The Occurrences and Habitat Characteristics of Mosquitoes in Accra, Ghana

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Abstract

A study to assess mosquito species occurrences and the effects of some ecological characteristics on their breeding was undertaken in Accra. Five species of mosquitoes, *Anopheles gambiae s.l, Culex decens, Culex quinquefasciatus, Anopheles melas and Aedes aegyptii* were found occurring in a wide variety of places. *C. decens* were the most abundant and widely distributed, occurring sympatrically with *C. quinquefasciatus* in rice fields and fishponds. The *Culex* species occurred largely in pools of water with high nutrient levels equivalent to or slightly lower than 2.8 mg/l $NH_{4,}$ 3.9 mg/1 NO_3, 3.9 mg/l NO_2, 2.2 mg/l $S0_4$, 9.6 mg/l PO_4 and dissolved oxygen (DO) levels of range 2.9–8.8 mg/l. The *Anopheles* species, on the other hand, occurred largely in pools of water of low nutrient levels equivalent to or less than 0.5 mg/l NH_4, 0.6 mg/l NO_3, 0.8 mg/l $N0_{2,}$ 1.3 mg/l $S0_{4,}$ 0.8 mg/l PO_4 and high dissolved oxygen levels ranging from 5.5–18 mg/l. The *p*H, habitat size and temperature were also identified as determinants in the species occurrence, abundance and distribution.

Introduction

The rapid rate of urbanisation of Accra has come with its attendant sanitation and public health problems. These problems have arisen as a result of inadequate waste disposal facilities, poor drainage system and poor water supply, among many others. The presence of either one or a combination of these factors have led to the creation of a congenial environment for the breeding of water-related insect vectors such as mosquitoes which are responsible for the transmission of malaria, filariasis and yellow fever. Currently, malaria control, which is part of the WHO Global Malaria Strategy, is of paramount concern to the Government of Ghana, and the need for a vigorous intervention cannot be over-emphasised.

Some urban dwellers, in an effort to meet the food demands of the rising population, have undertaken some water-related projects involving the impoundment of drains or streams to create reservoirs for the purposes of irrigating vegetable farms. Despite the economic significance of these projects, they have led to the creation of breeding grounds of mosquitoes in many parts of Accra. Infrastructure developments in Accra have lagged behind urbanisation, leading to the creation of peri-urban shanty towns and slums. These developments have resulted in changes in the ecosystem, which have affected the breeding patterns of mosquitoes, hence disease transmission. Diseases such as malaria, filariasis and yellow fever affect hundreds of millions of people every year, causing immense suffering and hindering development (Godal *et al*., 1998).

Malaria alone accounts for up to 25% or more of all hospital attendance, with young children under 5 years accounting for about 40% in Ghana (Anon., 1992). Globally, malaria causes 3,000 deaths per day, an annual total that exceeds one million deaths worldwide (WHO, 2002). Filariasis also has been shown to be a public health problem in Ghana, particularly in the northern savanna and in the south-western coastal parts (Gyapong *et al*., 1994; Dunyo *et al*., 1996). Similarly, Hunter (1992) demonstrated the public health importance of filariasis in a community in north-east Ghana and found that it was associated with the operations of a small-scale irrigation dam. Yellow fever transmission by *Aedes aegyptii* is under control in Accra as a result of mass immunisation undertaken in the country. The *Aedes* mosquito is, therefore, considered more of a nuisance than a public health risk.

These disease situations can be best tackled by improving the knowledge about the vectors. The information could aid in the risk assessment of diseases transmitted, and the planning of control measures in support of disease control programmes in Ghana. Since good health is a prerequisite to economic development, there is the need to focus on these vectors in order to put them in the right perspective. In the light of their economic importance, this study was undertaken to asses the mosquito species types in Accra, their abundance, and the effects of habitat characteristics on their breeding.

Materials and methods

Study area

The study area (Fig. 1) is within the Greater Accra Region of Ghana (5^0 30'–5^0 42' N; 0º 00-0º 20 W). It includes sampling sites in Ashaiman, Odorna/Adabraka, Gbawe, La and Chorkor (Table 1). The area lies within the equatorial belt with double maxima rainfall in June and October and a mean annual rainfall of 735 mm. It has a fairly high temperature of 32 ºC and a relative humidity of 65–95%.

