A long-term study on vector abundance & seasonal prevalence in relation to the occurrence of Japanese encephalitis in Gorakhpur district, Uttar Pradesh

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Background & objectives: Japanese encephalitis (JE) virus is an important cause of viral encephalitis in Gorakhpur district, UP. The area has been experiencing outbreaks of JE since 1978. No in-depth longitudinal studies have been carried out on the mosquito species, particularly JE vectors prevailing in the area. Entomological studies were carried out in the district in order to determine the species composition, relative abundance and seasonal prevalence of mosquitoes in relation to the incidence of JE.

Methods: Three JE affected villages were selected as study sites. Weekly visits were made to each village and mosquito collections were made in and around the pig enclosures and cattle sheds with the help of mouth aspirators, aided by flash lights at dusk.

Results: The overall mosquito population showed a bimodal pattern with short and tall peaks during March and September respectively. Based on the elevated density and infection with JE virus, Culex tritaeniorhynchus has been considered responsible for causing epidemics in the area. Cx. pseudovishnui, Cx. whitmorei, Cx. gelidus, Cx. epidesmus, Anopheles subpictus, An. peditaeniatus and Mansonia uniformis are suspected to have played some role in the epidemiology of JE in the region. JE cases were reported between August and November with the peak in October when the vectors population, particularly Cx. tritaeniorhynchus was on the decline.

Interpretation & conclusion: The results of the study indicate that Cx. tritaeniorhynchus, the most likely vector of JE together with other known vector species remained more active during the period of paddy cultivation. Integrated antilarval measures before the beginning of paddy irrigation may check the breeding of JE vectors in the paddy fields. It may prove beneficial in reducing the vector population during the JE transmission season.

Key words Culex tritaeniorhynchus - Cx. pseudovishnui - Gorakhpur district - Japanese encephalitis - JE transmission period - vector abundance - vectors of JE
undergone a lot of ecological changes in the form of construction of irrigation canals and small dams. The habitats have been modified for development of agriculture in the region which has resulted in the vast expansion of water bodies which support mosquito breeding. These environmental changes probably have triggered JE in the region. Information available on the mosquito species, particularly JE vectors prevailing in Gorakhpur district is scanty. Sixteen culicine species were recorded in 1961, but not in relation to the occurrence of JE. Nine species, including 5 JE vectors were documented while conducting entomological studies during the declining phase of the JE outbreak reported in 1985, however, this study provides little information on the endophilic behaviour of JE vectors. No detail information is available on the entomological aspect of JE in the district, which is known for its JE endemcity. In view of this, entomological studies were carried out in order to determine species composition, relative abundance and seasonal prevalence of mosquitoes in relation to the occurrence of JE in the district. The present paper reports the results of the study carried out from 1990 to 1996.

**Material & Methods**

**Description of the area:** Gorakhpur district has an area of about 3483.1 km² with a population of about 30.66 lakhs with an average density of about 880 persons/km². Paddy is cultivated during the monsoon season. Out of 410721 hectares of cultivable land, 154601 (37.64%) were under paddy cultivation (Gorakhpur district agriculture booklet 1990-91). The harvesting of paddy is completed by the middle of October, and wheat and gram are grown during the subsequent months. Sugarcane is an annual crop in the area. The year can be broadly divided into three seasons: summer (March to May), monsoon (June to September) and winter (October to February). The area receives a total annual rainfall varying from 807 to 1564 mm. Floods, water logging and formation of shallow ponds are annual features in the region.

**Mosquito collections:** Three villages viz., Bhathat under Bhathat Primary Health Centre (PHC) area, Kusmi-takia under Pipraich PHC area and Naharpur under Chargawan PHC area, were selected for regular mosquito collection. Each PHC covered more than one lakh human population. These study sites were chosen on the basis of past records of JE, presence of pigs and cultivation of paddy in the area. Weekly visits were made to each village and mosquito collections were carried out in and around pig enclosures and cattle sheds at dusk i.e., from 1915 to 2015 and 1750 to 1850 h during summer and winter respectively with the help of mouth aspirators, aided by torch lights. For monitoring mosquito population, this type of sampling method is considered superior quantitatively as well as qualitatively.

