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Impact of rapid ubanization on mosquitoes and their disease transmission potential in Accra and Tema, Ghana

WILLIAM ADDO CHINERY
Department of Microbiology, Ghana Medical School, P.O. Box 4236, Accra, Ghana.

Summary

The total of 75 mosquito species recorded in Accra have declined to 28 species. Contributing factors to this decline and the reduction in prevalence of malaria and bancroftian filariasis in Accra presently include extensive water pollution and a fairly high daily mosquito mortality due to several factors including loss of natural adult resting places, use of mosquito repellents and the probable increase of *Anopheles arabiensis* population. Presently low yellow fever incidence is due *inter alia* to loss of its feral vectors and reduced intradomiciliary breeding of *Aedes aegypti* (L) although more common species like *A. gambiae* s.l., *A aegypti* and *C. p. quinquefasciatus* could between them transmit many other arboviruses. However because of ready availability of human blood, spill-over of viruses from reservoir hosts to man will be rare. *Ipso factor*, malaria is the most common mosquito-borne disease with centripetal distribution of prevalence.

Résumé

La quantité tetale de 75 espèces de moustique enregistrée à Accra esten baisse à 28 espèces. Les facteurs favorisant cette diminution et la réduction de la fréquence de la Malaria et de la faliriose bancroftienne à Accra actuellement anglobent la pollution extensive d'eau et une mortalité quotidienne passablement haute des moustiques attribuable à de plusieurs facteurs y compris la perte des li eux de repos naturels pour les moustiques adultes, l'emploie des repoussants de moustique et la possible augmentation des *Anopheles arabienses.* A l'heure actuelle, la faible fréquence de la fièvre jaune est due, *inter alia* à la perte de ses vecteurs féraux et la diminution de la réproduction intradomicaire des *Aede aegypti* L bien que des espèces comme tels que *Anophèles gambiae* s.l., *A. aegypti* et *C. p. qinquefasciatus* pourraient entre aux, transmettre beaucoup d'autres arbovirus. Pourtant, dû à la disponibilité facile du sang humain, le renversement des virus des reservoirs hôtes à l'homme se raréfiera. *Ipso facto*, la malaria est la maladie la plus commune portée par le moustique avec une distribution de fréquence centripétale.

Introduction

Many mosquito species have been recorded in Accra over the past seven decades. In recent surveys, many of these species especially the rare ones, were not encountered in Accra[1,2], due most probably to environmental changes which have followed land development, rapid urbanization and population increase. Although much of the vegetation in Accra and Tema have been cleared, two forested areas namely a forest-thicket at Weija and a man-made forest reserve at Achimota and Legon (Fig. 1), both suburbs of Accra and some of the swamps and marshes still exist. Changes in the natural ecosystem resulting from the above processes are likely to affect mosquito species composition, abundance, distribution and disease transmission potential and therefore mosquito-borne diseases; this forms the theme of this paper. The ecological situation remains almost the same since the last surveys except an appreciable human population increase and its attendant increase in the number and size of polluted potential breeding waters. The mosquito fauna and their relative populations will therefore not have changed any appreciably.

In this discourse, all proved and potential vectors of major mosquito-borne diseases present in Africa will be considered in view of the closer contact between African states as a result of increased political, cultural and economic activities, facilitated by the enormous increase over the last three decades in air transportation which has completely changed the pattern and distribution of some mosquito-borne diseases, not only in Africa, but in the world as a whole.

