TEMPORAL VARIATIONS IN BITING DENSITY AND RHYTHM OF *CULEX QUINQUEFASCIATUS* IN TEA AGRO-ECOSYSTEM OF ASSAM, INDIA

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Abstract. Temporal changes in the biting density and host-seeking periodicity of *Culex quinquefasciatus*, the vector of bancroftian filariasis, were studied for two years in the tea agro-ecosystem of Assam, India. Average biting density of the vector varied from 0.8/hour in December to 13.3/hour in March. Minimum temperature was found to have a limiting effect on the biting density of the vector mosquitos. Multiple regression analysis showed that the rainfall and minimum temperature were significant factors influencing biting density of this vector mosquito. The biting rhythm of *Cx. quinquefasciatus* was found to be nocturnal with two distinct peak periods of biting activity. The first peak was around 19.00 to 20.00 hours and the second peak period was around 22.00 to 23.00 hours. Biting activity however was seen throughout the night with declining trend as the night proceeded.

INTRODUCTION

Lymphatic filariasis is one of the major public health problems in Assam. According to the recent estimate, 10.59 million people in Assam are exposed to the risk of filariasis of which 9.51 million live in rural areas and 1.08 million live in urban areas. A total of 0.40 million are carrying microfilariae in their blood and 0.09 million are suffering from chronic disease (National Filaria Control Program, India, 1996, unpublished data). Filariasis in Assam is mostly localized among tea garden workers and is due to *Wuchereria bancrofti* transmitted by *Culex quinquefasciatus* (Basu 1957; Dutta *et al*, 1995).

Tea plantations are perennial agro-crops. To maintain and produce tea large stretches of land with different landscapes are used. The tea industry is a major agro-industry in Assam and employs a huge labor force for tea production who live inside the tea gardens in housing colonies called labor lines. To protect tea bushes from pests and weeds, pesticides and herbicides are frequently used in this ecosystem which is expected to influence the vector fauna and its behavior in tea gardens. The information on biting behavior of the vector is important to understand epidemiology of filariasis in a region. Studies pertaining to biting behavior of *Cx. quinquefasciatus* in urban and rural areas elsewhere are available (de-Meillon and Sebastian, 1967; Gowda and Vijayan, 1993; Rajagopalan *et al*, 1977). However, studies pertaining to the biting behavior of *Cx. quinquefasciatus* in the tea agro-ecosystem is lacking. This study was initiated to: (1) investigate temporal changes in the biting density of *Cx. quinquefasciatus* in filaria endemic tea agro-ecosystem; (2) examine the role of meteorological factors in modulating seasonal variation in biting density of this vector; and (3) to find pattern of vector biting rhythm.

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MATERIAL AND METHODS

Study area

Studies were carried out in the state of Assam located in the northeastern region of India. Two tea gardens which are endemic for filariasis were selected in Dibrugarh district (94°45'-95°45' E and 27°15'-27°75' N). The region is characterized by absence of dry hot summer and receives high and widespread rainfall due to the southwest monsoon throughout the year. Relative humidity remains high throughout the year. Mean daily maximum temperature during this period ranged from 21.4 to 34.3°C and minimum temperature varied from 8.6 and 24.7°C.

Mosquito collection

Between September 1995 and August 1997, hourly indoor human bait collections were made on 24 nights. A local volunteer or a member of the study group acted as a bait. The volunteers were fully informed about the procedure and informed consent was obtained. Capture sessions extended from 18.00 to 06.00 hours inside a living room having a quiet environment. All the mosquitos landing on the bait were promptly collected by two trained collectors using mouth aspirators. Collectors were changed every 6 hours.

All female *Cx. quinquefasciatus* collected from indoor human baits were dissected for parity. Their ovaries were studied using standard techniques and graded as per Christopher stage 1, stage 2, stage 3 and stage 4 (WHO, 1975; Detinova, 1962).

Data on meteorological parameters were collected for the entire study period from the Toklai Tea Research Center at Dikom, which is located near the study gardens.

Data analysis

Statistical techniques were used to evaluate the role of environmental factors modulating and influencing temporal variations in biting density of adult female *Cx. quinquefasciatus*. Prior to analysis the average hourly biting densities of different months were transformed to log (biting density+l) to achieve linearity and to stabilize variance. Simple and multiple regression models were used to assess the role of each independent variable. In multiple regression analysis linear, quadratic, cubic and interactive combinations of variables were used to understand the effect of independent variables on the vector biting density.

