AQUATIC VEGETATION AND THEIR NATURAL HOSPITABILITY TO THE IMMATURES OF *MANSONIA* MOSQUITOS, THE VECTORS OF *BRUGIA MALAYI* IN SHERTALLAI, KERALA, INDIA

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Abstract. Prevalence of various aquatic vegetation and their role in supporting vector breeding were studied by drawing plant samples from natural fresh water habitats in Shertallai region which is endemic for *Brugia malayi*. As many as 30 aquatic plant species were identified in addition to the most abundant and preferred host plants such as *Pistia stratiotes, Salvinia molesta* and *Eichhornia crassipes* which are of major concern due to their contribution for vector proliferation. Fallow lands and paddy fields recorded relatively a higher number of plant species. Natural breeding of *Mansonia*, the vector mosquitos was observed in 16 of them. Using the data on the prevalence, proportion of samples positive for *Mansonia* breeding and immature density, two indices viz, natural hospitability Index (NH) and *Mansonia* host plant Index (MHI) were developed for each plant species. Ranking of these plants in relation to *Mansonia* breeding was done based on these indices. *Monochoria vaginalis* has been identified to be one of the most important auxiliary host plant. Three grasses viz, *Hygrorhiza aristata, Sacciolepis interrupta* and *Leersia hexandra* were found to support all the three species of *Mansonia* viz, *Ma. annulifera, Ma. uniformis* and *Ma. indiana* with considerable immature density. The inclusion of these plants for weed/vector control is emphasized.

INTRODUCTION

Shertallai, which lies in the central coastal part of Kerala, India is endowed with a wealth of perennial water spreads due to high water table. These water bodies are heavily infested with various types of aquatic vegetation serving as host plants for *Mansonia* mosquitos, the vectors of *Brugia malayi* which is endemic in this locality since early part of this century (Iyengar, 1938). The unique feature of *Mansonia* mosquitos is that the adults lay their eggs on the undersurface of the floating leaves of aquatic vegetation and to the roots of which immatures of these mosquitos attach themselves for respiration (Wharton, 1962). A wide variety of aquatic and semi-aquatic plants have been reported to be supporting the larvae of *Mansonia* mosquitos (Gillett, 1945; Laurence, 1960, Burton, 1959, 1960 a, b). *Pistia stratiotes, Salvinia molesta* and *Eichhornia crassipes* are the major host plants prevalent in Shertallai taluk (Rajendran *et al*, 1993). However, it is necessary to identify other natural host plants in order to constrain the breeding of these mosquitos through weed control as there exists the possibility of larvae adapting to alternative hosts when the control measures are targeted to only major host plants. Therefore, a survey of the prevalence of different aquatic plants in this region and their role in supporting natural breeding was carried out and the results are presented in this communication. We have also introduced two indices to rank the host plants based on their prevalence and support of vector breeding.

MATERIALS AND METHODS

Habitats representing all different types of fresh water bodies such as ponds, channels, canals, paddy fields and fallow lands in Shertallai taluk were selected at random. Plant samples, other than *P. stratiotes, S. molesta* and *E. crassipes* were collected and were examined separately for the presence of egg clusters, larvae and pupae of *Mansonia* mosquitos. A specially designed 'cloth dipper' (Krishnamoorthy *et al*, 1992) was used for sampling floating vegetation. For emergent, submergent and shoreline weeds, uprooting method (Baily, 1984; Chiang and Cheong, 1985) was followed. A standard unit area of 0.1 m^2, equal to that of dipper surface area, was maintained for collecting plants by this method so as to compare the larval density in floating weeds. Plant and mosquito immature samples were labeled and brought to the laboratory for identification. Species identification of the plants was confirmed at the Botanical Survey of India, Coimbatore. Immature stages of the mosquitos col-

lected from different plant species were reared separately to adults for species identification.