TABLE 1
Types of sampling sites and locations

Location	*Sampling site*
Ashaiman	Rice fields
	Fish ponds
	Shoreline of Lake Ashaiman
	Storm drain
Chorkor	Small pools
	Drains
	Shoreline of lagoon
Gbawe	Quarry pits
	Small pools
Odorna / Adabraka	Vegetable farm
	Scrap heap
	Storm drain
La	Kpeshie lagoon
	Drains
	Cesspool
	Small pool

Collection of mosquitoes

Sampling of larval forms of mosquitoes was conducted in stagnant and slow-moving waterbodies using standard 100 ml, 150 ml and 350 ml dippers with long handles. Each dip was put in a specimen bottles containing 70% alcohol and later examined for the presence of the mosquitoes. The bottle was labelled with all the pertinent data. The mosquitoes were identified by morphological characteristics (Gillies & Coetzee,1987; Gillies & de Meillon, 1968; Annoh, pers. comm., G.A.E.C.), and counted. Sampling was undertaken during the dry season period of 2003. The location, category of the breeding sites, type of mosquitoes and numbers were noted.

Water quality measurement

The following parameters of water quality were measured: temperature, *p*H, dissolved oxygen (DO), biochemical oxygen demand (BOD), nutrients such as orthophosphate (PO_4^{-p}), ammonia-nitrogen (NH_4-N), nitrate nitrogen (NO_3-N) and sulphates (SO_4). Other parameters studied were salinity and alkalinity.

Water samples from sites where larval forms of mosquitoes were found were collected into 500 ml bottles for physico-chemical analysis. Samples for dissolved oxygen (DO) and biochemical oxygen demand (BOD) were collected into dark bottles. The *p*H and temperature were taken *in situ*. Analysis was made according to standard methods (American Public Health Association, 1998). Table 2 shows the parameters and the various analytical methods employed for the determination.

TABLE 2
Parameters and their methods of determination

Parameter	*Method employed*
*p*H	Suntex Model SP 701 pH meter
Temperature	Mercury in glass thermometer
Nutrients	Ion Chromatogram
Alkalinity	Strong acid titration method
Dissolved oxygen	Azide modification of Winkler's method
Biochemical oxygen demand	Dilution and dissolved oxygen determined after incubation at 20 ^{o}C for 5 days.
Salinity	Salinity meter-Saltscan mod

Results and discussions

A total of 3,885 mosquitoes, representing five species and two genera were collected. These were *Anopheles gambiae* s.l, *Culex decens, Culex thallassius, Culex quinquefasciatus* and *Anopheles melas*. They were found in a wide variety of habitats. Table 3 shows a summary of location, types of mosquitoes, their habitats and their numbers.

TABLE 3
Summary of location, breeding habitats, mosquito species and numbers

Location	*Breeding habitats*	*Mosquito species*	*Mean No./dip*
Ashaiman	Rice field	*C. decens*	200
		C. quinquefasciatus	25
		C. thallasius	15
	Fish pond	*C. quinquefasciatus*	25
		C. decens	20
	Shoreline of lakes Ashaiman	*C. quinquefasciatus*	19
	Storm drain	*C. quinquefasciatus*	25
Chorkor	Small pools/	*A. gambiae*	20
	Drains	*C. decens*	140
	Shoreline of lagoon	*C. thallasius*	15
Gbawe	Quarry pit/pool	*A. gambiae*	50
	Pools in uncompleted buildings	*C. decens*	200
	Cesspools	*C. quinquefasciatus*	100
Odorna/Adabraka	Vegetable farms	*C. quinquefasciatus*	25
	Scrap heap	*A. aegyptii*	21

	Storm drains	*C. thallassius*	50
La	Kpeshie lagoon	*C. thall*asius	55
		A. melas	60
	Drains/Cesspool	*C. decens*	100
	Small pools/Drains	*A. gambiae*	120

At Ashaiman, *C. decens* was the most abundant with a mean 200 species per dip. They occurred in rice fields and in fishponds and accounted for 64.5% of the collection. *C. quinquesfasciatus* (28.1%) and *C. thallassius* (7.4%) were also collected. At Chorkor, *C. decens* was again the most abundant, with a mean of 140 species per dip accounting for 80% of the collection. *A. gambiae* (11.4%) and C. *thallassius* (8.6%) were also sampled. At Gbawe, *C. decens* was again the most abundant with a mean of 200 species per dip accounting for 57.1% of the collections. Other species collected were *C. quinquefasciatus (*28.6%) and *A. gambiae* (14.3%). At Odorna/Adabraka, *C. thallasius* accounted for 52.1% of the collection, *C. quinquefasciatus* 26% and *A. aegyptii*, 21.9%. At La, *A. gambiae* was the most abundant accounting for 35.8% of the collections, *Culex decens* 29.8%, *C. thallassius* 16.4% and *A. melas* 17.9%.

The data suggest that *C. decens* and *C. quinquefaciatus* are more common and abundant than the malaria transmitting *A. gambiae* and *A. melas* species. *C. decens*, the most abundant and widely distributed, is not known to transmit any known diseases in Ghana while *C. quinquefasciatus* is one of the chief vectors of filariasis.