RESULTS

Biting density

Temporal variations in monthly biting densities of *Cx. quinquefasciatus* are shown in Fig 1. Average biting densities in different months varied from 0.8/hour in December to 13.3/hour in March. Average monthly biting density per man per hour during the study period was found to be 5.2 (Table l). Minimum temperature was found to have significant curvilinear relationship with whole night biting density (r = 0.60; F = 6.0; p = 0.01). However maximum temperature did not seem to influence the monthly biting densities significantly. Temporal changes in the rainfall and biting density showed significant non-linear relationship which was best explained by a cubic regression model ($R^2 = 0.367$; F = 3.874; p = 0.0246). Multiple regression analysis showed that the rainfall of the current month along with average monthly minimum temperature were found to be most significant factors ($R^2 = 0.633$; F = 7.753; p = 0.0008; Table 2) influencing biting density of the vector.

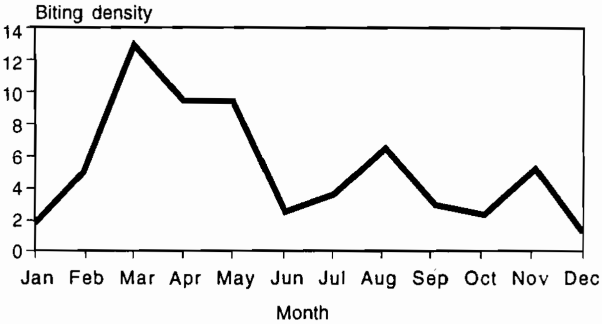

Fig 1–Graph showing monthly variations in the biting density of *Culex quinquefasciatus* (per hour per man) in tea agro-ecosystem of Assam, India (based on 2 years data of 24 whole nights).

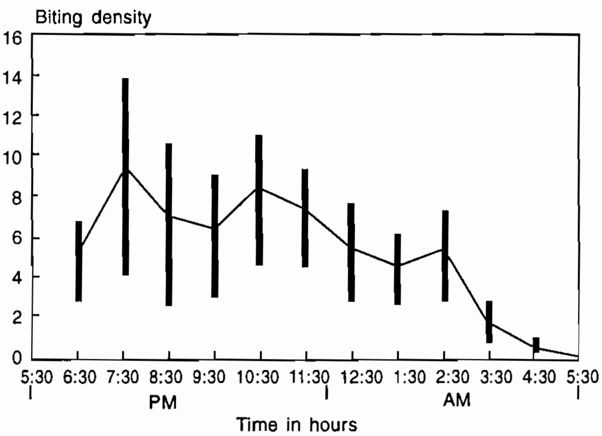

Fig 2–Biting rhythm of *Culex quinquefasciatus*. The graph shows mean biting density in different hours of night along with 95% CI based on 24 whole nights in different months.

Biting rhythm

The indoor biting rhythm of *Cx. quinquefasciatus* based on 24 whole nights is plotted in Fig 2 and shows a mean biting density with 95% confidence interval at different hours of night. The biting rhythm was found to be nocturnal with increased activity in the first quarter of the night. It showed two distinct peak periods of biting activity, one in the early hours of the night (19.00-20.00 hours) another at 22.00 to 23.00 hours. However, biting activity was spread through all quarters of the night with decreasing trend as the night proceeds. The mean biting density per man in different hours of

Table 1
Monthly hourwise whole night human biting *Cx. quinquefasciatus* in tea garden during September 1995 - August 1997.