The total number of habitats examined (TH), the number of habitats infested with a given plant species (NS) alone or in combination with other species and the number of habitats with a given plant species that was positive for *Mansonia* immatures (PS) were recorded. The prevalence of a given plant species was determined from the number of habitats with a given species out of total habitats examined. The average number of larvae and pupae per unit area (ALP) was calculated from the total number of larvae and pupae collected from a given plant species divided by the number of samples positive for *Mansonia* immatures. From these data the following indices were calculated for ranking these hydrophytes in relation to *Mansonia* breeding:

Natural Hospitability Index(NHI) = (PS\NS)*ALP.....(1)

Mansonia Host-plant Index (MHI) = (NS\TH)*NHI.....(2)

RESULTS AND DISCUSSION

A total of 100 habitats representing ponds (10), canals (10), channels (10), fallow lands (35) and paddy fields (35) was selected at random and examined for aquatic vegetation. In ponds and canals, the aquatic weeds recorded, other than the three major types of floating weeds *viz P. stratiotes, S. molesta* and *E. crassipes* were *Monochoria vaginalis* and *Isachne millaceae* with their prevalence being 10 and 30%. In all the 10 channels examined, only floating hydrophytes were present. From fallow lands and paddy fields as many as 30 species of aquatic plants were obtained. Fallow lands and paddy fields recorded a high diversity of plant species.

Data on the prevalence of different plant species and their relation to vector breeding were subjected to further analysis irrespective of the type of habitat. Among the 30 plant species, *M. vaginalis* and *I. miliaceae* were found to be the most prevalent species with their infestation in 28.00 and 27.00% of the habitats surveyed respectively (Table 1). The prevalence of the rest of the plant species ranged between 0.41 and 7.47%.

As many as 16 egg clusters of *Mansonia* mosquitos were collected from *I. miliaceae* while none was observed in the rest of the plants. *Mansonia* immature stages were obtained from 16 plant species and the percentage of samples positive for the immatures of *Mansonia* mosquitos ranged between 20.00 and 100% for different plant species. Immature vector density per unit area was recorded to be the highest in *Hygrorhiza aristata*, a grass followed by *Sacciolepis interrupta, M. vaginalis, Leersia hexandra* and *I. miliaceae* (Table 2). In the rest of the plant species, *Mansonia* immature density was below 10 per unit area.

Many other plant species such as *Commelina bengalensis, Azolla pinnata, Lemna perpusilla, Colocasia antiquorum, Alternanthera sessilis, Nymphea stellata* and *Ceratophyllum demersum* were reported to support *Ma. annulifera* and *Ma. uniformis* (Burton, 1960 a, b) under laboratory conditions. However, present study showed that none of these plants was found to foster the immatures of any of the *Mansonia* species in the natural habitats.

Natural Hospitability Index (NHI) calculated from the immature density and proportion of habitats with a given plant species positive for *Mansonia* breeding was highest in *H. aristata*, followed by *S. interrupta* and *L. hexandra*. This index can be considered as a measure of natural hospitability of host plants. When *Mansonia* Host-plant Index (MHI), derived by multiplying NHI and the proportion of prevalence was compared between different plant species, it was almost equal for *M. vaginalis* and *I. miliaceae*, while it was 2.048 for *H. aristata*. It fluctuated between 0.001 and 0.553 for other plant species. When a similar treatment was given for the data concerning the major floating aquatic weeds (Rajendran *et al*, 1993; VCRC unpublished observation), the NHI and MHI were found to be 95.03 and 57.99 for *P. stratiotes*, 23.67 and 14.827 for *S. molesta* and 18.68 and 5.322 for *E. crassipes*, respectively. These indices also revealed that these plants remain to be the major host plants for *Mansonia* breeding. When these three plants were ranked based on these indices, it was in the order of *P. stratiotes, S. molesta* and *E. crassipes* as reported earlier (Rajendran *et al*, 1993). Studies on the adult emergence pattern from different weed infested habitats also showed that *P. stratiotes* infested ponds contributed the maximum unit area production of 607.29 adults per day per 100 m^2. Considerable number of adults (227.7/100 m^2 per day) was also reported to be emerged from fallow lands infested with *I. miliaceae* (Pradeepkumar *et al*, 1991). Based on these indices, plant species such as *M. vaginalis, I. miliaceae* and *H. aristata* can be considered as host plants auxiliary to the well established host plants of *Mansonia* species.

Table 1

List of aquatic plants prevalent in fresh water habitats.

