

## THE BREEDING PATTERNS OF THREE MAJOR MOSQUITO SPECIES IN LENTIC-WATER HABITATS IN ACCRA, GHANA

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### Abstract

The breeding patterns of three major mosquito species, *Anopheles gambiae* s.l., *Aedes aegypti* and *Culex pipiens quinquefasciatus* in running (lentic) water habitats in Accra during a period of rapid urbanization (1964-66) were studied by comparing monthly larval prevalences of these mosquitoes with total monthly rainfall graphically by correlation coefficients and scattergraphs. Larval prevalence of *Cx p. quinquefasciatus* was consistently high during both years while that of *An. gambiae* s.l. was appreciably high but that of *Ae. aegypti* was consistently very low indicating that running-water habitats are not natural breeding places of *Ae. aegypti*. Positive association between larval prevalence of *An. gambiae* s.l. was underscored by significant correlation coefficients in both 1964-65 and 1965-66 years while the positive and negative associations between these two parameters for *Ae. aegypti* and *Cx p. quinquefasciatus*, respectively, were underscored by significant correlation coefficients in only the 1964-65 year. For *Cx p. quinquefasciatus*, a negative correlation between the two parameters in the dry months of the 1964-65 year changed to a positive correlation in the same season of the 1965-66 year. From the scattergraphs which were all straight lines, it was evident that rainfall had little impact on breeding of *Ae. aegypti* while it had a marked positive impact on the breeding of *An. gambiae* s.l. and a marked negative impact on the breeding of *Cx p. quinquefasciatus* in the 1964-65 year. In the case of the latter species, larval prevalence was highest when rainfall was nil while in the case of *An. gambiae* s.l. and *Ae. aegypti*, zero rainfall produced 4.2 per cent and 0.36 per cent larval prevalences respectively in the 1964-65 year. During the 1965-66 years, a more successful larval control in this less rainy year might have changed the breeding patterns of *Ae. aegypti* and *Cx p. quinquefasciatus* from significant positive and negative correlations respectively to no correlation between rainfall and larval prevalence. For the latter species, a positive association between the two parameters in the dry months changed to a negative association resulting in no correlation overall in 1965-66. Other factors which affected breeding pattern were whether the three running-water habitats were natural or unnatural breeding habitats for the three species, and the versatility and hardiness of the species. It is expected that larval control will reduce the level of correlation between rainfall and larval prevalence to a greater degree in an unnatural than in a natural breeding site.

### Introduction

Rapid urbanization in Accra since the early 1950s, and accentuated since 1961, has resulted in the creation of a multiplicity of mosquito-breeding-water habitats as well as elimination or modification of many natural mosquito-breeding waters. Different mosquito species have adapted variously to these changes resulting in the expected modification on vector populations and, therefore, vectorial capacity of vector species. Changes in vector populations were most marked in the case of the three most common species viz. *Anopheles*

*gambiae* s.l., *Aedes aegypti* and *Culex pipiens quinquefasciatus*, which were found in 67.12 per cent of all larval collections from running-water habitats in the year 1964-65 (Chinery, 1969).

The aim of the present paper is to compare the breeding patterns of these three most important disease vectors in Ghana and determine the impact of rainfall on their breeding in running-water habitats during a mosquito larval survey and control programme in a period of rapid urbanization in Accra (Oct 1964 - Sep 1966).

### Experimental

The field survey was undertaken as part of a pilot larval mosquito survey and control programme by larviciding (with oil and insecticides) and other methods of source reduction carried out in Accra and Tema between October 1964 and September 1967 (Chinery, 1969). The running-water habitats encountered in Accra are concrete drains, earth drains and streams or rivers. Of these three habitats, concrete drains were most polluted particularly with household and human waste; earth drains were moderately polluted and streams/rivers were least polluted. All stagnant parts of these run-

species) of each species in each of the three habitats were computed separately and compared with total monthly rainfall by the correlation coefficient and scattergraph, while the combined prevalences in all three habitats were compared with total monthly rainfall graphically by scattergraph and correlation coefficient during the 2-year period, October 1964 - September 1966 and also during the rainy and dry months of this 2-year period. The rainy months comprised all the months in which the total monthly rainfall was 28 mm or more, and the dry months comprised all the months in which total monthly rainfall was 25.4 mm or less.