**Results**

A total of 271355 mosquitoes belonging to 48 species and seven genera were collected in 3032 man hours. Fourteen species formed 98 per cent of the total catch. In order of preponderance these were: Cx. quinquefasciatus (25.3%), Cx. tritaeniorhynchus (23.9%), Cx. pseudovishnui (10.9%), An. subpictus (10.7%), Mansonia uniformis (7.0%), An. peditaeniatus (4.9%), Cx. gelidus (3.2%), Cx. whitmorei (3.0%), Cx. epidesmus (2.1%), An. annularis (2.0%), An. vagus (1.5%), Aedes lineatopennis (1.4%), Cx. fuscoccephala (1.2%) and Armigeres subalbatus (1.0%). Percentages of some of the predominant species are shown in the Table. The remaining 34 species, which accounted for two per cent of the total catch were: An. aconitus, An. barbirostris, An. culicifacies, An. nigerrimus, An. pallidus, An. stephensi, An. varuna, An. tessellatus, Ae. albopictus, Ae. assamensis, Ae. indicus, Ae. jamesi, Ae. pallidostriatus, Ae. pampangensis, Ae. pipersalatus, Ae. punctifemoris, Ae. scatophagoides, Ae. taeniorynchoides, Ae. yusafi, Aedomiya venustipes, Cx. bitaeniorhynchus, Cx. cornutus, Cx. fuscatus, Cx. infusa, Cx. (lophoceraomyia) species, Cx. malayi, Cx. sinensis, Cx. sitiens, Cx. vishnui, Ma. annulifera, Ma. crassipes, Ma. indiana, Mimomyia chamberlaini and Mi. luzonensis.

**Seasonal population fluctuations:** The seasonal fluctuations in the general mosquito population
Table. Percentage of some predominant species of mosquitoes collected between 1990 and 1996 in Gorakhpur district, UP

<table>
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<tbody>
<tr>
<td><em>Culex tritaeniorhynchus</em></td>
<td>22.9</td>
<td>19.3</td>
<td>24.9</td>
<td>25.8</td>
<td>24.3</td>
<td>27.2</td>
<td>22.1</td>
</tr>
<tr>
<td><em>Cx. pseudovishnui</em></td>
<td>13.0</td>
<td>10.0</td>
<td>13.8</td>
<td>10.4</td>
<td>11.7</td>
<td>9.8</td>
<td>7.4</td>
</tr>
<tr>
<td><em>Cx. gelidus</em></td>
<td>3.6</td>
<td>4.3</td>
<td>2.7</td>
<td>3.0</td>
<td>3.2</td>
<td>1.7</td>
<td>4.2</td>
</tr>
<tr>
<td><em>Cx. whitmorei</em></td>
<td>3.6</td>
<td>1.9</td>
<td>2.4</td>
<td>4.6</td>
<td>1.3</td>
<td>2.2</td>
<td>3.7</td>
</tr>
<tr>
<td><em>Cx. quinquefasciatus</em></td>
<td>26.2</td>
<td>25.5</td>
<td>16.8</td>
<td>18.1</td>
<td>32.5</td>
<td>27.6</td>
<td>33.4</td>
</tr>
<tr>
<td><em>Anopheles peditaeniatus</em></td>
<td>2.9</td>
<td>4.6</td>
<td>4.2</td>
<td>6.4</td>
<td>3.7</td>
<td>6.2</td>
<td>6.0</td>
</tr>
<tr>
<td><em>An. subpictus</em></td>
<td>8.4</td>
<td>14.8</td>
<td>15.6</td>
<td>9.9</td>
<td>9.5</td>
<td>10.2</td>
<td>7.6</td>
</tr>
<tr>
<td><em>Mansonia uniformis</em></td>
<td>5.8</td>
<td>7.6</td>
<td>8.4</td>
<td>9.0</td>
<td>4.2</td>
<td>7.0</td>
<td>6.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>47660</td>
<td>34439</td>
<td>35337</td>
<td>50372</td>
<td>31234</td>
<td>36300</td>
<td>36013</td>
</tr>
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</table>

recorded during the entire study period are shown in Fig. 1. The combined mosquito population followed a bimodal pattern. A short early summer peak was observed in March mainly due to the high prevalence of *Cx. quinquefasciatus*. Later, a tall late monsoon peak was noticed in September chiefly due to the high density of *Culex tritaeniorhynchus*. The same seasonal pattern was observed in all the years except...
in 1994 where the second peak was recorded in October instead of September. The other culicine species such as *Cx. pseudovishnui, Cx. whitmorei, Cx. gelidus* and *Ma. uniformis* had also shown peak occurrence in September. The seasonal prevalence of some of the *Culex* species is shown in Fig. 2. Among the *Anopheline* species, *An. subpictus* and *An. peditaeniatus* showed high prevalence during July and September respectively.

During the JE transmission period, *Cx. tritaeniorhynchus* was the predominant species, constituting 32 per cent of the total catch. This was followed by *Cx. pseudovishnui* (16.3%), *Ma. uniformis* (11.0%), *An. peditaeniatus* (8.6%), *An. subpictus* (5.7%), *Cx. whitmorei* (5.0%), *Cx. gelidus* (5.0%), *Cx. epidesmus* (3.1%), and *Cx. fuscocephala* (1.7%).