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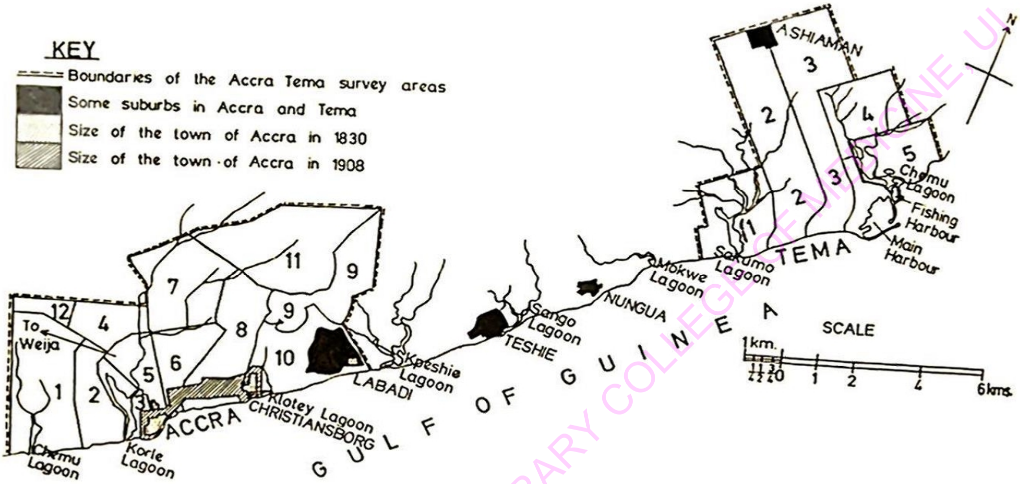

Fig. 1: A map of the greater Accra Region showing the Accra-Tema mosquito survey areas, the Accra plains and some of the irrigation dams.

Methods of survey

The methods of survey have been dealt with at length[2,3,4] and will not be considered here. Suffice it to say that in the most recent survey[2] spray-sheet collection of adult mosquitoes and examination of all breeding and potential breeding waters as well as all water-holding containers were routinely carried out over a three-year period (1964-67). It was not practicable in the course of these surveys to arrange for the differentiation within the *Anopheles gambiae* complex which presently comprise six species.

Mosquito species so far recorded in Accra:- The list of 68 mosquito species recorded up to 1964 was revised by the author following the nomenclature of Stone *et al.* [5] resulting in reduction in species numbers from 68 to 62 to which has been added *A. melas* physiologically determined as a species[6] and genetically underscored by hybridization tests[7], and *Anopheles arabiensis* now separated from *A. gambiae* s.l.

A preliminary survey in Accra[1], added 9 new names while a more comprehensive survey in the Accra-Tema survey area (Fig. 1) added one new name. The author collected a single *Anopheles (Myzomyia) demeilloni* in an out-door resting place bringing the total so far to 75 species.

Disease vector species in Accra and Tema

Of the 75 species recorded in Accra, 30 are known to be disease vectors (Table 1) of which only 15 (Table 2) were recorded in the most recent survey.

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Table 1: A list of mosquito species recorded in Accra up to 1966

