Reviews/Analyses

Larval habitat of *Anopheles philippinensis*: a vector of malaria in Bangladesh

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This article reviews the various types of larval habitat of the malaria vector *Anopheles philippinensis* Ludlow in Bangladesh and characterizes its breeding ecology. Discussed also are the possible implications of the environmental changes on its breeding habitats resulting from intensified land use brought about by population increase and developments in irrigation and water resources.

Introduction

Out of 34 known anopheline mosquitoes, four species (*Anopheles dirus*, *A. minimus*, *A. philippinensis*, and *A. sundaeicus*) are the principal vectors of malaria in Bangladesh (1–4). In 1991 and 1992, however, *A. aconitus* and *A. annularis* were also identified as vectors of epidemic malaria in Bangladesh (30, 32). Although some information on the vector potentiality and bionomics of the malaria-carrying mosquitoes in Bangladesh has appeared (5–9), detailed information on different types of breeding habitats, especially of the plain-land malaria vector *A. philippinensis* (6), is difficult to obtain. The present article reviews the various types of breeding habitats and characterizes the breeding ecology of *A. philippinensis* in Bangladesh. Discussed also are possible implications on its breeding habitats arising from intensified land use caused by population increases and irrigation and water resources developments.

Breeding ecology

The preferred breeding sites of *A. philippinensis* are tanks, ponds, marshy lands, and rice fields with good vegetation and with clean water (6, 10–18).

Both Christophers (10), in 1912, and Covell (12), in 1927, found that *A. philippinensis* bred in rice fields in the Andamans. Bose (12), in 1931, stated that this species could be attracted or repelled from village tanks by introducing or removing suitable vegetation. Sen, in 1935, reported that it bred in rice fields in Bengal but that its frequency was low (13). In 1936 Ramsay & Macdonald reported that *A. philippinensis* required cool water and hence favoured permanent pools with vegetation under slight shade (14).

In 1941 Sen reported that the relative frequency of *A. philippinensis* breeding in ponds overgrown with aquatic weeds was usually 35 times greater than that in rice fields (15). The larvae of this species were recorded also in Bengal in water containing all types of plants, except *Lemna* (duckweed); however, breeding was most frequently associated with the filamentous algae *Spirogyra*.

In 1942 Iyenger reported that *A. philippinensis* usually bred in ponds and that the main breeding season was from July to October (16). The depth of the water-table below the surface during the breeding season appears to have a marked influence on the prevalence of this species. In villages where the water-table was low, the density of *A. philippinensis*
was high; in villages where the water-table was close to the ground its density was very low. A significant positive correlation was observed between the density of this species and the depth of the water-table below ground level during the wet season.

In 1944 Lyenger reported that *A. philippinensis* larvae were not commonly found in rice fields and that this species bred mostly in large permanent rather than temporary ponds. Furthermore, it showed a definite preference for ponds fully exposed to sunshine that contained water with a high dissolved oxygen content. *A. philippinensis* bred only in clean water and not in water that was even slightly contaminated with sullage or decaying organic matter. The following types of submerged vegetation were most favoured by this species for breeding: *Hydrilla verticillata*, *Ceratophyllum demersum*, and the aquatic species of *Utricularia* and of *Najas*. These plants form dense subaquatic clumps, which often reach the surface and offer good shelter to the larvae without obstructing full illumination of the water by sunshine. Certain forms of nonfilamentous green algae were frequently found in association with *A. philippinensis* larvae, and evidently form their main food as shown by examination of their gut contents.

Stretches of water that contained certain types of aquatic vegetation such as *Lemma* and *Eichhornia speciosa* (water hyacinth) and some phytoplankton such as *Microcystis aeruginosa*, *Euglena* spp., and other blue-green algae (e.g., *Anabaena* spp. and *Oscillatoria* spp.) were unfavourable breeding areas for *A. philippinensis* mosquitoes (17). In 1944 Covell noted that it bred in tanks, pools, borrow pits and ditches with vegetation (18).

