444.2 b	0.60 (203) a	1,841	2.17	147.4 b	0.42 (210) c

* CDC = Centers for Disease Control; df = degrees of freedom; MS = mean sums of squares; NS = not significant; N = total number caught; Parity rate = numbers in parentheses are the total number dissected. Means and parity rates not followed by the same letter are significantly different at $P < 0.05$.
† Head, feet: head end or foot end of bed; low = 25 cm above bed level; high = 105 cm above bed level.
‡ $\chi^2 = 6.46$, df = 3, $P = 0.091$.
§ $\chi^2 = 16.71$, df = 3, $P = 0.0008$.

bed. The feet-high position sampled a higher proportion of older mosquitoes than the other trap positions, and this effect was significant for *Cx. quinquefasciatus.* However, pooled results showed that for both species traps near the top of the net caught significantly more parous mosquitoes than traps near the bottom ($\chi^2 = 4.36$, degrees of freedom [df] = 1, $P = 0.017$ for *An. gambiae*; $\chi^2 = 15.50$, df = 1, $P = 0.0001$ for *Cx. quinquefasciatus*).

Our results clearly demonstrate that catch size and parity rates of host-seeking females for both species differ according to the trap position in relation to the host occupying the bed net, but the factors causing this phenomenon are not yet understood. The host-seeking behavior of both species has been shown to be influenced by human foot odor,[13] which may in part explain higher catches in the feet-high position. Nevertheless, the results indicate that mosquito behavior around bed nets is not a random process and suggests that increased knowledge on their behavior may result in improved trap and bed net designs and their use for sampling mosquito populations. Furthermore, it follows that estimates of entomologic inoculation rates (EIRs) will be influenced by trap position since this in turn affects the numbers caught and sporozoite rates (which will increase with higher parity rates). Standardized use of light traps near bed nets (i.e., in the feet-high position) may thus contribute to a better understanding of the still poorly understood relationship between transmission intensity and disease through more accurate measurements of the EIR.

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