Aedes (Aedimorphus) abnormalis (Theo.) v
**Aedes (Aedimorphus) albocephalus* (Theo.) v
Aedes (Aedimorphus) apicoannulatus (Edws.)
Aedes (Aedimorphus) caliginosus (Grhm.)
Aedes (Aedimorphus) domesticus (Theo.)
Aedes (Aedimorphus) hirsutus (Theo.)
**Aedes (Aedimorphus) irritans* (Theo.) v
Aedes (Aedimorphus) minutus (Theo.) v
Aedes (Aedimorphus) nigricephalus (Theo.)
Aedes (Aedimorphus) orchraceus (Theo.)
Aedes (Aedimorphus) punctothoracis (Theo.)
Aedes (Aedimorphus) tarsalis (Newst.) v
Aedes (Aedimorphus) wellmani (Theo.)
Aedes (Diceromyia) furcifer (Edws.) v
Aedes (Mucidus) mucidus (Karsch)
Aedes (Mucidus) scathogoides (Theo.)
Aedes (Neomelaniconion) furcineryis (Edws.)
Aedes (Neomelaniconion) lineatopennis (Lud.) fv
**Aedes (Stegomyia) aegypti* (Linnaeus) fv
Aedes (Stegomyia) africanus (Lev. Lem.) v
Aedes (Stegomyia) apicoargenteus (Theo.)
**Aedes (Stegomyia) langata* (vom Som.)
Aedes (Stegomyia) luteocephalus (Newst.) v
Aedes (Stegomyia) metallicus (Edws.) v
Aedes (Stegomyia) simpsoni (Theo.) v
Aedes (Stegomyia) unilineatus (Theo.)
**Aedes (Stegomyia) vittatus* (Bigot) v
**Anopheles (Anopheles) coustani* s.l. (Lav.) v
Anopheles (Cellia) arabiensis[X] (Patt.) fmv
Anopheles (Cellia) demeilloni (Evans.)
Anopheles (Cellia) domicolus (Edws.)
**Anopheles (Cellia) funestus* (Giles) fmv
**Anopheles (Cellia) gambiae* s.l. (Giles) fmv
Anopheles (Cellia) marshallii (Theo.)
Anopheles (Cellia) melas (Theo.) m
**Anopheles (Cellia) pharoensis* (Theo.) fmv
**Anopheles (Cellia) rufipes* (Gough) m
**Culex (Culex) annulioris* (Beck) v
**Culex (Culex) antennatus* (Beck) v
**Culex (Culex) decens* (Theo.)
**Culex (Culex) duttoni* (Theo.)
Culex (Culex) ethiopicus (Edws.)
Culex (Culex) grahamii (Theo.)
Culex (Culex) guiarti (Blanc.) v
Culex (Culex) individuosus (Theo.)
Culex (Culex) ornatothoracis (Theo.)
Culex (Culex) perfidiosus (Edws.)
Culex (Culex) perfuscus (Edws.) v
Culex (Culex) pipiens quinquefasciatus (W) fv
Culex (Culex) poicilipes (Theo.)
**Culex (Culex) thalassius* (Theo.) v
**Culex (Culex) tritaeniorhynchus* (Giles) fv
**Culex (Culex) univittatus* (Theo.) v
**Culex (Culex) weschii* (Edws.) v
Culex (Culiciomyia) macfiei (Edws.)
**Culex (Culiciomyia) nebulosus* (Theo.)
**Culex (Lutzia) trigripes* (Gradpre & Charm.)
Culex (Mochthogenes) inconspicuosus (Theo.)
Culex (Neoculex) horridus (Edws.)
Culex (Neoculex) insignis (Cart.)
Culex (Neoculex) rima (Theo.)
**Eretmapodites chrysogaster* s.l. (Grhm.) v
Eretmapodites quinquevittatus (Theo.)
Ficalbia (Etorleptiomyia) mediolineata
Ficalbia (Mimomyia) hispida (Theo.)
**Ficalbia (Mimomyia) mimomyiaformis* (Theo.)
Ficalbia (Mimomyia) plumosa (Theo.)
Ficalbia (Mimomyia) splendens (Theo.)
Mansonia (Mansonioides) africana (Theo.) fv
Mansonia (Mansonioides) uniformis (Theo.) fv
Toxorhynchites brevipalpis (Theo.)
**Uranotaenia balfouri* (Theo.)
Uranotaenia bilinaeta (Theo.) connali (Edws.)
Uranotaenia mashonaensis (Theo.)
Uranotaenia mayeri (Edws.)

* Species which were recorded in Accra in the most recent survey
Ae. = Aedes; *An.* = Anopheles; *Cx.* = Culex
E. = Eretmapodites; *M.* = Mansonia.
X *Anopheles arabiensis* has not been identified in Accra but on ecological grounds it is suspected to be one of the members of the *gambiae* complex present in Accra.
f = Filariasis vectors
m = Malaria vectors
v = Arbovirus vectors

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Table 2: A list of mosquito species involved in the cycle of other arboviruses other than yellow fever.

