STUDIES ON THE MOSQUITO VECTORS OF JAPANESE ENCEPHALITIS VIRUS IN MANDYA DISTRICT, KARNATAKA, INDIA

G Geevarghese, AC Mishra, P George Jacob and HR Bhat

National Institute of Virology, 20-A, Dr Ambedkar Road, Pune-411 001, India

Abstract. Entomological investigations were carried out in areas affected by Japanese encephalitis (JE) in Mandya District, Karnataka, India, from 1983 to 1988, to determine species composition and the density of mosquito vectors, in relation to the incidence of JE cases. JE cases occurred in two spells in a year, one during April-June (summer epidemic) and another during October-December (winter epidemic). There was very high incidence of JE cases in extensively irrigated areas and a low incidence in some of the taluks with less or no irrigation systems. Among culicines, *Culex tritaeniorhynchus* was the most predominant species (20.54%), followed by *Cx. fuscocephala* (16.94), *Cx. vishnui* (16.48%), *Cx. gelidus* (10.70%) and other species. The overall mosquito population showed two peaks in a year, one during the March-April, and another during September, usually preceding the human epidemics. Relative abundance of certain species varied in different years.

INTRODUCTION

Among Japanese encephalitis (JE) endemic areas in India, Mandya District in Karnataka state is unique in having two seasons of epidemics, one during April to June and other during October to December (Mishra *et al,* 1984; Geevarghese *et al,* 1991). Outbreaks of JE of varying intensity have been occurring in Mandya District since 1979 with a major outbreak in 1983. Entomological studies were carried out in Mandya District from April, 1983 to December, 1988 to study the vector density and seasonal prevalence in relation to JE epidemics. The results of preliminary studies carried out during the initial 4 months, *ie,* April-July 1983, has been already reported earlier (Mishra *et al,* 1984). The present paper reports the results of the studies carried out during the entire period from 1983 to 1988.

MATERIALS AND METHODS

Description of the area

Mandya has a total area of about 4,961 km^2 with a population of about 14.14 lakhs with an average density of about 285 persons/km^2. It is divided into two sub-divisions : Mandya subdivision comprising Mandya, Maddur and Malavalli taluks; and Pandavapura sub-division comprising Srirangapatna, Nagamangala, Pandavapura and Krishnarajpet taluks. The Mandya sub-division is mostly irrigated by Vishweshwaraiah canal systems, from Krishnarajasagar reservoir on the Kaveri river. Pandavapura sub-division was comparatively dry during the initial stage of the study but was brought under irrigation recently via the east bank canal from Hemavathi dam in Hassan District, Karnataka State. The average rainfall in the district is 691.2 mm. South-west (June to September) and north-east monsoons (October to December) share 37.9% and 35.6% of the annual rainfall, respectively. The showers during the interventing periods contribute 26.5% of the total rainfall. Rice and sugarcane are the major crops. Usually 2 crops of paddy are cultivated, the first crop from March to June and the second from August to January. One of the largest wetland bird sanctuaries in the country is located at Ranganathittu in Srirangapatna taluk. In addition, breeding places of ardeid and other wetland birds are found in many localities in the district.

Mosquito collections

Four villages under Mandya sub-division, *viz* Hemmige, Madarahalli, Peehalli and Bevinahalli were selected for periodic mosquito collections. These localities had records of JE cases in earlier outbreaks. Regular fortnightly mosquito collections were carried out around animal sheds and hosts

tethered in the open during dusk hours with mouth aspirators and with the help of torch lights. This type of collection is considered superior quantitatively as well as qualitatively for monitoring the population (Mitchel and Chen, 1973; Mahadev *et al*, 1978; Mishra *et al*, 1984). A total of 4 man hour collections were made from each locality every fortnight.

RESULTS

In all 200,295 specimens representing 45 species were obtained by 1,120 man hour collections, with a man hour density (MPH) of 178.83. 98.29% of the total collection were represented by thirteen species as follows: 1. *Culex tritaeniorhynchus* (20.54%); 2. *Cx. fuscocephala* (16.94%); 3. *Cx. vishnui* (16.48%); 4. *Cx. gelidus* (10.70%); 5. *Anopheles peditaeniatus* (10.51%); 6. *Mansonia uniformis* (9.63%); 7. *An. subpictus* (4.33%); 8. *An. vagus* (3.92%); 9. *Cx. pseudovishnui* (2.53%); 10. *Cx. quinquefasciatus* (0.73%); 11. *An. culicifacies* (0.72%); 12. *An. nigerrimus* (0.64%); 13. *Aedes vexans* (0.62%).

