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Impact of season on filarial vector density and infection in Raipur City of Chhattisgarh, India

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Abstract

Background & objectives: Bionomics and transmission dynamics of vector population are profoundly influenced by local climatic conditions. The study monitored variations in density, infection and infectivity rates of *Culex quinquefasciatus* with respect to season in randomly selected localities of Raipur City of Chhattisgarh state.

Methods: The indoor resting density of *Cx. quinquefasciatus*, *Wuchereria bancrofti* infection and infectivity rates were monitored in Raipur City at regular monthly intervals for over a period of 12 months and the impact of meteorological conditions on transmission indices were assessed. The frequency distribution of different stages of filarial larvae in naturally infected vector population, host efficiency and transmission intensity index of the vector population was also worked out.

Results: The mean vector density of *Cx. quinquefasciatus* during the study period was 55.22 while the mean vector infection and infectivity rates recorded in Raipur were 4.05 and 0.25% respectively. A gradual increase in *Culex* infection rate was recorded from June onwards with a maximum (22.14%) in August and minimum (2.38%) in February. No vector with filarial infection was detected during December when the vector density was high. Analysis of frequency distribution of different stages of larvae revealed dominance of microfilarial stage with a mean larval intensity of 5.37. The highest infectivity rate was observed during June (1.15%) and the lowest was in March (0.41%). Both the infection and infectivity rates were at their low during winter season although the density of *Cx. quinquefasciatus* was at its maximum. Highest mean host efficiency of 0.44 was recorded in February. The annual transmission intensity index (TII) was 32.72. The highest TII was recorded during January and February months.

Interpretation & conclusion: The climate appeared to have profound impact on vector density, infection and infectivity rates. The vector infection and infectivity rates were high in rainy season followed by summer and winter seasons. The highest host efficiency was observed in winter followed by summer and rainy seasons. An apparent negative correlation was observed between vector infection rate and vector density. Lower temperatures (23–25°C) with low rainfall favoured progression of mf to L_3 in *Cx. quinquefasciatus* in the study region.

Key words *Culex quinquefasciatus* – density – infection – infectivity – seasonal variation

Introduction

Seasonal fluctuations of climatic conditions appear to influence parasite development and thus vector infection and infectivity rates. Very low or very high temperature is known to be detrimental not only for the mosquitoes but also to development of filarial larvae in the mosquito. In an experimental study on *Culex quinquefasciatus* (Diptera : Culicidae), it was noted that both temperature and relative humidity play a very important role in the transmission of *Wuchereria bancrofti* in man[1]. Samarawickrema *et al*[2] observed that the development of *W. bancrofti* larvae in *Aedes polynesiensis* took shorter time (12 days) in warm season than cool season (14 days). No vectorial transmission was observed when the temperature was above 37°C and relative humidity below 65% in Khurda district of Orissa[3]. There is no detailed study on impact of season on vectorial capacity of *Cx. quinquefasciatus* in Raipur available to date and hence the present study was designed to record monthly prevalence of *W. bancrofti* larval stages in naturally infected *Cx. quinquefasciatus* during different seasons of the year and evaluate host efficiency (HE) and transmission intensity index (TII) at Raipur City in central India.

Material & Methods

Study area: The study was conducted in Raipur City of Raipur district in Chhattisgarh state, India which is considered filarial low endemic zone. Raipur City lies between 19°57' and 21°55' N latitudes and 81° 25' and 83°38' E longitudes. The region has a typical monsoon climate. In general, the region is characterized by hot and dry summer season from March to mid-June, dry and cool winter season from November to February and rainfall is generally concentrated from mid-June to October. The housing pattern in the locality was mainly *kutcha*, *semi pucca* and *pucca* type. The analysis of residential densities at Raipur City has revealed average density of 416 persons per hectare which is rather high in relation to hot climate and the size of the city. The study area is not covered by sewage system. Six localities in Raipur were randomly selected for the present study and no specific control measures were undertaken by any agency during the study period.

