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The distribution and frequency of *Culex pipiens quinquefasciatus* Say 1823 (Diptera, Culicidae) breeding places on the Kenya Coast in relation to human sociological factors

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Introduction

Environmental management and health education should play an increasing role in the non-chemical control of domestic mosquitoes such as *Culex pipiens quinquefasciatus* (formerly *C. p. fatigans*) which is notorious for its ability to develop resistance to insecticides (Hamon & Mouchet 1967). This resistance to DDT and to the group Dieldrin/HCH is now general (WHO 1976). Different levels of resistance to chlorpyrifos and other organophosphates have been found in strains from urban areas of Tanzania, Liberia, Sri-Lanka and Brazil (Curtis & Pasteur 1981). This mosquito breeds in sanitary facilities such as latrines and cesspools. Non-chemical methods are mainly applied when the mosquito is at its pre-imaginal stage and can be oriented either against the breeding-places themselves or against mosquito pre-imaginal populations (Curtis & Feachem 1981). The first alternative would be assisted by identification of the sociological factors responsible for the building of potential breeding-places and for their frequency and distribution in the human environment. In order to develop long term control measures it is necessary to assess how the situation will evolve in the future. The coastal belt of Kenya is appropriate for such a study. *C. p. quinquefasciatus* is not only a nuisance mosquito as in many parts of Africa, but is also an important vector of filariasis in this area. In addition to its normal presence in urban areas, an interesting distribution of this mosquito species was observed in rural areas where the present study was conducted. Our aim was to find out whether there existed any relationships between the frequency and distribution of *C. p. quinquefasciatus* breeding-places and the following sociological factors: history of construction of sanitary facilities; type of housing and social category of the inhabitants; size of human settlements.

The study sites

In the context of Bancroftian filariasis and its vectors the Kenya Coast should be considered as two separate systems of human ecology as already observed by Wijers & Kinyanjui (1977) and Wijers & Kiilu (1977): the coastal settlements which have been for several centuries inhabited by Moslems, and the more inland area where people are largely non-Moslems. Moslems tend to be more urbanized than other communities. They usually live in large villages of several hundred houses arranged on a town-like pattern, along streets and lanes. In rare cases they may live in small villages of few tens of houses, more or less scattered. Non-Moslems belong to the Mijikenda peoples. For several centuries they used to live in 'Kayas', compact settlements of several hundred houses from which they started to migrate by the mid 19th century, to establish new villages on the nearby vacant lands (Spear 1978). Although the number of these villages is increasing, their size has remained small in contrast with the original Mijikenda settlements. Each village is usually inhabited by members of one extended family.

Four villages were chosen as representative Moslem settlements. The largest, Vanga, lies in a mangrove area on the South Coast of Kenya close to the Tanzanian border. At the time of

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this study it had about 350 houses set in a very compact pattern. The three others are much smaller, but are also located on the South Coast. They had 45, 42 and 24 houses respectively.

The study on non-Moslem settlements was conducted in the Rabai area, 15 km NW of Mombasa. The villages which were surveyed had between 8 and 38 houses.

The majority of the rural inhabitants of the Kenya Coast have traditional occupations, e.g. farmers and/or fishermen. These constitute our 'social category 1'. There are also some traders, civil servants and employees who usually have higher levels of income and education. These are grouped in our 'social category 2'.

Three different types of houses have been recorded in these areas: traditional houses with mud walls and thatched roof; modern houses with cement walls and corrugated iron roof which are obviously stronger and more comfortable than traditional ones; intermediate types with mud walls and corrugated iron roof or with cement walls and palm leaf roof.

Along the East African Coast *C. p. quinquefasciatus* has three main types of breeding-places, and this was confirmed in occasional searches concurrent with the studies reported here: pit latrines when they are deep enough to reach the water table; cesspools which collect used water and which are most often simple holes dug into the soil; 'birikas': uncovered cement containers of about 1 m^3 where people keep water for ritual ablutions.

The three types were found to be present in Moslem settlements. In non-Moslem villages only latrines were present. For the purpose of the present socioeconomic survey the total number of each type of breeding site was recorded without checking the presence of *C. p. quinquefasciatus* in all of them. Thus the results are expressed in terms of potential rather than actual breeding-places.

Results

Distribution of breeding-places in relation to sanitary construction, considered in a historical context

In Moslem settlements the use of cesspools, latrines and 'birikas' seems to be an ancient practice as old as the settlements themselves, i.e. several centuries (Kirkman 1964, Allen 1974). In the Rabai area on the other hand, latrines do not seem to have been built until a very recent date. It has not been possible to obtain any information either from literature or from personal discussions with elders of the Rabai area about the existence in the past of any sanitary system, even when the Mijikendas were living in their 'kayas', which were more compact settlements than the present villages. All the latrines observed during this study had been constructed within the previous decade with the exception of only one village which was unusual in having a Moslem chief and where a latrine had been established for many years. This tendency to improve sanitary facilities is developing very fast. Out of eight villages found negative in 1978, seven had at least one latrine by May 1980. Even in this area, villages without such a facility should become the exception in the near future.

Frequency of breeding-places in relation to type of house and social category of the inhabitants

The data obtained are recorded in Table 1 as percentages and statistical analysis.

In Vanga, within social category 1, the percentage of houses with at least one potential breeding-place was significantly higher in modern and intermediate houses than in traditional ones. A similar significant difference was also observed within social category 2 where the percentages for modern/intermediate and traditional houses were 81% and 28% respectively. In this village there is an increase in the proportion of houses with breeding-places when there is an improvement of the housing. A similar, but not significant trend was observed in small Moslem villages within category 1. In non-Moslem villages no calculation was possible within category 1 and the apparent difference within category 2 did not prove to be significant.