Mosquito Species	Associated Arbovirus
*Ae. (Ae.) abnormalis***	Ndumu[1], Semliki[1].
*Ae. (Ae.) albocephalus**	Middleburg[1].
*Ae. (Ae.) minutus***	Wesselsbron[1].
*Ae. (Ae.) irritans**	Hepatitis-B Surface antigen[1] (H.Bs.Ag.).
*Ae. (Ae.) tarsalis***	Wesselsbron.[1]
*Ae. (Ae.) furcifer-taylori***	Bouboui[1] Chikungunya[3,4]
Ae. (N.) lineatopennis**	Middleburg[1], Wesselsbron[1].
Ae. (S.) aegypti	Bunyamwera[3], Bwamba[2], Chikungunya[1,2,3,4], Dengue(1&2)[1,2,3,4], Germiston[2], Ilesha[2,3], Igwayuma[2,3], Koutango[2,3], Mayaro[2], Middleburg[1], Nola[2,3], Ntaya[2], Nyando[2], Onyonyong[2], R.V.F.[2,3], Semliki[2,3], Simbu[2], Sindbis[2,3], Tanga[2], Uganda-S[2,3], Usutu[1], Wesselsbron[2,3], Zika[1,2,3].
*Ae. (S) africanus***	Bouboui[1], Chikungunya[1,3], Rift Valley Fever (R.V.F.)[1], Zika[1,2,3].
*Ae. (S.) apicoargenteus***	Zika[1]
*Ae. (S.) luteocephalus***	Zika[1].
*An. (An.) coustani**	Bwamba[1], Pongola[1], West Nile[1], AR/1169/64[1].
*An. (C) funestus**	Bwamba[1], Germiston[1], Nyando[1], Onyonyong[1,2,3], Semliki[1], Tanga[1], Tataguine[1].
An. (C) gambiae s.l.	Germiston[1], Ilesha[1], Onyonyong[1,2,3], Sindbis[1], Tataguine[1], Wesselsbron[1].
*An. (C) pharoensis**	Birao[1], Sindbis[1], Wesselsbron[1].
*Cx. (Cx.) annulioris**	Kamase[1].
*Cx. (Cx.) antennatus**	Acado[1], Arumowot[1], Pongola[1], Sindbis[1], West Nile[1].
*Cx. (Cx.) guiarti***	Botambi[1], Igwayuma[1], Ntaya[1].
Cx. (Cx.) p. quinquefasciatus	Arumowot[2], Bwamba[2], Chikungunya[1], Germiston[3], Igwayuma[2,3], Itaporanga[2], La Crosse[2], Lebombo[2], Ntaya[2], Onyonyong[2], Simliki[2], Simbu[2], Sindbis[2,3], Tensaw[2], Wesselsbron[2,3], West Nile[1], Zika[2], H.Bs.
*Cx. (Cx.) perfuscus**	Bangoran[1], Gomoka[1], M'poko[1], Nola[1], Usutu[1].
*Cx. (Cx.) tritaeniorhynchus**	Sindbis[1,2,3]
Cx. (Cx.) univittatus	Acado[1], Banzi[3], Igwayuma[1], Sindbis[1,2,3,4], Spondweni[1], Usutu[1], Wesselsbron[1], West Nile[1].
*Cx. (Cx.) weschei**	West Nile[1].
E. chrysogaster s.l.*	Chikungunya[2,3], Nkolbisson[1], Okala[1], R.V.F[1,2,3,4], Simbu[1], Spondwen[1].
*M. (M) africana***	Banzi[1], Bunyamwera[1], Chikungunya[1,3], Lebombo[1], Middleburg[1], Pongola[1], R.V.F.[1], Semliki[1], Spondweni[1].
*M. (M) uniformis***	AR/1169/64[1], Barur[1], Bunyamwera[1], Bwamba[1], Chikungunya[1], Ilesha[1], Malakal[1], Middleburg[1], Ndumu[1], Pongola[1], R.V.F.[1], Sango[1], Spondweni[1], Wesselsbron[1].

* Species which were rarely collected in the most recent survey.
** Species which were not recorded in the most recent survey.
1. Species from which the virus has been isolated in nature.
2. Species in which the new virus multiplies.
3. Species which can transmit the virus experimentally.
4. Species which are natural vectors of the virus.