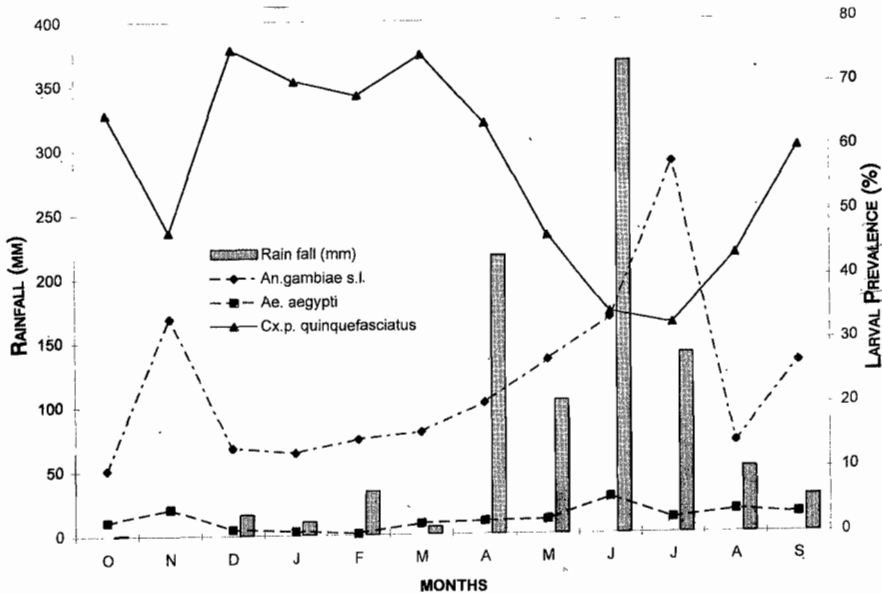


Fig. 1. Relationship between monthly rainfall and larval prevalence of three major mosquito species in running-water habitats in Accra (1964-65).

ning-water habitats were examined and all species of larvae encountered therein were collected into specimen bottles which were fully labelled. Larvae were identified in the laboratory, immature larvae being reared to the mature stage if necessary for identification. Monthly larval prevalence (percentage incidence of occurrence of larvae of a

The rainy months numbered seven while the dry months numbered five.

Larval prevalence is defined as the number of samples with larvae of any of the three mosquito species in each of the three habitats expressed as a percentage of the total number of samples collected in each of the three habitats in each month.

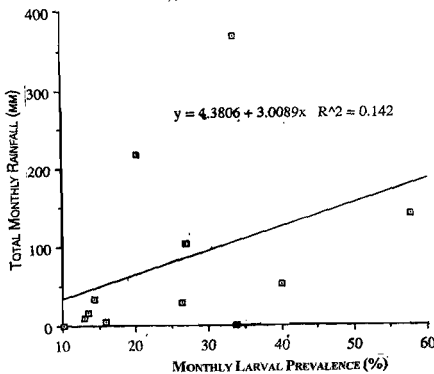


Fig. 2. Scattergraph on the relationship between monthly rainfall and larval prevalence of *An. gambiae* s.l. in running-water habitats in Accra (1964-1965).

Larval prevalence served as an index of breeding frequency.

### Results

#### *Anopheles gambiae* s.l.

There was a positive association between rainfall and larval prevalence during the 1964-65 year (Fig. 1), larval prevalence reaching its highest level at the peak of the rains in July. This positive association was underscored by a positive correlation coefficient (viz.  $r = +0.5124$ ,  $P = 0.02 < 0.01$ ). The scattergraph was a straight line expressed by the equation  $y = 4.3806 + 3.008 \times R^2 = 0.142$  (Fig. 2) and intercepted the y axis at about 33 mm rainfall, implying that 33 mm rainfall will be associated with 10 per cent larval prevalence while prevalence will be zero when the rainfall is 20 mm. During the 1965-66 year, a more successful larval control in this less rainy year apparently changed the breeding pattern of *An. gambiae* s.l., positive association between rainfall and larval prevalence being imperceptible (Fig. 3). However, a correlation coefficient of  $r = +0.5708$ ,  $P = 0.01 < 0.001$  indicated a clearcut correlation. The scattergraph was a straight line expressed by the equation  $y = 17.087 + 3.8984 \times R^2 = 0.326$  (Fig. 4) and intercepted the x axis at about 4.2 per cent larval prevalence indi-

