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Behavioural biting preference of *Culex quinquefasciatus* in human host in Lagos metropolis Nigeria

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Abstract

Background & objectives: Olfactory cues play an important role in the attraction of major disease vectors towards their host. Hence we intend to investigate the contribution of selected parts of the human host on the behavioural biting preference of *Culex quinquefasciatus*.

Methods: Two volunteers were trained to collect host seeking female mosquitoes landing to feed on different parts of the lower limbs. The *Cx. quinquefasciatus* were collected in paper cups with the aid of a flash-light and aspirator. Each paper cup was labeled to represent the selected parts where the mosquitoes were collected.

Results: The composition of *Cx. quinquefasciatus* from the total mosquitoes collected showed that *Cx. quinquefasciatus* was more predominant (90%) over other species present. The average minimum and maximum atmospheric temperature recorded during the night catches were 27 and 29.5^{o}C while the average relative humidity range was 78–81.6%. The behavioural biting preference results obtained showed that the density of *Cx. quinquefasciatus* mosquitoes preferring the foot region (298) was significantly higher ($p > 0.05$) when compared with other different parts of the human host such as the ankle, calf and the thigh.

Interpretation & conclusion: The study indicates that the foot region of the human host has a stronger influence in orientating mosquitoes towards the human host. Hence, the exploitation of the characteristic human odour will add to the existing vector control strategies.

Key words Biting preference – control – *Culex quinquefasciatus* – human host

Introduction

Mosquitoes are known to perceive visual, thermal and olfactory stimuli which enable them to detect light source, odour and several other volatile chemicals emanating from the skin, breath and waste products of their hosts[1,2]. These host seeking potentials are usually necessary for the female mosquitoes which require a meal of blood in order to lay eggs. The anthropophilic behaviour of vector species is responsible for the transmission of diseases such as malaria, filariasis and yellow fever which have become a burden in different parts of the world[3]. The study of olfaction in mosquitoes and its role in enhancing their host seeking abilities have been studied widely in *Anopheles gambiae* (Diptera : Culicidae) the major vector of malaria in Africa[4-6]. Several other reports have established the involvement of host odour, carbon-dioxide, lactic acid, sebum and sweat as attractants for these mosquitoes towards man[7-9], yet the potential opportunities inherent in the use of attractants in the control of mosquito vector have not been fully utilised. Emphasis is placed mainly on the use of insecticide, which seem more rapid and instantaneous in action[10].

However, there is an increase in the incidence of insecticide resistance, a development which a number of authors have attributed to uncontrolled insecticide use which has selected resistant populations in mosquitoes. Insecticide resistance has been reported in a number of mosquito vectors across the continents of the world today. In Benin, Nigeria (West Africa) and Thailand (Southeast Asia), resistance to pyrethroid insecticide has been reported in *An. gambiae* and *An. minimus*[10,11]. These anopheline species are the major vectors of malaria in these regions. This is a major setback to vector control, bearing in mind that pyrethroid insecticides are the only class of insecticide approved by the World Health Organization for the impregnation of bednets[10-12]. Also, the local *Culex quinquefasciatus* (Diptera : Culicidae) mosquitoes responsible for transmission of Bancroftian filariasis in Sao Paulo, Brazil, was also reported to be resistant to malathion, fenitrothion and propoxur[13]. This development, therefore, makes it necessary to exploit other alternative methods of vector control which can form strong components of the integrated vector control management.

Presently, efforts are geared towards using transgenic technologies to provide control methods rooted in vector biology. Identification and characterisation of olfactory genes in the *An. gambiae* mosquito have already been elucidated; this would help in understanding olfactory proteins involved in host odour attractions. This is a welcome development as it could in the nearest future lead to the development of mosquito population having genes for anthropophilly replaced by zoophilic genes[5].

This study is providing information on which body parts of the human host are likely to exert a stronger influence in the attraction for mosquitoes, which can be exploited for alternate vector control strategies.