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Vectors of malaria — Malaria is mesoendemic to hyperendemic in Accra[8] and presumably so in Tema on climatic and ecological grounds. Out of the 6 anopheline vectors, only *A. gambiae* s.l. and *Anopheles melas* will be important in malaria transmission in Accra and Tema. *A. gambiae* s.l. was found in fairly high densities in adult collections in Accra and Tema (viz. 0.62 and 0.73, respectively; Chinery 1965, unpublished data). This included a high proportion of fed individuals (viz. 98.4% and 88.9% for Accra and 100% for Tema; Chinery 1966, 1967 unpublished data). On ecological grounds *A. gambiae* s.s. could occur sympatrically with *A. arabiensis* in Accra and Tema as it does in savannah areas[9] with *A. arabiensis* predominantly with increasing aridity[10]. Zoophilic *Anopheles quadrimaculatus* is unlikely to be present in Accra and Tema since the mean minimum temperature recorded in hilly areas in Accra for several years were 21.96°C, 23.18°C and 23.03°C (Quarcoo pers. comm). Absence in Accra and Tema of spring waters (present in the Volta Region; Ayibotele, pers. comm) with which breeding of *A. gambiae* species D is associated[11] will preclude its existence in these localities.

In Accra and Tema sporozoite rates in *A. gambiae* s.l. including *A. melas* are relatively low. Colbourne and Wright[8] recorded an annual average sporozoite rate of 3.2% in Accra, almost similar to that recorded by Muirhead-Thompson[12] (viz. 3.1%) in *A. gambiae* s.l. at Weija, a suburb of Accra, (Fig. 1), while Chinery (1965 unpublished data) recorded much lower sporozoite rates in Accra and Tema (viz. 0.32% and 0.36% respectively). Although present in coastal lagoons in Accra[8], the breeding intensity and adult population density of *A. melas* in Accra and Tema have not been studied. However, this species which constituted an appreciable proportion of in-door *Anopheles* population in the Gambia[13] will support *A. gambiae* s.l. in malaria transmission in coastal areas of Accra and Tema perennially, although it is a species of lower vectorial capacity in nature[7].

Anopheles funestus was rarely encountered in Accra[8] and was recorded once in a recent preliminary survey (Chinery 1964 unpublished data). This is due most probably to scarcity in Accra and Tema of its larval habitats, but not the absence of the adult sheltering places of this predominantly endophilic mosquito which has led to its virtual disappearance from Accra. This is likely to affect malaria parasite rates especially in the dry season and just after rains[3]. In Weija, a suburb of Accra (Fig. 1) where its larval habitats exist, adult densities of *A. funestus* almost equalled those of *A. gambiae* s.l. and was responsible for dry season malaria transmission[12] but showed much lower sporozoite rate (viz 1.2%) due to shorter adult longevity [cf. 12].

Although it was recorded in Tema in appreciable numbers particularly in the rainy season, sporozoites were not detected in *Anopheles pharoensis* which had been previously collected in appreciable numbers as adults in Accra for almost a whole year predominating in the catches between April and July[29]. This is not unexpected since this species is associated with low infectivity in tropical Africa [cf. 14].

Anopheles caustani s.l. and *Anopheles rufipes* which were seldomly encountered in Accra and Tema may not act as secondary vectors because of low sporozoite rates recorded in *A. caustani ziemani* in different places in tropical Africa[15,16] and their marked zoophilism[17,18]. *A caustani* s.l. which also bred in concrete storm drains, sandcrete water tanks and discarded tin cans in Accra[2,19] was also collected in-doors as adults in Tema mainly in the rainy season (viz. 41 ♀♀ in 1965 and 33 ♀♀ in 1966; Chinery, unpublished data).

Vectors of filariasis — In both Accra and Tema, *A. gambiae* s.l. showed higher annual filarial infection rates than *Culex pipiens quinquefasciatus* viz. *A. gambiae* s.l. 0.41% and 0.58%, *C. p. quinquefasciatus* 0.21% and 0.27% in Accra and Tema, respectively (Chinery 1965 unpublished data). No infective stage was detected but larval infections of the thorax showed the same pattern (viz. *A. gambiae* s.l. 0.08% and 0.22%; *C p. quinquefasciatus* 0.06% and 0.11% in Accra and Tema, respectively, Chinery 1965 unpublished data). These differences however, are not significant ($0.4 < p < 0.5$) and may therefore support the view that an appreciable proportion of the *gambiae* complex in Accra is *A. arabiensis* [3] which is subordinate to *A. gambiae* s.s., *A. funestus* and *C. p. quinquefasciatus* in filariasis transmission[20].