When comparing members of the two social categories living in traditional houses, it appeared that the proportion who had mosquito breeding-places in their houses were equal in these two categories both in Vanga and in small Moslem villages. On the other hand, modern/intermediate houses had a significantly higher proportion of potential breeding-places when occupied by people belonging to category 2 (81%) than category 1 (49%). In non-Moslem villages, positive traditional houses were significantly more abundant in category 2 (14%) than in category 1 (1/108). Such comparison was not possible for modern/intermediate houses due to the small sample sizes.

Table 1. Distribution of breeding-places in relation to social category and house structure in Moslem and non-Moslem villages

		Proportion of houses with breeding places (total no. houses)	
Type of village	Type of house	Social category 1	Social category 2
	Traditional	15% (241) ← $\chi^2 = 0.26$ n.s. →	28% (25)
Vanga		↑ $\chi^2 = 26.9$*** ↓	↑ $\chi^2 = 14.3$*** ↓
	Modern/Intermediate	49% (47) ← $\chi^2 = 7.1$** →	81% (26)
Moslem:	$\chi^2 = 7.86$**		
	Traditional	4% (83) ← $P = 0.12^a$ →	2/8
Small villages		↑ $P = 0.062^a$ ↓	
	Modern/Intermediate	3/11	– (0)
	Traditional	1/108 ← $P = 0.014^a$ →	14% (29)
Non-Moslem			↑ $P = 0.25^a$ ↓
	Modern/Intermediate	1/1	4/11

[a] By Fisher's exact test.
$^{**}P < 0.01$.
$^{***}P < 0.001$.
n.s. = not significant.

Frequency of breeding-places with relation to size of human settlements

We compared the proportion of houses with breeding-places between Vanga and the small villages taking into account only traditional houses of the social category 1, the numbers for other categories being too small (Table 1). The proportion observed in Vanga (15%) was higher than that for small villages (4%), these data being significantly different ($\chi^2 = 7.86$; 1 d.f.; $0.01 > P > 0.001$).

Discussion and conclusion

Several major factors appear to play an important role in the distribution and frequency of *C. p. quinquefasciatus* breeding-places in the coastal areas of East Africa. These factors may function either in combination or independently. The first is the family's income level. With increasing income there is an improvement in housing and sanitation facilities which leads to an increase in breeding-places for *C. p. quinquefasciatus*. Furthermore the same trend is associated with improvement in the standard of education, even if income levels remain more or less stable. With increase in the size of human settlements the proportion of houses with potential breeding-places also increases even when the other factors are constant, as already observed by Subra and Hebrard (1975) in Mayotte (Comoro Islands). Moreover the tendency to develop sanitary facilities seems now to be general, in all inhabited areas of the East African Coast as shown by the Rabai example, where the recent digging of latrines is the result of both the progress of general education and the sanitary health education campaign launched a few years ago to control the spread of cholera.

One can only speculate on how these three factors will evolve in the near future in Africa South of the Sahara. While in some countries the standards of living will continue to improve, in others they may remain stable or even regress for economic reasons. On the other hand, it is expected that the level of education will improve in the majority of the areas. In all African countries and especially in Kenya, human populations will continue to increase dramatically (Myers 1980) by natural increase in rural areas, and by both natural increase and migration in urban areas (Subra 1975). Even if all three factors do not develop and interact, at least one or two of them are likely to evolve in ways favouring the multiplication of *C. p. quinquefasciatus.* Thus, the problems generated by this mosquito can be expected to worsen.

The need to curb such a situation is obvious, so that the individuals and/or the community need to be guided to adopt waste disposal systems which prevent mosquito breeding and which are known under the general name of 'sanitation without water'. Such systems have been devised and discussed by Wagner & Lanoix (1958). Pit latrines can be replaced by systems which avoid contact with the water table. Several models have been designed and successfully tested recently in some African countries, especially in Tanzania (Winblad *et al.* 1978). Cesspools should be modified so that waste water is not exposed and gravid females of *C. p. quinquefasciatus* are denied access to the contaminated water. The success of these different systems depends on several prerequisites. They must be acceptable to local populations who may not fully understand their health benefits (Muhondwa 1976). In this respect health education appears to be of primary importance. Secondly, there must be proper utilization of those systems. This can also be obtained through health education (Kilama & Winblad 1978). Lastly, in order to meet the expenses for building and maintaining these systems, it is necessary to make available a low cost technology which can be implemented by everyone (Rybczynski *et al.* 1978).

The elimination of 'birikas', the third type of *C. p. quinquefasciatus* breeding-place on the Kenya Coast might be achieved through installation of a piped water supply. This technology has to be implemented at community level. It is expensive and the full benefits have come under comprehensive evaluation in only a few African countries (Feachem *et al.* 1978). But the advantages of piped water supplies are not limited to mosquito control, since they bring other improvements in public health and the general well-being of the human population.

These various measures for reduction in the availability of *C. p. quinquefasciatus* breeding sites would be more likely to be implemented if they could be integrated with general development programmes, rather than being isolated actions in the context of public health (WHO 1980).

Summary

In rural settlements of the Kenya Coast *C. p. quinquefasciatus* develops in three major types of breeding-places. These are pit latrines, cesspools and small cement cisterns which man builds to improve his sanitary facilities. All three types are present in Moslem villages. At present only latrines have been recorded in non-Moslem villages. Building of such facilities is an established practice in Moslem villages while it is recent in non-Moslem ones. The proportion of houses with potential breeding-places is increasing with the standard of living of the inhabitants and with the size of the settlements. Since the building of sanitary facilities will probably increase in the future the mosquito breeding situation will tend to worsen accordingly. Thus there is an urgent need to curb such breeding by developing low cost technology which can easily be implemented.

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