Although *A. philippinensis* did breed in rice fields in Bengal, Sen, in 1948, attributed its generally limited tendency to breed in such fields to the following factors (19). First, the absence of green algae (*Spirogyra*) in rice fields because of the increased shade when rice plants grow to heights ≥75 cm. Second, the water temperature in rice fields, which reaches ≥42°C, i.e., beyond the tolerance limit of the species.

Quraishi et al., in 1951, reported that because of changes in the courses, a number of dead rivers had formed in East Bengal (currently Bangladesh) and that *A. philippinensis* bred in and around such rivers (20).

In 1952 a study carried out in Mymensingh district reported that *A. philippinensis* usually bred in dead rivers or marshes with submerged vegetation located 0.9–1.80 m from the edges (21). The incidence of heavy rainfall had a considerable influence on the breeding of this mosquito. Krishnan, in 1969, reported that the favoured breeding places of *A. philippinensis* were tanks, pools and ditches (22).

In 1964 Ghiasuddin reported that tanks with clear water and aquatic vegetation were the preferred breeding sites of this mosquito, and that most of the larvae avoid the heavy shade of overhanging trees. The larvae were also collected from stagnant water around rice fields, but not in the rice fields themselves. During entomological investigations between 1966 and 1968 in greater Rangpur district (Rangpur, Gaibandha, Kurigram, and Nilphamari districts), *A. philippinensis* larvae were also collected from tanks and *beels* (marshlands) with aquatic vegetation. In the course of malaria eradication and control programme activities, *A. philippinensis* larvae have been found in several other districts in tanks, ponds, and *beels* associated with submerged vegetation (N.P. Maheswary, personal communication, 1982).

In 1982 Elias et al. also noted that the favoured breeding places of *A. philippinensis* were tanks, ponds and ditches associated with submerged vegetation (3). Also, in 1987, in Gazipur district (Dhaka) Elias et al. found that the distribution of *A. philippinensis* larvae was as follows: 64.1% in *beels* with vegetation; 33.3% in rice fields; and 2.6% in ponds with vegetation.

In 1972, in Burma, Khin-Maung-Kyi reported that *A. philippinensis* bred in stagnant water, especially in wide stretches of water with emergent vegetation, as well as in ponds, tanks, or swamps with grassy edges (28). Also, Macan, in 1948, reported that in Burma it bred in derelict or cultivated rice fields (29).

The preferred larval habitat and breeding ecology of *A. philippinensis* are summarized in Table 1. Owing to its breeding specificity, insecticidal susceptibility (23), pressure of DDT residual house spraying, as well as environmental and socio-cultural changes (e.g., intensive land use with modification of crop cultivation pattern, large-scale use of tanks, ponds and marshes for irrigation purposes, increased fishing, repeated flooding of permanent and suitable breeding sites), the presence of *A. philippinensis* and the incidence of malaria have decreased in the plains of Bangladesh in recent years. For example, in 1949–50 in a district of Mymensingh division Quraishi et al. recorded catching an average of 6.2–11.7 *A. philippinensis* per bedroom over 30 min in some villages, where the parasite rate lay in the range 18.7–30.7% (20); they also recorded 168 *A. philippinensis* larvae in 280 shallow areas in marshy

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### Characterization of the breeding ecology of Anopheles philippinensis in Bangladesh