A t-test comparative analysis of the larval density in the mixed population in the rice fields at Ashaiman showed that the higher density of *C. decens* over *C. quinque-fasciatus* and *C. thallasius*, respectively, was significant ($P < 0.05$). Similarly, a higher density of C. *quinquefasciatus* over *C. decens* was also significant ($P < 0.05$) in the fishponds. *C. quinquefasciatus* density in Ashaiman was not significantly different from that of Gbawe. ($P > 0.05$) but significantly higher than that occurring at Odorna ($P < 0.05$). The larval density of *A. gambiae* at La was significantly higher than Gbawe and Chorkor, respectively, at ($P < 0.05$). The density at Gbawe was, however, higher than the density at Chorkor ($P < 0.05$).

Open, clear and sunlit pools appeared to favour the breeding of *A. gambiae* and it was found largely in ephemeral pools (hoof prints, footprints, roadside ditches, natural depressions, holes created by man, etc.) These small pools with surface areas < 0.2 m^2 account for the majority of sites where *A. gambiae* was present while the remaining *A. gambiae* sites were charac-terised by pools with surface areas exceeding 0.2 m^2. The breeding sites of *A. melas* occurred in habitats characterised by the prevalence of short plants while no *Anopheles* spp. occurred in habitats populated with floating plants.

The preponderance of *A. gambiae* in such small, open, temporal pools in Gbawe, La and Chorkor locations can be explained by the fact that the female species of *A. gambiae* preferentially select them for oviposition and this is evidently demonstrated by the works of Bentley & Day (1989). Their ability to survive in these small pools compared to permanent large pools could also be that larval predation is less prevalent or non-existent in these temporal pools as opposed to large permanent habitats. This view is shared by Service (1977), Mogi (1981), Washburn (1995) and Sunahara *et al*. (2002).

The relatively low larval density of *A. gambiae* occurrences at Chorkor and Gbawe could be attributed to either (i) a rapid development of the larval forms, a necessary pre-requisite for successful reproduction of *A. gambiae* because larval habitat may dry out, or (ii) drying up of breeding sites due to its non-permanence. Despite its relative low density, only small numbers of *Anopheles* mosquitoes are usually required to maintain any high levels of malaria endemicity.

All the breeding sites were characterised by moderately high temperatures ranging between 30-36.2 ºC (Table 4), very ideal for the development of the mosquito larvae. These temperatures are likely to create adequate warmth that enable the larvae to exploit the resources of the warm, open habitats for rapid development. This view is shared also by Gimming *et al*. (2002). According to Gillies & De Meillon (1968), warm temperatures encountered in small, open habitats also shorten larva-pupa development and, therefore, hasten adult fly emergence.

TABLE 4

Physico-chemical parameters of breeding sites

Location	*pH*	*Temp ºC*	*NH_4mg/l*	*NO_3mg/l*	*NO_2mg/l*	*SO_4mg/l*	*PO_4mg/l*
Chorkor	6.8–7.1	31–36.2	0.5–2.8	0.6–3.9	0.8–3.9	0.2–2.2	0.5–0.78
Ashaiman	8–8.2	31–33.2	0.80–1.7	3.8–3.9	3.8–3.9	0.9–1.1	0.8–9.6
Gbawe	6.3–6.5	33.4–33.7	0.2–0.5	0.1–0.2	0.03–0.1	1.3–1.5	0.8–0.9
La	6.5–7.6	30–31	0.2–0.6	0.18–0.2	0.05–0.2	1.1–1.3	0.4–0.8

The creation of reservoirs for irrigating rice fields at Ashaiman are big contributors to the propagation of mosquitoes. The irrigation come with the creation of additional or permanent breeding sites in both the reservoir and in the rice fields which leads to higher densities of mosquitoes. Such observations have been made in many parts of Africa (Dolo *et al*., 2004; Lindsay *et al*., 1991).

Conditions such as high humidity (65-95%), high temperature (30–36.2 ºC), abundant water, and abundant sunshine that favour the production of rice at Ashaiman, are also conducive for the breeding and proliferation of many species of mosquitoes. This form of irrigated rice growing can alter the transmission pattern of malaria from seasonal to perennial as illustrated by Dolo *et al*. (2004).

The occurrence of the *Culex* species in all the five locations shows that they are very versatile and highly adapted to all the different types of environments found in the sampling areas. The sympatric occurrence of *C. decens* and *C. quinquefasciatus* in a number of places shows that they compete successfully in establishing themselves. The presence of salt tolerant *C. thallassius* in some rice fields in Ashaiman could indicate the presence of saline conditions. It is likely that the waterlogged areas may have high evaporation as a result of high temperatures leading to an increase in the saline content of water and the soil.