Other species which constituted less than 0.5% of the catch were: 1. *An. barbirostris*, 2. *An. tesselatus*, 3. *An. aconitus*, 4. *An. pallidus*, 5. *An. annularis*, 6. *An. fluviatilis*, 7. *An. minimus*, 8. *An. varuna*, 9. *An. jamsii*, 10. *An. karwari*, 11. *An. stephensi*, 12. *Ae. linneatopennis*, 13. *Ae. pseudomediofasciatus*, 14. *Ae. pipersalatus*, 15. *Ae. jamesi*, 16. *Ae. vittatus*, 17. *Ae. albopictus*, 18. *Ae. unilineatus*, 19. *Cx. infula*, 20. *Cx. whitmorei*, 21. *Cx. bitaeniorhynchus*, 22. *Cx. minutissimus*, 23. *Cx. malayi*, 24. *Cx. fuscanus*, 25. *Cx. univittatus*, 26. *Cx. sitiens*, 27. *Coquillettidae crassipes*, 28. *Mimomyia luzonensis*, 29. *Mi. hybrida*, 30. *Armigeres subalbatus*, 31. *Ma. annulifera*, 32. *Uranotaenia recondita.*

Seasonal prevalence

The mosquito population in general showed two peaks of density in a year, one during March-April and another during September, preceding the epidemic (Fig 1). The same seasonal trend was observed in the mosquito catches of all the years except in 1983 during which the second peak was observed in November instead of September. Culicine species such as *Cx. tritaeniorhynchus, Cx. vishnui, Cx. psuedovishnui* and *Cx. fuscocephala* showed the above pattern in their seasonal activity

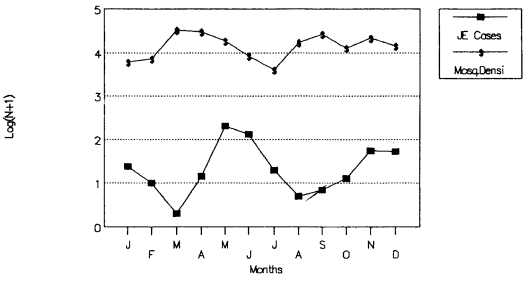

Fig 1—Mosquito populations and JE cases.

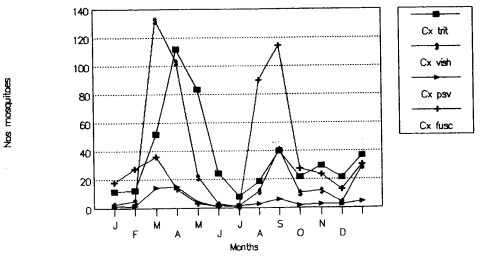

Fig 2—Seasonal prevalance of some culicines.

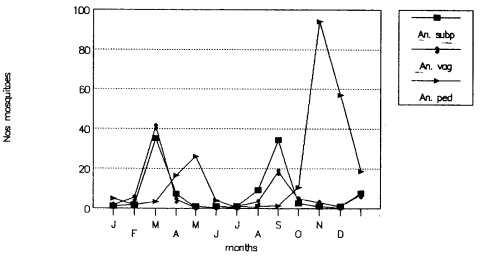

Fig 3—Seasonal prevalance of some anophelines.

(Fig 2). Similar pattern was also observed in certain anophelines such as *An. subpictus, An. culicifacies* and *An. vagus* (Fig 3). However, *An. peditaeniatus* and *An. nigerrimus* showed peaks later in May and October. *Ma. uniformis* which breeds mainly in puddles and ponds with aquatic vegetation was found having a stable population throughout the year with a peak in September month. The highest prevalence of *Cx. gelidus* was observed in July.