Collection of mosquitoes: Indoor resting mosquitoes were collected at regular monthly intervals from selected localities of Raipur City for over a period of 12 months between October 1995 and September 1996. The collections were done regularly between 0600 and 0800 hrs using aspirator tube and torch light by a single person (first author) throughout the study period. All possible resting sites of mosquitoes inside the houses were searched spending 10 min in each of the six houses selected for the study from every locality. The identification of mosquitoes was done using the key of Barraud[4]. The mosquito species were scored, tabulated and subjected to detailed analysis, locality-wise. Only *Cx. quinquefasciatus* was retained and other species were discarded. The resting density was determined by dividing the total number of female mosquitoes collected by the total number of man-hours spent and expressed as number/man hour. Follow-up studies were done in March 1999 and March 2006.

Meteorological conditions: Weekly variations at maximum and minimum temperatures, humidity and rainfall in the region during October 1995–September 1996 were collected with the assistance of the Department of Meteorology at Indira Gandhi Agricultural University, Raipur.

Vector infection, infectivity, host efficiency and transmission intensity index: Each female *Cx. quinquefasciatus* collected from the field was dissected separately for presence of *W. bancrofti* larvae. The mosquitoes brought alive from the field were anaesthetized with ethyl ether; wings and legs were removed; head, thorax and abdomen were teased apart in normal saline and were examined carefully for several minutes under microscope for filarial larvae. The larvae recovered were identified and different stages of larvae were enumerated. The vector infection and infectivity rates were worked out at monthly intervals for each locality surveyed. All live *Cx. quinquefasciatus* in each collected lot were dissected out. Vector infection and infectivity rates[5], host efficiency[6] and transmission intensity index[7,8] were calculated using the formulae mentioned below.

$$\text{Infection rate (\%)} = \frac{\text{No. positive for } L_1, L_2 \text{ \& } L_3}{\text{No. of mosquitoes dissected}} \times 100$$

$$\text{Infectivity rate (\%)} = \frac{\text{No. of mosquitoes +ve for } L_3 \text{ stage}}{\text{No. of mosquitoes dissected}} \times 100$$

$$\text{Host efficiency} = \frac{\text{Mean No. of } L_3 \text{ larvae}}{\text{Mean No. of microfilariae}}$$

$$\text{Transmission intensity index} = \text{Vector density} \times \text{Vector infectivity rate} \times \text{Average no. of } L_3 \text{ per infective mosquito}$$

As a follow-up, the vector infection and infectivity rates in all localities were reassessed randomly once after a gap of few years. The statistical analyses (Chi-squared and correlation tests) of the data were carried out using Co-stat software.

Results

Variations in temperature, humidity and rainfall: The mean maximum and minimum temperatures (°C) for the year 1995–96 were recorded to be 33.31±0.73 and 20.33±0.76. The mean temperature increased from January and reached peak in May (43.58±0.37) with a downward trend from June onwards. The lowest mean temperature recorded was 12.15±0.67 in December (Fig. 1). The rainfall started rising from June onwards with a peak in July, accounting for 80% of the total rainfall. The total annual rainfall during 1995–96 was 1091.2 mm. (Fig. 1). The humidity increased from June (63%) onwards and with minor variations it remained constant at about 90% till the end of January. The humidity declined thereafter and

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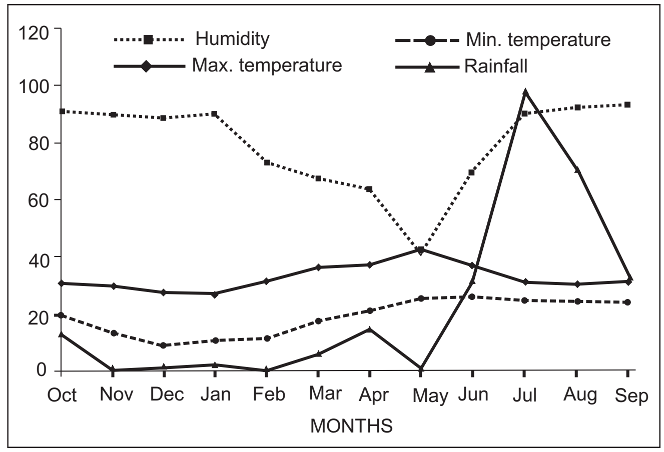

Fig. 1: Monthly variation in temperature, rainfall and humidity during the study period (Oct 1995–Sep 1996)

was minimum in May (40%) (Fig. 1).