Tables 4 and 5 show the physico-chemical parameters of the breeding sites. The *p*H range between 6.3 and 8.2 established at the breeding sites is an indication that mosquitoes can be found in both acid and alkaline environments. Breeding sites such as the open storm drains, fish ponds and rice fields at Ashaiman, as well as the open drains and the shorelines of the Chemu lagoon at Chorkor, receive large loads of waste materials. These sites had high levels of nutrients equivalent to, or exceeding 0.8 mg/l NH_4, 3.6 mg/l NO_3, 3.8 mg/l NO_2, 0.9 mg/l SO_4, 0.5 mg/l PO_4, and supported large populations of *Culex* species. These sites were also characterized by high alkalinity levels. Almost all the breeding sites at Ashaiman were characterized by high alkalinity and moderate dissolved oxygen levels ranging from 6.4 to 7.5 mg/l (Table 4).

TABLE 5

Chemical parameters (mg/l) of breeding sites

Location	*Alk.*	*Sal.*	*DO*	*BOD*

Chorkor	320–350	6.5–22.7	2.9–5.5	16–18
Ashaiman	480–550	2.7–4.5	6.4–7.5	4.9–8.4
Gbawe	20–140	2.6–6.2	8.8–18	6–12.4
La	0–30	0.6–18.1	2.8–6.5	8–12

The dissolved oxygen (DO) range of 2.9–5.5 and the biochemical oxygen demand (BOD) value of 16–18 mg/l recorded at sites in Chorkor indicate the different levels of pollution encountered in the Chorkor environment. The Chemu lagoon at Chorkor which periodically receives inflow of seawater and had salinity level of 6.5–22.7 was colonised exclusively by *C. thallassius*, an indication that the species colonising these areas had to be both tolerant of salt, as well as pollution, to be able to survive.

At Gbawe, the predominant *Culex* spp. (Table 3) were found in pools with moderate nutrient values (Table 4). Generally, these nutrient levels were sufficient to enhance the breeding of all species of mosquitoes. In the quarry pits where the mean nutrient values were 0.2 mg/l NH_4, 0.1 mg/l NO_3, 0.03 mg/l NO_2, 1.3 mg/l SO_4, and 0.8 mg/l PO_4, only the breeding of *A. gambiae* occurred and most of the pools that bred *A. gambiae* had oxygen levels in excess of 8.8 mg/l (Table 4).

It was observed that habitats which favoured the breeding of *Anopheles* were characterised by high dissolved oxygen and low nutrient levels, and this confirms the assertion that *A. gambiae* are normally found in good quality water. According to Minakawa *et al*. (1996), the occurrence of *A. gambiae* was significantly associated with type of water as well as the vegetation type. However, a BOD range of 6–12.4 mg/l recorded is an indication that the *A. gambiae* are adapted to some level of pollution in the water. The predominant *C. thallassius* found in the storm drains at Odorna/Adabraka occurred sympatrically with large populations of chironomids and these types are known to tolerate very high levels of organic pollution, suggesting that the mosquito may not only be salt-tolerant but pollution-tolerant as well.

The breeding and proliferation of the *A. aegyptii* among the scrap heaps is enhanced only during the rains, and are, therefore, found to be rain-dependent and seasonal as reported by Chinery (1969). According to Chinery (1969), industrialization and other developments in Accra resulted in changes in the mosquito larval habitats, and these favoured the rapid and extensive colonisation of *A. aegyptii*.

The Kpeshie lagoon is a major source of mosquito breeding, principally of *A. melas* and *C. thallassius* and is a big menace to the hotel industry. It has grasses and weeds along the bank providing shade and shelter for the mosquito larvae while the mangrove trees provide resting sites for adults. The nutrient levels of the breeding sites which were 0.2–0.4 mg/l NH_4, 0.18–0.19 mg/l NO_3, 0.06–0.1 mg/l NO_2, 1.1–1.2 mg/l SO_4 and 0.4–0.6 mg/l PO^{3}-$_4$ were moderate values providing favourable conditions for the breeding of bacteria, alga, yeast fungal spores and protozoa, which are the type of food that majority of mosquito larvae ingest, hence, the prolific breeding in the lagoon area. Salinity levels of 7–18 mg/l in the Kpeshie lagoon indicate that those areas could only facilitate the breeding of salt and pollution tolerant species.

The study demonstrated that the C*ulex* species encountered occur in large numbers in a wide variety of places with high nutrient values and low oxygen levels. The *Anopheles* species also occurred in a wide range of habitats but with relatively low nutrient status and high oxygen levels. The *Aedes* appear to be more rain dependent and seasonal. This information on the type of species, numbers and habitat characteristics is useful in determining the distribution and abundance of vectors for future interven-tions.

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