Mosquito species occurring in peak densities preceding the summer and winter epidemics were different. *Cx. vishnui* (38.63%), *Cx. tritaeniorhynchus* (15.14%), *Cx. fuscocephala* (10.46%) and *An. subpictus* (10.24%) occurred in peak densities during March whereas *Cx. fuscocephala* (38.38%), *Cx. tritaeniorhynchus* (13.46%), *Cx. vishnui* (13.85%) and *An. subpictus* (11.63%) occurred in peak densities in September. Peak density of *Cx.*

vishnui was in March, preceding by a month that of *Cx. tritaeniorhynchus.*

Encephalitis cases in humans

A total of 539 cases were reported during the period, the largest number of cases (233) were recorded in 1983. Maddur (266 cases) was the worst affected taluk followed by Mandya (177 cases) and Malavalli (65 cases) taluks. Nagamangala (15 cases), Srirangapatna (5 cases), Pandavapura (2 cases) and KR Pet (1 case) taluks reported fewer cases (table 2). The incidence of JE cases showed two peaks in a year, one during April-June and another during October-December, the former having more cases. Each peak was generally preceded by a spurt in the vector population (Fig 1).

DISCUSSION

The whole Mandya District was considered to be a dry area before the introduction of Vishveshwaraiah canal system in the early 1930s, which gave an irrigation coverage of approximately 83% of the total irrigated area in the district (Rao, 1981). The network of canals has provided assured irrigation resulting in large scale cultivation of paddy and sugarcane. This has created vast expanse of water bodies for the breeding of mosquitos in the form of paddy-fields, tanks, seepage swamps, numerous ground water pools, etc which appears to have resulted in the increased incidence of mosquito-borne diseases. Rao (1981) had already reported an increase in the incidence of malaria cases in Mandya District when the canal system was

Table 1

Frequency (%) of some predominant mosquito species in different years.

Species	1983	1984	1985	1986	1987	1988
Cx. tritaeniorhynchus	15.65	21.62	22.29	24.14	23.96	15.66
Cx. vishnui	16.09	16.15	14.31	13.81	21.93	19.32
Cx. pseudovishnui	3.66	2.98	2.72	1.59	1.68	1.49
Cx. fuscocephala	10.59	18.84	16.7	21.60	18.54	19.06
An. peditaeniatus	14.94	11.69	12.48	6.43	4.93	8.36
An. subpictus	8.43	2.35	3.20	2.85	4.95	3.99
Cx. gelidus	15.72	5.36	8.75	13.68	10.98	10.95
Total	40,494	41,994	40,742	29,835	24,646	22,581

Table 2

Taluk-wise incidence of JE cases in Mandya District from 1983 to 1988.

Taluk	1983	1984	1985	1986	1987	1988	Total
Mandya	86	5	37	20	18	11	177
Maddur	117	10	67	32	13	27	266
Malavalli	22	5	14	16	7	1	65
Nagamangala	5	3	2	3	2	-	15
Srirangapatna	1	1	2	-	-	1	5
Krishnaraj Pet	-	-	-	1	-	-	1
Pandavapura	-	-	-	2	-	-	2
Other	2	-	3	1	2	-	8
Total	233	24	125	75	42	40	539

initially introduced. During the present study mosquito population showed two density peaks in a year, one during March-April and another during September preceding the JE epidemics and coinciding with the seroconversions against JE virus in the sentinel pigs, reported earlier (Geevarghese *et al,* 1991). An earlier entomological study carried out before the JE activities were recorded in Srirangapatna taluk in 1970-71 had also shown high prevalence of mosquitos twice in a year, corresponding with two paddy crops (Soman, 1984). Eight isolations of JE virus were obtained during the present study from five species, *viz, Cx. tritaeniorhynchus, Cx. vishnui, Cx. gelidus, Cx. fuscocephala* and *An. peditaeniatus* (Mourya *et al,* 1989). All these species except *An. peditaeniatus* have been incriminated as the vectors of JE in other countries (Rosen, 1986). *Cx. vishnui* and *Cx. tritaeniorhynchus* were collected in good numbers throughout the epidemic seasons. Preponderance of these two species during the course of the epidemics has been found to be characteristic of the JE affected areas in many countries including India (Rosen, 1986; NIV; 1980). Isolation of JE from *Cx. fuscocephala* and *Cx. gelidus* which appear in large numbers preceding and epidemic incriminates them as the vectors. These species may be playing an important role in the enzootic cycle which usually precedes the epidemic because the peak densities of these mosquitos precede the epidemic. Krishnaraj Peth, Pandavapura, Srirangapatna and Nagamangala taluks showed a low incidence of JE cases. These taluks are comparatively dry with none or partial irrigation systems and limited paddy cultivation. It is obvious that the irrigation system plays an important role in increasing the mosquitogenic conditions and the resultant increase in mosquito-borne diseases in the study areas. The situations prevailing in the study area are comparable to that reported in Sri Lanka, Queensland and Brazil, where increased activities of arboviruses and malaria were observed subsequently to the introduction of irrigation systems. (Ramasamy *et al,* 1992; Smith, 1970; Degallier *et al,* 1989; Kay *et al,* 1990).

