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Effects of rainfall and salinity increase on prevalence of vector mosquitoes in coastal areas of Alappuzha district, Kerala

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Abstract

Seasonal abundance patterns for Japanese encephalitis vectors along climatic variations were studied in the coastal areas of Alappuzha district from June 2012 to May 2013. A total of 10563 female mosquitoes belonging to eleven species were collected. *Culex gelidus* Theobald (50.04%), *Cx. tritaeniorhynchus* Giles (26.50%), and *Cx. sitiens* Wiedemann (7.55%) were found to be most common in these areas. *Cx. sitiens* females were collected from each sampling occasion from early monsoon season June to late summer May with a distinct peak in April at 7.18 electrical conductivity (EC). *Cx. sitiens* abundance increased rapidly when monthly salinity level consistently exceeded 7.76, occurring in March at 7.76 and April at 7.18 electrical conductivity (EC). While analyzing correlation of *Cx. sitiens* density with salinity and rainfall was significant. High density of *Cx. gelidus* was greatly influenced by total rainfall and it was found to be significantly correlated with Per Man Hour (PMH) (P<0.05), whereas salinity was inversely correlated with mosquito density (P<0.001). The abundance of *Cx. tritaeniorhynchus* was lowest in June (rainy season) and increased in October, with densities increasing sharply during summer season in April (83 PMH). During summer, due to increased salinity *Cx. sitiens* density increased. These areas may develop in to brackish and saline water populated by *Cx. sitiens*, which can be new vectors for Japanese encephalitis or West Nile virus in these areas.

Key words

Introduction

Mosquitoes (Diptera: Culicidae) are known to respond to a range of environmental conditions, including disturbance, which can have direct or indirect effects on their colonization events (Williams, 2006; Carver *et al.,* 2009a). In India, climate change represents an additional stress on ecological and socioeconomic systems that are already facing tremendous pressures due to rapid urbanization, industrialization and economic development (Sumana *et al.,* 2006). Mosquito borne diseases, like dengue, chikungunya, Japanese encephalitis and filariasis are major public and veterinary health and West-nile virus cases have been reported in Alappuzha district (Anukumar *et al.,* 2013). Japanese encephalitis outbreak has been occurred in many states (Thenmozhi *et al.,* 2013). Alappuzha is listed as highly vulnerable because maximum percentage of the population relies on agriculture, sensitive wetlands, lagoons and sandy beaches. The projected climate change scenario estimates that the atmospheric temperature across Kerala will rise by 2 °C by the year 2050 (SAPCC, 2014). Also, it is projected that if the sea level rises by one meter, 169 km² of the coastal region surrounding Kochi would be inundated.

Saline water intrusion in paddy fields has been reported from various parts of Kerala. The total area affected is estimated to be 68,011 ha. in the state and of it, the maximum area in which crop is badly hit is 33,306 ha. in Alappuzha district. During monsoon, floodwater passes through paddy fields and does a cleansing operation by removing saline in paddy fields (Padmakumar, 2013). Rain deficiency following the onset of summer in April/May may worsen the situation by increasing the salinity of water manifold. High salinity tolerance may be favourable for *Cx. sitiens* salinity tolerant species, a secondary vector of Japanese encephalitis disease in Srilanga and a common coastal species in Australia (Ramasamy and Surendran, 2012; Carver *et al.,* 2009a). *Cx. sitiens* is widely distributed in mangrove forest and other areas of Kerala (Rajavel *et al.,* 2006; Jomon *et al.,* 2009).

Among the potential effects of climate change on human health, the impact of vector borne diseases has attracted increasing attention in recent years. Kerala is a suitable place to carry out studies on mosquito and mosquito-borne diseases, since warm temperature and rainfall in the area favor the development and survival of mosquitoes and humans are heavily exposed to mosquito biting. Moreover, Kerala not only holds high biodiversity of mosquitoes, but has nearly half of its population living and working in coastal areas and maintaining close contact with Sea, creating situation for epidemiological process. Though being aware of the presence of climatic disturbance in Kerala, data about the potential of mosquito abundance and their distribution in connection with climate change is meagre. Hence, the proposed study was carried out to establish baseline distribution of mosquito abundance and their distribution.