cating that larval prevalence will be 4.2 per cent when rainfall is zero while a large volume of rainfall, e.g. 200 mm, will be required to produce about 50 per cent larval prevalence.

#### *Aedes aegypti*

Frequency of breeding of *Ae. aegypti* in running-water habitats was very low during both years (Fig. 1 and Fig. 3). Positive relationship between rainfall and larval prevalence was not clearly evident, although the positive correlation between rainfall and larval prevalence in 1964-65 (viz.  $r = +0.5659$ ,  $P = 0.01 < 0.001$ ) underscored this. The scattergraph was a straight line expressed by the equation  $y = -15.404 + 40.992 \times R^2 = 0.310$  (Fig. 5) which intercepted the x axis at 0.36 per cent (at zero rainfall), indicating the reliance of *Ae. aegypti* on rain water for breeding in running-water habitats. A large volume of rainfall will be required to produce a larval prevalence of 6 per cent indicating the unsuitability of running-water habitats for *Aedes aegypti* breeding. There was no significant correlation between rainfall and larval prevalence of *Ae. aegypti* during the 1965-66 year but there was a negative correlation between rainfall and *Ae. aegypti* prevalence during the rainy months of the 1965-66 year (viz.  $r = -0.5886$ ,  $P = 0.05 < 0.02$ ) probably due to successful larval control of *Ae. aegypti* in this less rainy year.

#### *Culex p. quinquefasciatus*

The relationship between monthly rainfall and larval prevalence during the 1964-65 year was a negative one, prevalence declining with increase in rainfall and vice versa (Fig. 1). The two lowest larval-prevalence figures were association with the highest rainfall. This negative association was underscored by a negative correlation coefficient (viz.  $r = -0.5992$ ,  $P = 0.01 < 0.001$ ). This is to be expected since breeding of *Cx p. quinquefasciatus* is associated with intensively-polluted water so that as rain water dilutes the water in the running water habitats, breeding frequency and breeding intensity will decline. The scattergraph was a straight line expressed by the equation  $y =$

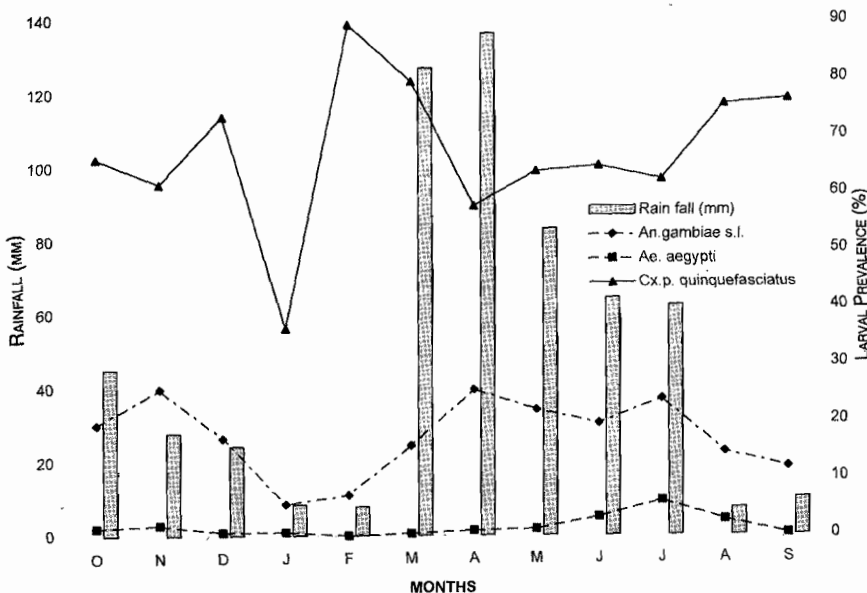


Fig. 3. Relationship between monthly rainfall and larval prevalence of three major mosquito species in running-water habitats in Accra (1965-66).