Material & Methods

Study area: The study was carried out in three randomly selected local government areas of Lagos state, Nigeria. The three study sites fell within Eti-Osa, Agege and Kosofe local government areas. Lagos is a highly urban centre with an estimated population of about 5.6 million people living within a land area of 3,345 km^2.

Mosquito collections: Mosquito collections were made near human dwellings and close to natural and artificial breeding sites along Adetokunbo, Ademola street (Eti-Osa), Yakubu street (Ketu) and Oko oba (Agege). Adult host seeking female *Cx. quinquefasciatus* were collected from the lower parts of the body of the trained volunteer. The mosquito landing collections on human bait were made from 2200–0200 hrs as this being the peak biting time for this species. The collections were done between September and December 2002 which fall within the dry season. The mosquitoes were caught using the aspirator and the exact landing sites were recorded. The mosquitoes caught were released into paper cups and taken to the laboratory for further analysis. The temperature and relative humidity of the environment was also recorded during these period.

Preference of Cx. quinquefasciatus mosquitoes for specific landing sites on the human host: Two trained volunteers (human bait) were used during the study. Each was assigned to collect and record the number of mosquitoes landing on specific parts of the exposed body. The parts exposed were the thigh, calf, ankle and the foot region which were more easier to be observed by the collectors when in a sitting position. Free and informed consent was obtained from the human volunteers who served as bait.

Data analysis: Chi-square test at a significance level of 5% was applied to test the significance of preference of *Cx. quinquefasciatus* to bite at different parts of the human host.

Results

Behavioural preference for different landing site on the human host: The total number and percentage of *Cx. quinquefasciatus* mosquitoes collected (pooled data of 12 nights) in Victoria Island preferring to land at the following parts of the human host such as foot, ankle, calf and thigh were: 87 (39.2%), 66 (29.7%), 50 (22.5%) and 19 (8.6%) respectively (Table 1). Similar trend was also observed in Ketu, where the number and percentage of *Cx. quinquefasciatus* mosquitoes preferring the foot, 144 (48.3%) and ankle, 101 (33.9%) were higher than those preferring the calf 32 (10.7%) and thigh 21 (7%) regions of the human host (Table 1). The trend was also the same in Agege where the numbers and percentages of mosquitoes that landed on different parts of the lower limb of the human host were: 67 (48.2), 37 (26.6), 20 (14.4) and 15 (10.8) respectively. Findings from the three study sites, therefore, showed a common pattern of preference for specific parts of the lower limb. Preference for the foot region was observed to be highest, with a downward trend observed towards the thigh region (Fig. 1). Analysis of the biting preference for specific parts on the human

Table 1. Preference of *Cx. quinquefasciatus* mosquitoes to bite at different parts of the human host at three different urban settlements

Body parts	Locality			
	Victoria Island	Ketu	Agege	Total
Foot	87 (39.2)	144 (48.3)	67 (48.2)	298
Ankle	66 (29.7)	101 (33.9)	37 (26.6)	204
Calf	50 (22.5)	32 (10.7)	20 (14.4)	102
Thigh	19 (8.6)	21 (7.0)	15 (10.8)	55

Figures in parentheses indicate percentages; (χ^2 = 17.64, df = 6; p > 0.05).