Sl No.	Plant species	Family	NS	Prevalence (%)	PS	+ve for vector breeding (%)
1.	*Monochoria vaginalis*	Pontederiaceae	28	28.00	14	50.00
2.	*Isachne miliaceae*	Gramineae	27	27.00	17	62.96
3.	*Hygrorhiza aristata*	Gramineae	5	5.00	4	80.00
4.	*Ceratopteris thalictroides*	Polypodiaceae	18	18.00	9	50.00
5.	*Sacciolepis interrupta*	Gramineae	4	4.00	3	75.00
6.	*Leersia hexandra*	Gramineae	2	2.00	2	100.00
7.	*Asteracantha longifolia*	Acanthaceae	13	13.00	5	38.46
8.	*Ipomoea aquatica*	Convolvulaceae	10	10.00	4	40.00
9.	*Jussiaea repens*	Onagraceae	7	7.00	4	57.14
10.	*Marsilea quadrifoliata*	Marsiliaceae	16	16.00	4	25.00
11.	*Limnophylla heterophylla*	Scrophulariaceae	10	10.00	2	20.00
12.	*Limnanthemum cristatum*	Hydrophyllaceae	2	2.00	2	100.00
13.	*Ipomoea biloba*	Convolvulaceae	5	5.00	1	20.00
14.	*Cyperus halpan*	Cyperaceae	4	4.00	1	25.00
15.	*Scirpus mucronatus*	Cyperaceae	3	3.00	1	33.33
16.	*Eleocharis fistulosa*	Cyperaceae	7	7.00	1	14.29
17.	*Ottelia alismoides*	Hydrocharitaceae	9	9.00	0	0
18.	*Commelina bengalensis*	Commelinaceae	12	12.00	0	0
19.	*Alternanthera sessilis*	Amaranthaceae	3	3.00	0	0
20.	*Colocasia antiquorum*	Araceae	7	7.00	0	0
21.	*Azolla pinnata*	Azollaceae	9	9.00	0	0
22.	*Lemna perpusilla*	Lemnaceae	13	13.00	0	0
23.	*Nymphea stellata*	Nymphaeaceae	5	5.00	0	0
24.	*Ceratophyllum demersum*	Ceratophyllaceae	2	2.00	0	0
25.	*Ludwigia parviflora*	Onagraceae	4	4.00	0	0
26.	*Herpestris monniera*	Scrophulariaceae	7	7.00	0	0
27.	*Eclipta alba*	Compositae	1	1.00	0	0
28.	*Struntium paragynophra*	Cyperaceae	2	2.00	0	0
29.	*Aponogeton natans*	Aponogetonaceae	4	4.00	0	0
30.	*Lemna* sp	Lemnaceae	2	2.00	0	0

NS : Number of habitats with a given plan species
PS : Number of habitats with a given plant species for *Mansonia* immatures stages

The species of *Mansonia* mosquitos supported by different plant species were also analysed and it was found that grasses such as *H. aristata, I. miliaceae, S. interrupta, Ma. vaginalis, C. thalictroides* and *A. longifolia* supported all the three species of *Mansonia* that are prevalent in this region (Table 3). These plant species can be considered as host plants with less species specificity. Except these plants, all other plants that had considerable larval density were found to harbor larvae of *Ma. uniformis* in more numbers than the other two species. *Ma. indiana*, the least abundant species in this area (Sabesan *et al*, 1991) was found to be supported by 50% of the natural host plants recorded. However, intensity of the immatures was relatively lower. These observations suggest that a wide range of host plants naturally support the breeding of *Ma. uniformis* (93.75%). The proportion of plant species supporting the breeding of *Ma. annulifera* (62.5%) is significantly ($p = 0.041$) lower when compared to *Ma. uniformis*. In spite of this, *Ma. annulifera*

Table 2

Natural hospitability index and *Mansonia* host-plant index for different aquatic plant species.