319.57 - 4.186 × R<sup>2</sup> = 0.332 and intercepted both the y and x axes (Fig. 6) indicating the limitation imposed by rainfall on its breeding in running water habitats. Larval prevalence attained its highest value (76.25%) at zero rainfall while a substantial rainfall (342.56 mm) was required to produce zero larval prevalence. During the 1965-66 year, larval control might have affected the breeding pattern appreciably because there was a clear positive association between larval prevalence and rainfall in the dry months (October-January) (Fig.3) while the negative relationship between these two parameters during the rainy months (Fig.3) was not strong enough resulting in an insignificant correlation coefficient ( $r = -0.0771$ ). however, a significant positive correlation coefficient ( $r = + 0.7197$ ,  $P = 0.02 < 0.01$ ) in the dry season of the 1965-66 year indicated a change from negative to positive association between larval prevalence and rainfall.

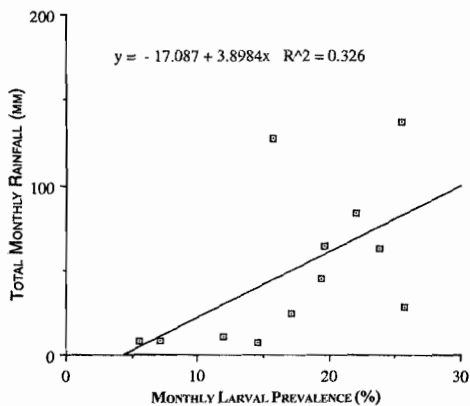


Fig. 4. Scattergraph on the relationship between monthly rainfall and larval prevalence of *An. gambiae* s.l. in running-water habitats in Accra (1965-66).

**Discussion and conclusion**

The present study has shown differences in the breeding patterns of the three mosquito species under consideration with some indications on varying impact of larval control on breeding patterns. Breeding of *Cx p. quinquefasciatus* was persistently high throughout the 2-year period especially the second year while that of *An. gambiae* s.l. was appreciably high but that of *Ae. aegypti* was relatively very low. While the positive correlation between rainfall and larval prevalence of *An. gambiae* s.l. was maintained throughout the 2 years, that of *Ae. aegypti* changed from positive in the first year to no correlation in the second year while the negative correlation observed in the breeding of *Cx p. quinquefasciatus* during 1964-65 year changed to no correlation due to a change from positive association between rainfall and larval prevalence in the dry months to a negative association between these two parameters in the rainy months of the second year. These

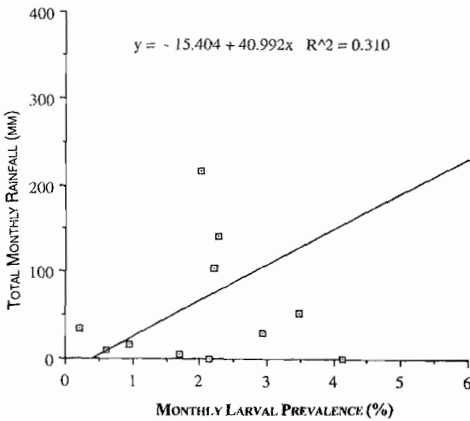


Fig. 5. Scattergraph on the relationship between monthly rainfall and larval prevalence of *Ae. aegypti* in running-water habitats in Accra (1964-65).