Materials and Methods

Alappuzha is a district with the Arabian Sea on the west, a vast network of backwaters, lagoons and fresh water rivers crisscrossing the land. The district receives an average rainfall of 2965.4 mm and has a coastline of 82 km. The general elevation of the area is less than 6 m above mean sea level with some parts of the area below mean sea level in the range of 1-2 m. It represents low-lying deltaic region characterized by wet lands.

Mosquito sampling : Adult mosquitoes were collected at fortnightly intervals from the four sites, near the coastal line, within a maximum distance of 5 km from June 2012 to May - 2013. Adult mosquito catch was made from resting on vegetation, walls of cattle sheds and human dwellings with the help of cell flashlight and oral aspirator equipped with flexible vinyl tubing and polystyrene vial during dusk hours (1900 hr to 2000 hr). The collected mosquitoes were identified to species level using a key prepared by Sirivanakarn (1976).

Meteorological data : Meteorological parameters like temperature, rainfall and relative humidity were obtained from the Meteorological Department, Trivandrum. Salinity (EC) data was obtained from the Rice Research Station, Kerala Agricultural University, Alappuzha, Kerala.

Data analysis : Pearson correlation was calculated for three dominant species (*Cx. gelidus, Cx. tritaeniorhynchus* and *Cx. sitiens*) with weather variables such as rainfall, salinity and temperature using PASW statistics Version 18, 2009 SPSS Inc, SPSS (Hong Kong) Ltd.

Results and Discussion

A total of 10563 female mosquitoes, belonging to five genera and eleven species, were collected. Mosquito species such as *Cx. gelidus* (50.04%), *Cx. tritaeniorhynchus* (26.50%) and *Cx. sitiens* (7.55%) were found to be the most common in these areas, whereas other species like *Ar. subalbatus* (7.86%), *Ma. uniformis* (1.33%), *Ma. annulifera* (2.66%), *Ma. indiana* (1.29%), and other species were found to be <1% of the total mosquitoes collected. Among the entire mosquito species collected, *Cx. gelidus* and *Cx. tritaeniorhynchus* were reported to be the most important Japanese encephalitis vectors and during summer *Cx. sitiens* was the predominant species in nearby coastal area.

Cx. sitiens females were collected on each sampling occasion with a distinct peak in April. The density of *Cx. sitiens* varied from 0.5 to 57.6 per man hour density during various seasons of the study period. Seasonal abundance patterns of *Cx. sitiens* showed that peak abundance of females was greater in April at 7.18 EC level as compared to 0.06 and 0.07 EC level. At these low saline levels, first abundances were recorded during September 0.07 EC saline and then gradually, both saline and mosquito density increased. As illustrated in Fig.2, *Cx. sitiens* abundance increased rapidly when monthly salinity level consistently exceeded 7.76 EC, occurring in March at 7.76 EC and in April at 7.18 EC, respectively. This linkage indicated that heavy salinity was generally associated with increased summer *Cx. sitiens* abundance. Positive correlation between monsoon rainfall deficiency and summer abundance of *Cx. sitiens* was somewhat stronger. While analyzing correlation of mosquito density with salinity, it was found to be statistically significant ($P<0.01$). The average rainfall was negatively correlated with density of *Cx. sitiens* ($P<0.05$). This showed that abundance of *Cx. sitiens* females peaked during summer, reflecting low rainfall, higher salinity and declined gradually thereafter. *Cx. sitiens* have a broad salinity tolerance, and their abundance is positively associated with increasing salinity, irrespective of the variability in their abundance, due to standing water and rainfall (Gatton *et al.,* 2005; Jardine *et al.,* 2006; Carver *et al.,* 2009a, Surendran *et al.,* 2012). To date, no virus isolates have been obtained from *Cx. sitiens* in India, however, Japanese encephalitis virus isolation has been obtained from *Cx. sitiens*, collected from Malaysia (Jude *et al.,* 2012). Environmental changes, especially temperature and rainfall probably altered the abundance of *Cx. sitiens* mosquitoes (Gage *et al.,* 2008; Ramasamy *et al.,* 2011; Carver *et al.,* 2009b).