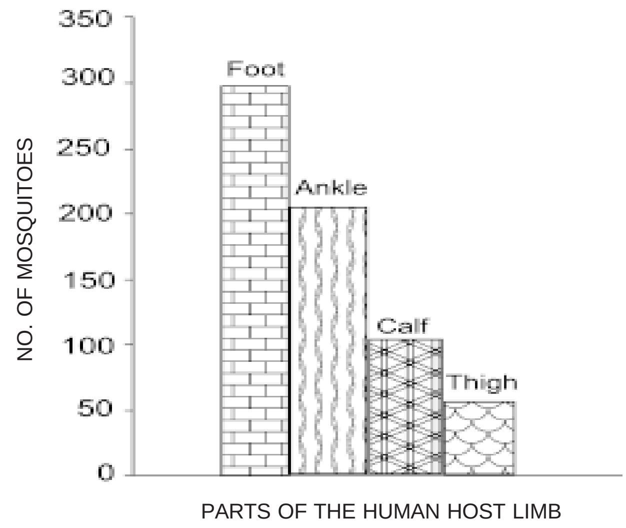

Fig. 1: Density of *Culex quinquefasciatus* attracted to feed on differnt parts of the human host limbs

host at each of the sampling locations did not reflect any statistical significance. Hence, the data from these points were pooled together (Table 1) and subjected to chi-square tests. Results from the chi-square analysis, showed that the differences in the density of *Cx. quinquefasciatus* mosquitoes preferring to bite at specific parts of the human host were statistically significant (χ^2 = 17.64, df = 6, p > 0.05). Thus, the numbers of mosquitoes preferring to bite on the foot and ankle of the human host were significantly higher than those biting on the other parts of the human host. Although the foot region attracted a relatively high number of *Cx. quinquefasciatus* more than the ankle region, there was, however, no statistical difference in the density of mosquitoes preferring to bite on these two parts of the human host limb (χ^2 = 1.54, df = 2, p > 0.05).

Discussion & Conclusion

The development of insecticide resistance in major vectors has shown that single vector control options do not always posses a final solution to control vectors of debilitating diseases affecting mankind. As such a number of control options should be incorporated into the integrated vector control management.

This will allow individuals, communities and governments under the disease burden to make choices in the combination of a number of options available so that adequate protection against disease-transmitting vectors is ensured.

Results obtained from this study, therefore, revealed that different parts of the lower human host elicited different responses which affected the behavioural landing site preference of *Cx. quinquefasciatus* in their attempt to feed on their host blood. In this study, the foot region of the human host was observed to attract *Cx. quinquefasciatus* than other parts of the lower limb of the human host exposed. The replication of this study in three different sites did not show any significant variation from the common pattern observed from the results. The strong biting preference for the foot observed in all the three sites may have been influenced by the characteristic odour of the foot sweat gland output. This has been reported by Geier *et al*[14] to be more attractive to mosquitoes. However, the contribution of other attractants in the orientation of mosquitoes towards the human host can not be under emphasised, since they often collectively enhance the movement of these vectors toward their hosts for example, carbon-dioxide had long been confirmed as a long-range airborne attractant to mosquitoes[15,16]. It has also been reported that the first host cues to reach a mosquito are usually volatile chemicals emanating from the skin, breath and waste product of a potential host[1].

The preference of the vectors for the foot region of the human host in all the sites sampled as shown in the results may have resulted from the concentration of secretory oil glands around the foot region over the other parts of the human host limb. This further establishes the strong role of sweat odour in mosquito attraction. Though our study was only restricted to the lower limb, other studies have made significant contributions on the role of different components of human sweat from other parts of the human host in the attraction of mosquitoes[7,14,18], for example, in an experiment involving eight species of mosquitoes, five species preferred to receive their blood meals at the head, facial region and the upper torso of the human host[17]. However, this is not to conclude that host cues and volatile chemicals emanating from human host are the only factors determining mosquito attraction or preference. Other factors such as; environmental (odours from other sources, prohibitive wind speeds); physiological conditions (circadian phase, gonotrophic stage and nutritional status); and the mosquito genotype (olfactory proteins involved in response to external stimuli). All these factors have been reported to affect the responsiveness of mosquitoes[6].

It is therefore, presumed that the understanding of all the factors involved in mosquito attraction towards human host, will facilitate the development of control options based on the isolation and use of compounds involved in host attraction. This can be used in the production of mass trapping devices which will be used to lure these anthropophilic mosquitoes away from man and possibly for vector control.

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