<table>
<thead>
<tr>
<th>Breeding place type</th>
<th>Very favourable</th>
<th>Favourable</th>
<th>Unfavourable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tanks, permanent ponds, marshland (beel)</td>
<td>Temporary ponds, permanent pools, ditches, dead rivers, rice fields</td>
<td>Rivers, drains, temporary pools, small water collections, seepage, saline water, containers</td>
<td></td>
</tr>
<tr>
<td>Filamentous alga Spirogyra; Submerged vegetation such as Hydrilla verticillata, Ceratophyllum demersum; aquatic species of Utricularia and of Najas; and nonfilamentous green algae</td>
<td>Other filamentous algae and submerged vegetation</td>
<td>Lemma (duckweed), Eichhornia speciosa (water hyacinth); some phytoplankton such as Microcystis aeruginosa and Euglena spp.; blue-green algae such as Anabaena spp. and Oscillatoria spp.; plants which grow above the water surface in such a manner as to block direct sunlight; certain floating waterplants such as Azolla pinnata, Salvinia natans and S. cucullata</td>
<td></td>
</tr>
<tr>
<td>Clean water exposed to sunshine with high dissolved oxygen content</td>
<td>Clean water, light shade</td>
<td>Contaminated water with sullage or decaying organic matter; dense shade; heavy flooding and heavy rainfall</td>
<td></td>
</tr>
</tbody>
</table>

Areas or dead rivers in this district. During a pre-eradication survey in 1960, an average of 0.05–0.29 A. philippinensis were caught per man per hour in the same district of Mymensingh division, and the parasite rate varied from 0.69% to 29.0%. In contrast over the period 1981–92 in the same district only seven adult female A. philippinensis were caught in 190 villages surveyed (N.P. Maheswary, personal communication, 1992), and the annual malaria slide positivity rate was 0.29–4.13%.

A very low density of A. philippinensis (0.02–0.03 man biting rate per night) was also recorded in Rangpur division (zone-3) in 1966–68 (slide positivity rate, 0.06–0.42%).

In 1993 Birley reported that although the land west and south of the Jamuna river was highly malarious in 1916, it is not so today, while the area east of this river still has a small risk (31). The reduction in malaria risk in the plains of Bangladesh can be attributed to the intensification of land use and increase in human population density, while the abundance of the A. philippinensis vector appears to have declined as environmental changes have displaced its breeding sites. Concomitantly, it has been reported that A. philippinensis has almost disappeared from West Bengal, India (25–27).

Nevertheless, the revival or establishment of new and/or alternative water stretches that are ecologically suitable for mosquito vector breeding and the resurgence of A. philippinensis and of malaria in the vast plains of Bangladesh cannot be ruled out.

On the other hand, the recently identified secondary/suspected malaria vectors (A. aconitus, A. annularis, A. vagus, and A. subpictus) may assume an important role in reintroducing malaria to the plains. Environmental changes brought about by intensified land use, fishing, and the creation of embankments, dams, barrages, irrigation channels, changes in river courses for flood action plans, and/or any other water resources developments in the plains of Bangladesh could also alter the malaria transmission pattern. The surveillance and monitoring of disease vectors and of malaria and other vector-borne diseases need, therefore, to be carried out at regular intervals.

### Résumé

**Habitat larvaire d’Anopheles philippinensis, vecteur du paludisme au Bangladesh**

Cet article présente les divers types d’habitat larvaire du vecteur du paludisme Anopheles philippinensis au Bangladesh et les caractéristiques écologiques de sa reproduction. On y examine aussi les répercussions possibles des modifications considérables de l’environnement, qui ont perturbé les gîtes larvaires de cette espèce et qui ont été principalement dues à l’intensification de l’utilisation des sols et au développement de l’irrigation et des ressources en eau. Globalement, ces modifications ont entraîné une réduction de la densité d’A. philippinensis. Il ne faut toutefois pas négliger le rétablissement ou la création possibles de nouvelles étendues d’eau.

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*See footnote a, p. 447.*
qui conviendraient comme gîtes larvaires pour les moustiques vecteurs, ni la résurgence d’*A. philippinensis* et par conséquent du paludisme qui s’en suivrait dans les vastes régions de plaine du pays. Il est par conséquent important d’exercer à intervalles réguliers une surveillance des vecteurs de maladies et une surveillance du paludisme et autres maladies à transmission vectorielle.

**References**


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