The mean number of *Cx. gelidus* per man hour density varied between 18 to 126 PMH during various season of the year. Abundance of *Cx. gelidus* occurred during the monsoon season July to November, corresponding with the period of rice cultivation. High density of *Cx. gelidus*, greatly influenced by the total rainfall, was found to be highly correlated with PMH ($P<0.05$) Fig. 1, whereas salinity was inversely correlated with mosquito density ($P<0.01$). It showed that *Cx. gelidus* population was strongly affected by the availability of suitable breeding habitats. *Cx. gelidus* population more abundant during the monsoon and post monsoon seasons due to availability of rain water. The

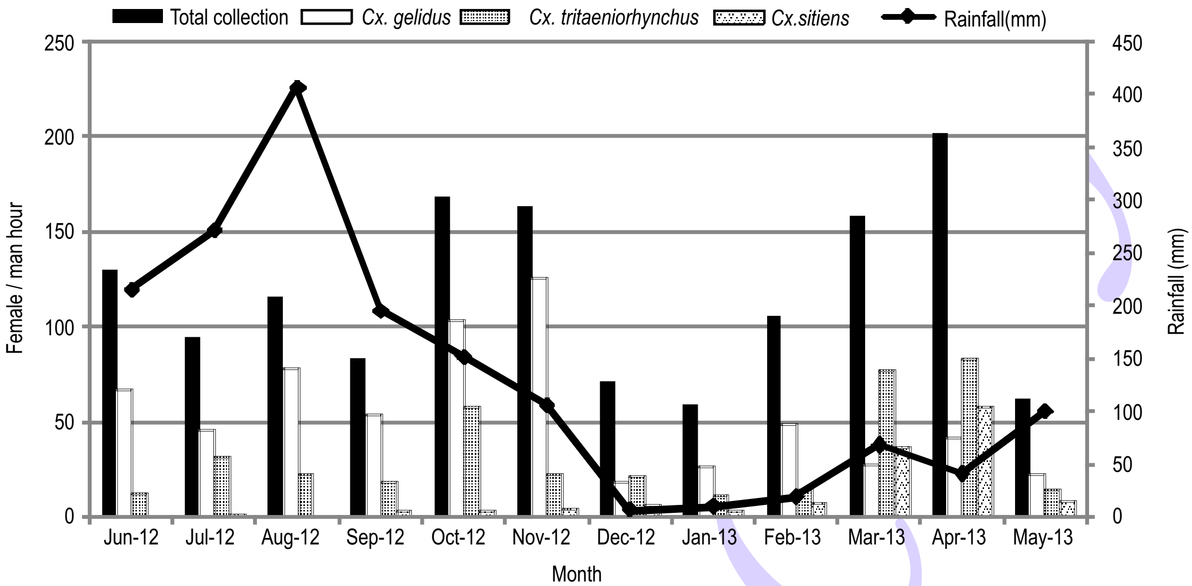

Fig. 1 : Relationship between (a) total density of mosquitoes; (b) *Cx. gelidus;* (c) *Cx. tritaeniorhynchus* and (d) *Cx. sitiens* and rainfall