Entomological studies carried out in other JE affected areas in India such as North Arcot and Madurai in Tamil Nadu, Bankura in West Bengal and Kolar in Karnataka, have shown only one peak in the mosquito activity preceding the epidemic (NIV, 1980; Mani *et al,* 1991; NIV unpublished data). Mandya is therefore unique in having two spells of JE epidemic coinciding with two peak densities of the vector population.

ACKNOWLEDGEMENTS

The authors wish to thank Dr KM Pavri (former Director) and Dr K Banerjee, Director, for their encouragement during the study. The assistance rendered by the field staff of NIV field units at Kolar is also gratefully acknowledged.

REFERENCES

Degallier N, Travassos da Rosa APA, Herve JP, *et al.* Modifications of arbovirus-epidemiology in Tucurui, Para, Brazilian Amazonia, related to the construction of a hydroelectric dam. Arbovirus Research in Australia. Proc 5th Symposium 1989: 124-35.

Geevarghese G, Shaikh, BH, George Jacob P, Bhat HR. Monitoring of Japanese encephalitis virus activity using domestic sentinel pigs in Mandya district (India). *Indian J Med Res* 1991; 93 : 140-2.

National Institute of Virology, Pune Japanese encephalitis in India, Information document. 1980.

Kay BH, Barker-Hudson P, Piper RG, Stallman ND. Arbovirus disease and surveillance methodology related to water resource development in Australia. *Water Resour Devel* 1990; 6 : 95-103.

Mahadev PVM, Dhanda V, Geevarghese G, *et al.* Studies on the mosquitoes of Bankura District, West Bengal. Adult populations. *Indian J Med Res* 1978; 68 : 248-63.

Mani TR, Mohan Rao CVR, Rajendran R, Deveputra M, Prasanna Y, Hanumaiah A. Surveillance of Japanese encephalitis in villages near Madurai, Tamil Nadu, India. *Trans R Soc Trop Med Hyg* 1991; 85 : 287-91.

Mishra AC, George Jacob P, Ramanujam S, Bhat HR, Pavri KM. Mosquito vectors of Japanese encephalitis epidemic in Mandya district (India) (1983). *Indian J Med Res* 1984; 80 : 377-89.

Mitchel CJ, Chen PS. Entomological studies on the vectors of Japanese encephalitis. *Bull WHO* 1973; 49 : 247.

Mourya DT, Ilkal MA, Mishra AC, *et al.* Isolation of Japanese encephalitis virus from mosquitoes collected in Karnataka State, India from 1985 to 1987. *Trans R Soc Trop Med Hyg* 1989; 83 : 550-2.

The Anophelines of India. ICMR, New Delhi. 1981:

594.

Ramasamy R, Alwis RDE, Wijesundera A, Ramasamy MS. Malaria transmission at a new irrigation project in Sri Lanka. The emergence of *Anopheles annularis* as a major vector. *Am J Trop Med Hyg* 1992; 47 : 547-53.

Rosen L. The natural history of Japanese encephalitis virus. *Ann Res Microbiol* 1986; 40 : 395-414.

Soman RS. A report on the mosquitoes of Mandya district; an irrigated rice growing track of Karnataka. Oriental Entomolgy Symposium, Trivandrum, 1984: 43-8.