Sl No.	Plant species	NS	PS	ALP	NHI	MHI
1.	*Monochoria vaginalis*	28	14	18.2	9.10	2.548
2.	*Isachne miliaceae*	27	17	14.6	9.19	2.482
3.	*Hygrorhiza aristata*	5	4	51.2	40.96	2.048
4.	*Ceratopteris thalictroides*	18	9	9.9	4.95	0.891
5.	*Sacciolepis interrupta*	4	3	24.3	18.23	0.729
6.	*Leersia hexandra*	2	2	17.5	17.50	0.350
7.	*Asteracantha longifolia*	13	5	5.9	2.27	0.295
8.	*Ipomoea aquatica*	10	4	2.5	1.00	0.100
9.	*Jussiaea repens*	7	4	2.2	1.26	0.088
10.	*Marsilea quadrifoliata*	16	4	1.7	0.43	0.068
11.	*Limnophylla heterophylla*	10	2	1.5	0.30	0.030
12.	*Limnanthemum cristatum*	2	2	1.0	1.00	0.020
13.	*Ipomoea biloba*	5	1	1.6	0.32	0.016
14.	*Cyperus halpan*	4	1	0.9	0.23	0.009
15.	*Scirpus mucronatus*	3	1	0.3	0.10	0.003
16.	*Eleocharis fistulosa*	7	1	0.2	0.03	0.002

NS : Number of habitats with a given plant species
PS : Number of habitats with a given plant species positive for *Mansonia* immatures stages
ALP : Average number of larvae and pupae per unit area
NHI : Natural hospitability index
MHI : *Mansonia* host-plant index

remain to be the most abundant species (Sabesan *et al*, 1991) and this could be due to high survival of immatures of this species in its most preferred plant, *P. stratiotes* (Rajendran *et al*, 1993) which is the most prevalent floating hydrophyte in this area, than *E. crassipes*, the preferred host plant of *Ma. uniformis* and *Ma. indiana* (Rajendran *et al*, 1993). Such a wide range of host plants has already been reported for *Ma. uniformis* (Carter, 1950; Wharton, 1962).

Vector control indirectly through weed control either with herbicides (Chow, 1953; Chow *et al*, 1955) or by environmental methods (Hoedojo and Oemijati, 1972) or by integrated approach (Rajagopalan *et al*, 1990) including naturalistic methods (Panicker *et al*, 1991) has been demonstrated in different epidemiological situations. Situations where control tools are targeted to a particular plant species, as in the case of herbicides, information on the prevalence of alternative natural host plants will be useful so as to include accessory control tools to cover all the host plants. However, when the given choice of the control strategy covers a wide range of host plants of the vector mosquitos, the problem of vector breeding due to shifting to alternative hosts will not arise as is evident in Shertallai where the vector control is attempted through weed control using phytophagous fishes (Panicker *et al*, 1992) and environmental (deweeding) measures (Anonymous, 1992).

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Table 3

Species composition of *Mansonia* determined from larval samples isolated from different plant species.

Sl No.	Plant species	Total larvae	*M.a*		*M.u*		*M.i*	
			No.	%	No.	%	No.	%
1.	*Monochoria vaginalis*	395	117	29.62	271	68.61	7	1.77
2.	*Sacciolepis interrupta*	45	8	17.78	18	40.00	19	42.22
3.	*Marsilea quadrifoliata*	15	10	66.67	5	33.33	0	0.00
4.	*Ceratopteris thalictroides*	119	35	29.41	83	69.75	1	0.84
5.	*Limnophylla heterophylla*	8	0	0.00	4	50.00	4	50.00
6.	*Asteracantha longifolia*	31	6	19.35	22	70.97	3	9.68
7.	*Cyperus halpan*	7	0	0.00	5	71.43	2	28.57
8.	*Hygrorhiza aristata*	87	12	13.79	70	80.46	5	5.75
9.	*Leersia hexandra*	24	0	0.00	24	100.00	0	0.00
10.	*Ipomoea aquatica*	15	6	40.00	9	60.00	0	0.00
11.	*Jussiaea repens*	11	1	9.09	10	90.91	0	0.00
12.	*Eleocharis fistulosa*	1	1	100.00	0	0.00	0	0.00
13.	*Limnanthemum cristatum*	2	0	0.00	2	100.00	0	0.00
14.	*Scirpus mucronatus*	1	0	0.00	1	100.00	0	0.00
15.	*Isachnae miliaceae*	302	71	23.51	208	68.87	23	7.62
16.	*Ipomoea biloba*	5	0	0.00	5	100.00	0	0.00

M.a : Mansonia annulifera
M.u : Mansonia uniformis
M.i : Mansonia indiana

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