Variation in vector density: The highest density of 162.67 was recorded in December and the lowest of 14.5 in June during 1995–96 (Table 1). The density was maximum in winter followed by rainy and summer seasons. Locality-wise, locality 1 recorded the highest average resting density as compared to locality 5 (Table 2).

Variation in vector infection rate: Monthly variations in vector infection and infectivity rates from each lo-

Table 1. Variations in vector density (No./man hour), infection and infectivity rate, host efficiency (HE) and transmission intensity index (TII) of indoor resting *Cx. quinquefasciatus* between October 1995 and September 1996

Month	Mosquito density	No. of mosquitoes dissected	Average L_3	Infection rate	Infectivity rate	Host efficiency	transmission intensity index
Oct'95	68.67	209	0	0	0	–	0
Nov	86.83	298	0	0	0	–	0
Dec	162.67	688	0	0	0	–	0
Jan'96	47.50	285	2	2.81	0.70	1.07	67.45
Feb	35	210	4	2.38	0.48	2.67	67.20
Mar	43	245	1	2.45	0.41	0.21	17.63
Apr	51.17	285	0	2.81	0	–	0.
May	20.67	118	0	0	0	–	0
Jun	14.50	87	3	4.59	1.15	0.69	50.02
Jul	40.50	239	3	10.50	0.42	0.51	51.03
Aug	40.17	241	2	22.41	0.83	0.27	66.66
Sep'96	52	308	0	6.49	0	–	0
Average	55.22	267.75	2.37	4.05	0.25	0.44	32.72

Table 2. Locality specific vector density (No./man hour), infection and infectivity rates, host efficiency (HE) and transmission intensity index (TII) of indoor resting *Culex quinquefasciatus* during 1995–96

Locality (No.)	Mosquito density	No. of mosquitoes dissected	Average L_3	Infection rate	Infectivity rate	Host efficiency	Transmission intensity index
Budhapara (1)	77.33	561	0	4.81	0	0	0
Fafadih (2)	39.33	472	3	6.36	0.21	0.39	24.78
Gudhyari (3)	55.75	586	2	4.27	0.17	0.53	18.95
Kankalipara (4)	52.92	524	2	3.44	0.38	0.71	40.22
Rajatalab (5)	49.83	569	1.5	2.64	0.35	0.46	26.20
Tikrapara (6)	56.17	501	3.5	2.99	0.40	0.49	78.64
Average	55.22	267.75	2.37	4.05	0.25	0.44	32.72

Table 3. Follow-up studies* on filarial infection and infectivity rates of the filaria vector *Cx. quinquefasciatus* in March 1999 & March 2006

Locality (No.)	March 1999			March 2006		
	Mosquito dissected	Infection rate	Infectivity rate	Mosquito dissected	Infection rate	Infectivity rate
Budhapara (1)	63	14.28	0	39	10.25	0
Fafadih (2)	41	12.19	0	42	4.76	0
Gudhyari (3)	55	10.90	0	30	13.33	0
Kankalipara (4)	53	11.32	0	20	10	0
Rajatalab (5)	65	9.23	0	35	5.71	0
Tikrapara (6)	43	6.98	0	54	9.26	0
Total	53.33	10.94	0	220	8.64	0

*Follow-up study was done only in the month of March.