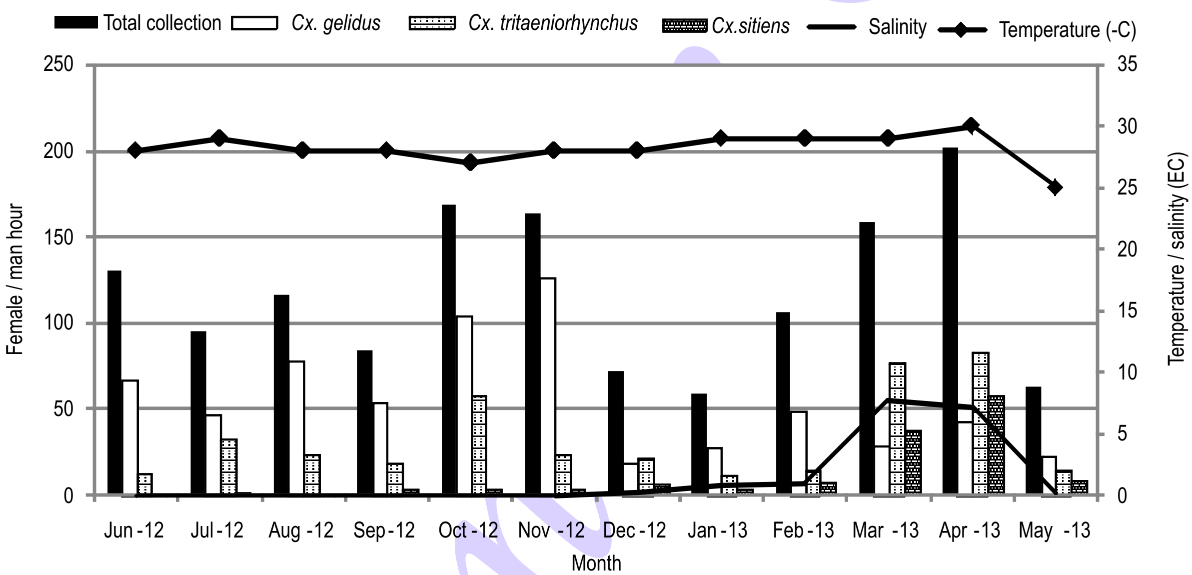

Fig. 2 : Relationship between average salinity value of ground water temperature (a) total mosquito density; (b) *Cx. gelidus;* (c) *Cx. tritaeniorhynchus* and (d) *Cx. sitiens.* Salinity was measured as electrical conductivity (EC)

abundance of *Cx. tritaeniorhynchus* was lowest in June, increased in October, and reached maximum in April (83 PMH) (Fig. 2). The increased corresponded with the period of rice cultivation. Monthly abundance of *Cx. tritaeniorhynchus* was not correlated with temperature or salinity (P >0.05). Japanese encephalitis in Kerala is considered to be mainly transmitted by *Cx. tritaeniorhynchus* and *Cx. gelidus* and occurrence of disease is associated with rice cultivation and piggeries with high incidence reported from the Kuttanad Wetlands of the district (Arunachalam *et al.,* 2009; Arunachalam *et al.,* 2004; Jude *et al.,* 2012). Since pigs are also reared in coastal areas of the district, there is a potential for *Cx. sitiens* to transmit Japanese encephalitis in the Alappuzha district. *Mansonia* species such as *Ma. annulifera, Ma. indiana* and *Ma. uniformis* were collected throughout the year. However, *Ma. annulifera* was more abundant than the other two species. The abundance of *Mansonioides* was not correlated significantly with any other meteorological parameters. *Ma. annulifera* was also found to be highly anthropophilic species in Kerala and was found to be a highly efficient vector of Malayan filariasis when compared with *Ma. indiana* and *Ma. uniformis* (Arunachalam *et al.,* 2004; Samuel *et al.,* 2004).

Seasonal variation in salinity of these lands showed that high level of salinity occurred during the summer months. This change increased densities of salinity-tolerant vector mosquitoes and led to the adaptation of freshwater vectors to breed in brackish and saline water (Ramasamy and Surendran, 2012). Higher vector densities can increase transmission of vector-borne infectious diseases in coastal localities, which can then spread to other areas (Ramasamy and Surendran, 2011). Some of these areas may develop salinity that would be inhabilated by *Cx. sitiens* and become a carrier of the virus. Since this area is endemic for Japanese encephalitis and West Nile virus, *Cx. gelidus* and *Cx. sitiens* may become a potential vector.

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