**Epidemiological features:** A total of 885 JE cases were reported from the 20 PHCs of the district between 1990 and 1996 (JE cell, district hospital, Gorakhpur). The maximum number of cases (313) were registered in 1991. Nagar Mahapalika PHC was the worst affected and 142 JE cases were reported from this area followed by Chargawan (116), Pipraich (90), Sardarnagar (79), Bhatat (71), Jangal Kodia (37), Khorabar (36), Gaugaha (32), Kauri Ram (29), Bansgaon (28), Sahjanawa (28), Campierganj (27), Derwa (26), Piprauli (26), Brahmpur (25), Gola (24), Khajani (19), Uruwa (16), Belghat (13), Pali (12) and untraced (9). Generally, cases were reported between August and November with a peak in October. But during 1995 and 1996 cases were reported a little earlier i.e., in June and July respectively. During 1990, the epidemic prolonged up to December. Age-wise analysis revealed that the maximum number of cases occurred in children aged between 1 and 15 yr with the highest occurrence in the age group 6-10 yr. It was also observed that males were more affected than females. The epidemics were usually preceded by substantial rainfall followed by an elevation in mosquito population.

![Fig. 2. Seasonal abundance of *Culex* species.](image)
Discussion

The combined mosquito population showed two density peaks, one a short peak in March where *Cx. quinquefasciatus* contributed in large measure to the total density. The population of this species increases during March due to the availability of favourable breeding sites containing stagnant water polluted with decayed organic matter. Another tall peak was observed in September in which *Cx. tritaeniorhynchus* was the main contributor. This species is known to breed in paddy fields and its abundance is related to rice cultivation. In Gorakhpur, a single paddy crop is grown and as a result the majority of JE vectors have shown one peak in a year *i.e.*, in September. The occurrence of JE in the region was closely associated with this peak. Similarly, a peak of JE vectors was observed in the Kolar district of Karnataka where a single paddy crop was raised (NIV, unpublished data). But two peaks of JE vectors were recorded in the areas where double paddy crops were cultivated in South Arcot and Madurai districts of Tamil Nadu.

During the JE transmission period, *Cx. tritaeniorhynchus* was the most abundant species and constituted 32 per cent of the total collection. The major proportionate contribution of this species has been found to be a typical feature in several JE affected areas in India. *Cx. tritaeniorhynchus* has also been incriminated as a major vector of JE in India as well as in many countries of Southeast Asia. JE cases were first reported in August, coincided with the high density of mosquitoes, chiefly contributed by *Cx. tritaeniorhynchus*. Generally, the epidemics reached their peak during October, which coincided with a decline in the general mosquito population, particularly *Cx. tritaeniorhynchus*. Such a relationship between the epidemic and declining vector population has also been observed in Japan and this type of pattern was attributed to the differences in total and infected populations of vector species. Predominance of the vector species prior to the occurrence of the epidemic might hasten the enzootic infection and result in a large number of infected mosquitoes being present in the population. One isolate of JE virus was obtained from *Cx. tritaeniorhynchus* during the study period. In view of its abundance and large number of virus isolates that have been made in India and elsewhere in Southeast Asia, this species is likely to be a vector of JE virus in Gorakhpur district.

*Cx. pseudovishnui* was the second most abundant species encountered during the JE transmission period. This species is considered to be an important vector of JE in India and Sri Lanka.

*Cx. whitmorei* and *Cx. gelidus* were the other abundant species caught during the JE transmission period. *Cx. whitmorei* is considered to be a secondary vector of JE in India and Sri Lanka, where few isolates of JE virus have been obtained. *Cx. gelidus* has been recognized as the most important vector of JE in Sri Lanka, Thailand, Malaysia, Vietnam and Sarawak. But relatively few isolations have been made from this species in India and Sri Lanka. Recently, JE virus has been isolated from *Cx. gelidus* in Australia.

*Cx. fuscocephala* was also collected in appreciable density during the JE transmission period. This species is an efficient vector of JE in Thailand. Experimental transmission studies carried out in that country demonstrated its high vector efficiency. Isolations from field caught specimen have been reported from India and Sri Lanka. But vector competence studies on *Cx. fuscocephala* failed to prove its transmission capability though mosquitoes got infected with JE virus (NIV unpublished data). Hence, it seems that this species may differ in its susceptibility in different geographical areas. The other known vectors of JE in India *viz.*, *Cx. epidesmus*, *An. subpictus*, *An. peditaeniatus* and *Ma. uniformis* were also caught in good numbers during the JE transmission season. This suggests that all these species may be playing some role in the epidemiology of JE in the area.

*Cx. quinquefasciatus* was found to be the predominant species during the drier months of the year. A few isolates of JE virus have been made from this species in India and Vietnam but the species is regarded as a poor vector of JE.

Surface water bodies like ponds and tanks are the perennial breeding sources. Antilarval applications
of chemical larvicides (organophosphate), larvivorous fish Gambusia affinis and biological larvicides (Bacillus thuringiensis) to all the permanent water bodies before the commencement of paddy irrigation may check proliferation of breeding of Cx. tritaeniorhynchus as well as other JE vectors in the rice fields and may contain the vector population during JE transmission season.

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References


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