cality are presented in Tables 1 & 2. The mean vector infection and infectivity rates in indoor resting *Cx. quinquefasciatus* during 12 months study period were 4.05 and 0.25%, respectively. The highest vector infection rate (22.14%) was recorded in August when mean maximum temperature was 30.38±0.52°C, humidity 93±0.82% and rainfall 57.53±24.74 mm. The lowest infection (2.38%) was recorded in February when rainfall was as low as 2.75±2.49 mm. No vector with filarial infection was detected during December which recorded the highest density of mosquitoes (Table 1). Season specific analysis revealed high vector infection in rainy season followed by summer and winter seasons (Fig. 2). Locality-wise, the highest vector infection was observed in locality 2 (6.36%) followed by locality 1 (4.81%), locality 3 (4.27%), locality 4 (3.44%), locality 6 (2.99%) and locality 5 (2.64%) (Table 2). The infection rates were low during winter season although vector density was at its maximum. Negative correlation was apparent be-

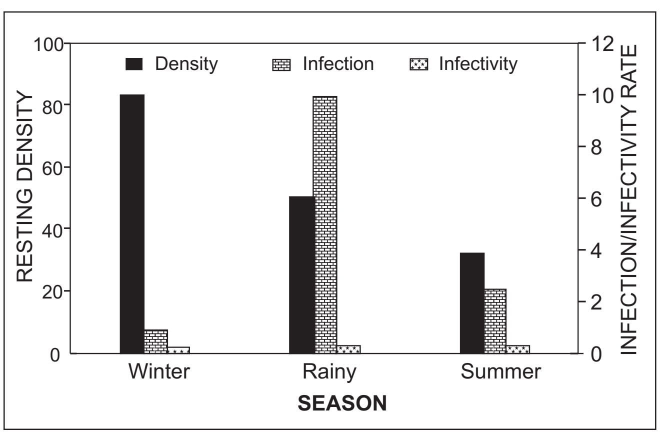

Fig. 2: Influence of season on vector density (No./man hour), infection and infectivity rates in indoor resting *Cx. quinquefasciatus* during 1995–96

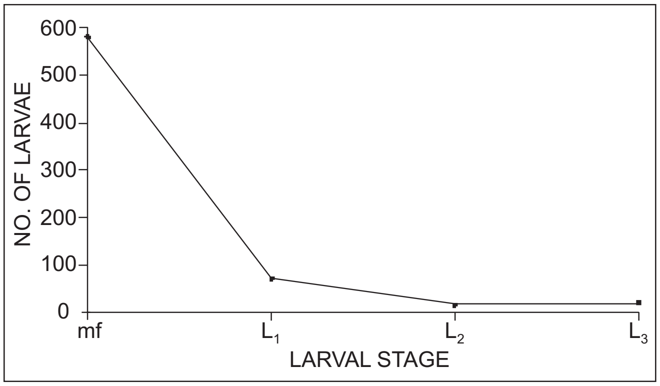

Fig. 3: Distribution of different stages of *W. bancrofti* larvae in naturally infected *Cx. quinquefasciatus*

tween infection rate and the vector density (Fig. 2). Monthly variation in vector infection rate shows significant relation with rainfall ($p < 0.01$) but not with humidity or minimum temperature. A significant rise in vector infection rate was recorded in subsequent follow-up studies in March 1999 and March 2006 (Table 3).

Variation in vector infectivity rate: Of the 130 *Cx. quinquefasciatus* recorded with filarial larvae over a 12 months initial phase of study, only eight mosquitoes showed L_3 stage larvae giving a mean infectivity rate of 0.25% (Table 1). The highest infectivity rate was observed in June (1.15%) when the mean maximum temperature was 38.03±2.06 ^oC and rainfall was 23.90±17.81 mm. The lowest was in March (0.41%) when rainfall was zero and mean maximum temperature was 37.27±1.55 ^oC. The infectivity rate was higher in rainy season followed by summer and winter seasons (Fig. 2). Locality-wise, the infectivity rate was highest in locality 6 and lowest in locality 3. Interestingly, infectivity rate was zero in locality 1 although considerably high vector infection rate (4.81%) and density were recorded from that locality (Table 2). Monthly variation in vector infectivity rate did not show any significant relationship with variations in rainfall, humidity and minimum temperature. Monthly variations in maximum temperature and vector density exhibited negative correlation ($p < 0.08$) with vector infectivity rate.