A. melas will also play an appreciable role in filariasis transmission particularly in coastal locations where rapid urbanization and population increase will have negligible impact on its population density. This species which in experimentation showed similar infectivity to *Wuchereria bancrofti* as *A.*

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arabiensis and *A. gambiae* s.s. [21] is the only specie known to sustain endemic foci of the disease in concert with *A. gambiae* s.l. Absence of head and proboscis infections and low thoracis infection rates in *A. gambiae* s.l. may be due partly to endophilly as well as indirect effect of larviciding and direct adverse effect of adulticiding on adult longevity as well as low microfilaria rates in the human population[3]. However, the incidence of human infection is likely to be higher in the peripheral areas (areas of settlement) and the suburbs such as Weija, where Muirhead-Thompson[12] recorded an infectivity rate of 1.2% in wild-caught *A. gambiae* s.l. *A. funestus* and other vectors (Table I) will be inconsequential in filariasis transmission in the Accra-Tema due to scarcity of their breeding places.

Other mosquitoes infected with filarial parasites in Accra and Tema were *A. pharaoensis* 6.58%; head and proboscis infection being 1.32% and *Culez decens* 0.5% (Chinery 1965 unpublished data). Although it is possible that all the *A. pharoensis* might have obtained the infection from localised sources, particularly when all the adults were collected from the same area during a single rainy season (Chinery 1965 unpublished data), it nevertheless underscored the high receptivity of this species for filarial larvae recorded by Smith[22] (viz. 13%) and this requires further investigation. The observed filarial larvae are likely to be those of *W. bancrofti* because of the high anthropophilly of *A. pharoensis* in Nigeria and Cameroons (viz. HBI of 80%) [17] and the fact that all the Accra and Tema collections were made in dwelling rooms.

Vectors of Arboviruses — At least 30 of species listed in Table I are known to be involved in various arbovirus transmission. Of these, only 15 species were recorded in the most recent survey.

In Accra and Tema, intrahuman transmission of yellow fever will be effected only by the semidomestic and the domestic urban varieties of *Aedes aegypti* which has shown an appreciable decline in its larval prevalence in traditional domestic water containers in Accra[4], where it also bred appreciably in concrete drains, soak-aways of septic tanks, sandcrete water tanks and pit latrines[2,19,23]. Demonstration of transovarial and therefore vertical transmission of yellow fever virus by *A. aegypti* as an alternative to its biological survival in the absence of the reservoir[24] indicates several possibilities in areas of settlement by rural immigrants in Accra and Tema where *A. aegypti* bred most frequently[2,19]. Primate vectors like *Aedes africanus* and *Aedes simpsoni* which were not recorded recently, although previously recorded in Accra[25], will not be vectorially active in Accra-Tema. Because of the association of its larval stages with banana, plantain and pineapples and its adults with maize, it will be interesting to determine the impact of operation feed yourselves in Accra and Tema on the incidence of *A. simpsoni* which readily fed on man when offered the opportunity in Nigeria[26]; where a man- biting strain apparently exists[27]. If it is able to establish itself in these localities, then it may extend its breeding to peridomestic receptacles like bottles, tin-cans and coconut shells which supported its breeding in Accra where there are common peridomestic breeding receptacles[2] as well as in domestic receptacles which supported its breeding in Accra[28,29]. Notwithstanding its perennial abundance and ubiquity in Accra and Tema, *C. p. quinquefasciatus* will be vectorially inconsequential because of poor survival of yellow fever virus in this mosquito. It is doubtful whether *Culex thalassius*, another common species in Accra and Tema[2,30,31] could support *A. aegypti* in the intra-human spread of yellow fever in view of the long extrinsic incubation period of the virus in this mosquito. Although, breeding appreciably in tin-cans and domestic water receptacles in Accra[2], it is doubtful whether *Aedes vittatus*, an important sylvatic[32] and rural epidemic vector in West Africa[38], could support *A. aegypti* in transmitting yellow fever in Accra since it was infrequently taken from human bait in Nigeria[34].