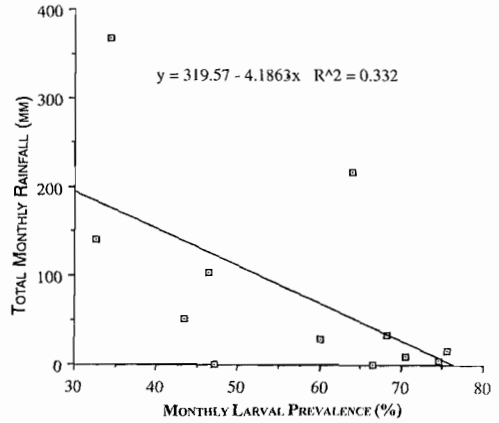


Fig. 6. Scattergraph on the relationship between monthly rainfall and larval prevalence of *Cx p. quinquefasciatus* in running-water habitats in Accra (1964-65).

changes in breeding patterns may be due to more successful larval control during the second year. This indicates that rainfall affected the breeding patterns of each species differently. Other factors which will affect breeding patterns include the naturalness and unnaturalness of the habitat for each species, the degree of preference of each species for each habitat, the hardiness and versatility of each species, and the varying impact of larval control on each species in each of the running-water habitats. Thus, rainfall had a significant negative impact on the breeding of *Cx p. quinquefasciatus*, the most versatile and hardy of the three species capable of breeding in any water habitat although it prefers polluted water.

Generally, a large amount of rain caused only a slight increase in the breeding frequency of *An. gambiae* s.l. and even more so in the case of *Ae. aegypti* (Fig. 1 and Fig. 3), and this was most evident in streams/rivers and earth drains (which contained cleaner water) than water in concrete drains. Some strains of *Ae. aegypti* breed in soil-associated water habitats (e.g. pools in the river

bed) in feral locations (Garnham, Highton & Harper 1946). This may explain the significant positive correlation between rainfall and larval prevalence of *Ae. aegypti* in earth drains and streams/ rivers during the rainy months of the 1964-65 year (viz.  $r = +0.5961$ ,  $P 0.05 < 0.02$  and  $r = +0.8928$   $P > 0.001$ , respectively), indicating a marked impact of rainfall on its breeding in the rainy months when rain water can cause the hatching of many desiccated eggs.

The impact of larval control will depend *inter alia* on the degree of preference of each species for each habitat. Thus, successful larval control may cause disruption in the normal breeding pattern resulting in insignificant correlation between rainfall and larval prevalence. Thus, the negative and positive correlations between rainfall and larval prevalence observed for *Cx p. quinquefasciatus* and *Ae. aegypti* respectively during the 1964-65 year became insignificant during the second year (1965-66) when larval control was generally more successful. Similarly, the significant negative correlation between rainfall and larval prevalence of *An. gambiae* s.l. in concrete drains in the 1965-66 year (viz.  $r = -0.6487$   $P = 0.02 < 0.01$ ) may be due to its more successful control in concrete drains. Also the negative correlation be-

tween rainfall and larval prevalence of *Ae. aegypti* in running water habitats during the rainy months of the 1965-66 year (viz.  $r = 0.5886$ ,  $P = 0.05 < 0.02$ ) may be due to its more successful control in the rainy months of the 1965-66 year. Heavy rainfall could also flush out larvae into the sea via the coastal lagoons (Chinery, 1969).

#### Acknowledgement

The author wishes to thank Mr Alfred Quartey of the Data Processing Centre for the scattergraphs and Mr H. Ikeda, Consultant, Statistical Service, Ministry of Finance, for the graphs and histograms.

#### References

- CHINERY, W. A. (1969) A survey of mosquito breeding in Accra and Tema, Ghana, during a Two-year Period (Sep, 1964 - Aug, 1966) of Larval Mosquito Control with Suggestions for Future Control Consideration. (Mimeo., 86 pp. Library, University of Ghana Medical School, P.O. Box 4236, Accra; Library, CSIR, P.O. Box M.32, Accra.
- CHINERY, W. A. (19..) Impact of urbanization and rapid population increase on mosquitoes and their disease transmission potential in Accra, and Tema, Ghana. *Ghana J. Sci.* 39, 111-115.
- GARNHAM, P. C. C., HARPER, J. A. & HIGHTON, R. B. (1946) The mosquitoes of Kaimosi Forest, Kenya Colony, with special reference to yellow fever. *Bull. ent. Res.* 36, 477-96.

Received 16 Aug 96; revised 22 Nov 99.