Frequency distribution of W. bancrofti larvae: A total of 685 *W. bancrofti* larvae were recovered from 130 naturally infected *Cx. quinquefasciatus* mosquitoes with a mean density of 5.27. The microfilarial stage dominated all other stages with a mean density of 5.37 (Fig. 3). The frequency of microfilariae in vector population ranged from 1–30. There seems to be a negative correlation between number of microfilariae recovered and mosquito frequency. The density of various other stages of filarial larvae also varied widely in infected vector population. The microfilarial density was in the order of L_1, L_2 and L_3 stages respectively (Fig. 3). The number of L_1 ranged from 1–10, while L_2 and L_3 ranged from 1–5 in infected populations of *Cx. quinquefasciatus*. Locality-wise, variations in infection and infectivity rate could be attributed to variation in microclimatic conditions.

Host efficiency index: The average host efficiency recorded was 0.44 with highest in February and least in March (Table 1). The highest host efficiency was observed in winter season followed by summer and rainy seasons. Locality-wise, the highest host efficiency was recorded from locality 4 (0.71) and the lowest from locality 2 (0.39) (Table 2).

Transmission intensity index: The annual TII during the study period was 32.72 with highest during January and February while the lowest in March (Table 1). Season-wise, higher TII was recorded in winter followed by rainy season. Locality-wise, the highest TII was recorded from locality 6 (78.64) and the lowest from locality 3 (18.95). Since locality 1 had no L_3 stages of *W. bancrofti*, TII is zero (Table 2).

Follow-up study after a gap of 3 yrs and 10 yrs revealed an average vector infection rate of 11 and 8.6% respectively. The highest figures were from locality 1 followed by 2, 4 and 3. The infection rate was significantly high in these localities as compared to initial figures at all the localities (Table 3).

Discussion

The prevalence and intensity of filariasis in human population is directly related to the entomological parameters such as vector infection, infectivity and biting density of infective vector population in the endemic area which in turn are influenced by variations in climate. Rainy season recorded the highest vector infection and infectivity rates although vector density was maximum in winter months. The June month, which recorded the highest infectivity rate, experienced temperature between 28 and 42°C, moderate to heavy rainfall and relative humidity of 63±15. Rainfall appears to be the main influencing factor of vector infectivity rate when both temperatures and relative humidity were favourable.

Distribution of developing filarial larvae in naturally infected wild caught *Cx. quinquefasciatus* revealed dominance of microfilarial stage as compared to advanced larval stages. Dash *et a1*[3] observed a high correlation between infectivity rate and per man hour density of mosquitoes, however, no such correlation was recorded in this study.

Host efficiency index was very high in January and February months when mean temperature was 23–25.3°C; rainfall 3–7 mm and relative humidity of 81 to 90%. The rainy season which showed high vector infectivity rate recorded relatively lower host efficiency. The temperature appears to exert some influence on host efficiency index when relative humidity is >60%. Lower temperatures (23–25°C) with minimum rainfall appear to favour progression of mf to L_3.

Rao *et al*[7] and Rao[8,] suggested a comprehensive and practical entomological parameter, the "Transmission Intensity Index" (TII) as an alternative to Annual Transmission Potential for measuring the transmission intensities. Winter months recorded higher TII as compared to rainy season in the present study.

Re-examination of vector infection and infectivity rates once again in March 1999 and March 2006 showed a significant rise in the incidence of filarial infection in vector population from all the localities as compared to those of 1996 ($p < 0.05$), but the infectivity rate was zero. This is probably due to examination only once during 1999 and 2006. A significant decline in vector infection rates was recorded in 2006 as compared to those of 1999 ($p < 0.05$) and this could possibly due to the administration of single annual dose of Di-ethyl-carbamazine (6 mg/kg body wt) to whole population in the year 2005 in Raipur City. However, re-examination of these vector parameters in all seasons is needed in order to make a logical conclusion. Further studies are needed to analyze all exogenous and endogenous factors that contribute to the rapid progress of infection in the endemic community.

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