Other vectors and potential vectors which were either scarce or not recorded in recent times mainly because of scarcity or loss of arboreal vegetation with which their breeding and or sheltering are associated are: (a) *Eretmapodites chrysogaster* s.l., an experimental vector[35] which was recently recorded in Accra[1]; (b) *Aedes albocephalus, Aedes lineatopennis, Aedes luteocephalus, Aedes metallicus* and *Aedes unillineata* recorded quite frequently in extra-domestic locations (viz. larval prevalence of 4.08%-12.24%; 25.72%) [28,29] but rarely in domestic receptacles (viz. 0.18% to 0.7%) [28,29] in pre-urbanization times. They were either scarce or absent in rapid urbanization times[2]; (c) *Aedes* of the *furcifer-taylori* group which has yielded several strains of yellow fever virus[32] but was not recorded in the rapid urbanization period[2] presumably

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because of loss of rural-type vegetation associated with its maintenance.

The presence of these proved and potential vectors of yellow fever in both domestic and extra-domestic situations during pre-urbanization years implies effective coverage of yellow fever and a wide variety of Aedes-transmitted viruses and their transmission to man from a variety of vertebrates (viz, birds, wilds mammals and primates). This is among the contributory factors to the lower prevalence of detectable yellow fever cases in Accra in recent times.

Vectorial status of *Mansonia africana* remains underdetermined since it was not collected in the latest surveys, although it had been recorded together with *Mansonia uniformis* in live-adult catches in earlier years[36] but found in 0.2% of larval samples due most probably to filling of most of the pools in Christianborg which were covered with *Pistia striatiotes* [29]. Localisation of their larval habitats and study of their breeding and adult populations in parts of Accra and Tema where their larval habitats exist will be of considerable interest in view of their involvement in the cycles of many arboviruses[35].

Virus infections of *A. caustani* and *A. pharoensis* which have yielded several arboviruses[35] will be of localised and seasonal significance only because they bred appreciably in the rainy season but in limited areas in Accra and Tema.

Relevant information on mosquito species involved in the cycles of other arboviruses together with information on the extent of their involvement with these viruses are summarised in Table 2. Of the vectors listed in Table 2, those marked with a single asterisk were seldom collected in recent times while those with the double asterisk were not recorded in the recent survey. Virus transmission by any of these species whether as the sole or the principal vector will be insignificant in the Accra-Tema survey area.

Prospects of mosquito borne diseases in Accra and Tema

Prospects of mosquito borne diseases in any large town or city in most tropical countries will depend on the type of development whether administrative, industrial or agricultural, or combination of these. In Accra, the most important factors determining mosquito species distribution and abundance are the many different types of water habitat (including many polluted ones) created and the limited natural adult sheltering places available. A combination of one or both of these factors with intrinsic adult mosquito factors are the main determinants of mosquito abundance and distribution including the vector species in Accra and Tema. Thus, of the three most common species in Accra, endophillic and night-biting *C. p. quinquefasciatus* and *A. gambiae* s.l. which utilize the wide variety of larval habitats created were more common than *A. aegypti* with short adult life, crepuscuslar and day-time biting activity whose breeding is restricted to mainly rain-dependent larval habitats. This is more marked in the ecologically and climatically similar town of Tema where container habitats were relatively very few and where *A. aegypti* was the 5th commonest species with much reduced larval prevalence[2]. Although there has been a decline in breeding of this species in traditional domestic water container in Accra in rapid urbanization times[4], increase in such human activities like motor vehicle repairs, agriculture and those aimed at recapturing as much as possible of the original ecosystems may lead to an upsurge of *A. aegypti* populations in Accra and Tema. Because their larval habitats are not many and they were breeding less frequently in a wide variety of water habitats, *C. decens*, *C. thalassius* and *Culex univittatus* were ubiquitous but less abundant than the three commonest species in Accra. The more endophillic and anthropophillic *C. thalassius* was more common than the other two species in Accra while in Tema it was as abundant as *A. gambiae* s.l. during September 1965-August 1966 [2,31].

Although scarcity renders many of the vectors species vectorially less important, *A aegypti*, *A. gambiae* and *C. p. quinquefasciatus* are principal vectors of many diseases, especially arboviruses[35]. However, it is those diseases which are maintained either in the apparently healthy human population or hosted by animals common in urban situations which are likely to be common. It is therefore not surprising that malaria is the most common mosquito-borne infection in Accra and Tema, although environmental factors associated with rapid urbanization and development in Accra and considered *in extenso* elsewhere[3] have depressed the incidence of detectable malaria parasitaema[3]. These factors may be associated with fairly high daily mortality rates recorded in *A. gambiae* s.l. in Accra and Tema (viz. 45.2% and 42.0%, respectively, Chinery 1965, unpublished data).

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Despite the fact that the principal vectors of bancroftian filariasis namely *A. gambiae* s.l., *A. melas* and *C. p. quinquefasciatus* when operating simultaneously out-number the malaria vectors, prevalence of filariasis parasitaemia has always been low in Accra though it was higher in pre-urbanization years[3]. Factors leading to the decline in microfilaria rates have been considered elsewhere (*vide supra*) and include a probable shift in the relative proportions of members of the *A. gambiae* complex in favour of the vectorially less efficient species[3].

Discussion and Conclusion

Undoubtedly, rapid urbanization and human population increase in Accra have led to a reduction in the number of naturally occurring breeding sites particularly ponds, swamps, marshes, rot-holes, tree-holes as well as out-door adult mosquito sheltering places (particularly arboreal vegetation). This was compounded by the disappearance of much of the vegetation which harbour wild vertebrates acting as reservoir hosts for some mosquito-borne viruses. This loss of natural breeding and resting sites has led to the disappearance of many mosquito species (usually the rare ones) which almost invariably have limited or specialized larval habitats and more wide-spread breeding in urban situations, e.g. some of the more versatile species like *A. gambiae* s.l. albeit with reduced breeding intensity indicated by a decline in adult density in recent times[3].

Horizontal increase in breeding in a rapidly enlarging city like Accra, though not necessarily associated with increase in breeding intensity, has been associated with a significant increase in larval prevalence of *A. gambiae* s.l. in domestic water containers[3] and an appreciable decline in larval prevalence of *A. aegypti* in these containers[4].

As to be expected it was those species which lost both larval and adult habitats which were not encountered in recent times while those which lost one of these habitats were seldom collected. This is likely to alter the number, type and distribution of diseases vectored by these species. The likely event will be a general reduction in the number of most of these diseases and a wide-spread distribution of a few diseases vectored by the most common species. However, in a high urbanized situation such as the Accra-Tema survey area (Fig. 1) where most of the commonest vector species exhibit marked endophilly and anthropophilly, ready availability of human blood will make spill-over of viruses from the animal reservoir population into the human population a rare event. The dominant mosquito-borne virus diseases are likely to show a centripetal distribution with higher prevalence in the most vegetated peripheral areas of Accra where the highest frequencies of breeding of *A. gambiae* s.l. and *A. aegypti* were recorded[3,4] and where reservoir hosts are more common than in central Accra with negligible vegetation. Malaria parasitaemia has such a distribution in Accra[37] where rainfall affects breeding patterns and population density of the common mosquito species[2,38]; although in this extensive urban area, microclimatic and ecological diversities in different localities have affected breeding frequency and therefore indoor adult resting density of *A. gambiae* s.l. in various localities differently. This correlated with malaria parasite rates in various localities[37].

Even though no comparable studies on mosquito fauna was undertaken in the ecological and climatically similar town of Tema earlier on, similarities in the species composition and abundance of mosquitoes recorded in both Accra and Tema in recent times[2] would indicate a mosquito fauna in Tema that was similar to that of Accra in pre-urbanization times.

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