Month/Year	Hours													
	18-19	19-20	20-21	21-22	22-23	23-24	24-01	01-02	02-03	03-04	04-05	05-06	Total	Biting density
1995														
September	7	6	2	2	1	4	6	4	3	1	0	0	36	3
October	1	7	2	6	4	5	0	0	1	0	0	0	26	2.2
November	6	9	1	6	14	5	5	7	2	4	2	0	61	5.1
December	0	1	6	1	1	1	1	0	0	0	0	0	11	0.9
1996														
January	0	3	4	0	2	6	4	4	0	0	0	0	23	1.9
February	6	1	8	11	9	9	8	4	2	2	0	0	60	5
March	0	44	35	26	27	19	2	3	3	0	0	0	159	13.3
April	10	8	8	2	19	12	17	13	20	6	1	0	116	9.7
May	13	15	8	9	10	15	12	13	10	6	3	1	115	9.6
June	0	2	1	7	2	2	2	5	8	1	0	0	30	2.5
July	8	8	3	2	5	5	2	2	8	2	0	0	45	3.8
August	10	12	8	3	11	10	6	4	13	2	0	0	79	6.6
September	4	5	4	0	2	4	5	3	2	0	0	0	29	2.4
October	4	5	1	7	5	0	0	5	1	0	0	0	28	2.3
November	4	10	2	5	15	4	10	3	6	2	0	0	61	5.1
December	0	1	4	2	1	0	1	0	0	0	0	0	9	0.8
1997														
January	0	3	2	0	3	7	3	4	0	0	0	0	22	1.8
February	5	2	7	11	9	9	9	3	3	1	0	0	59	4.9
March	0	42	36	25	23	19	0	2	1	0	0	0	148	12.3
April	12	7	7	5	15	10	21	14	12	7	0	0	110	9.2
May	12	15	12	8	9	15	8	10	11	7	2	1	110	9.2
June	0	1	1	6	0	3	1	4	9	2	0	0	27	2.3
July	6	9	3	5	4	3	3	0	7	1	2	0	43	3.6
August	12	10	3	5	11	11	8	5	10	2	0	0	77	6.4
Total	120	226	168	154	202	178	134	112	132	46	10	2	1,484	

Table 2
Regression model: biting density *vs* environmental parameters.

Independent variables	B	SE-B	Beta co-eff	R	R^2	F-value	p-value
Rainfall	0.037967	0.010881	2.75912	0.795	0.633	7.753	p=0.0008
Rainfall square	-4.65E-04	1.51E-04	-1.97966				
Tmin	0.215714	0.05477	4.52677				
Tmin square	-0.0071	0.001601	-5.2184				
Constant	-1.0684	0.442911					

Tmin=average monthly minimum temperature
Note: Dependent variable transformed to log (biting density+1)
Sampling period is 2 years (September 1995- August 1997.

Table 3
Monthwise parity status of biting *Cx. quinquefasciatus* collected from human bait in tea agro-ecosystem (pooled data of 2 years).

Month	N.P.	Parous	%Parous	P1	P2	P3	P4	Total
January	16	29	64.4	18	9	1	1	45
Februry	44	75	63	49	24	2	0	119
March	143	164	53.4	116	42	5	1	307
April	116	110	48.7	79	29	2	0	226
May	122	103	45.8	75	25	3	0	225
June	22	35	61.4	27	7	1	0	57
July	34	54	61.4	39	12	3	0	58
August	89	67	40.6	45	15	7	0	156
September	38	27	41.5	19	7	1	0	65
October	26	28	51.9	20	7	1	0	54
November	50	72	59	50	19	1	2	122
December	8	12	60	7	4	1	0	20
Total	708	776	52.3	544	200	28	4	1,484

N.P. =Nulli parous; P1 = One parous; P2 = Two parous; P3 = Three parous; P4 = Four parous

night ranged from 0.08 (95% CI 0.05 to 0.21) to 9.42 (95% CI 4.26 to 14.57). In the present study an attempt has been made to depict the variations in the biting rhythm of *Cx. quinquefasciatus* in different months using a contour map (Fig 3). It can be seen from this figure that most of the biting takes place in the first quarter of night and also maximum biting density was in the months of March, April and May in both the years whereas during other months of the year the biting was patchy. Host seeking behavior of *Cx. quinquefasciatus* was studied by using human and animal baits. Both indoor and outdoor biting activity showing similar trend. However, outdoor biting was very minimal. Cattle biting behavior of the vector was also negligible.

Age composition of host seeking *Cx. quinquefasciatus*

Parous rate of host seeking *Cx. quinquefasciatus* varied from 40.6% during August to 64.4% in January. Parity rate remained high during winter months but nulliparous mosquitos dominate the biting population in rainy summer months. Overall parity rate was 52.3% of which 36.7% were belonging to 1 parous and 13.5 to 2 parous. 4 parous *Cx. quinquefasciatus* were only seen during November, January and March (Table 3). Biting densities of nulliparous mosquitos reached the peak during early hours of night (between 19.00 to 20.00 hours) and started declining as the night progressed, but the biting density of parous mosquito built gradually to

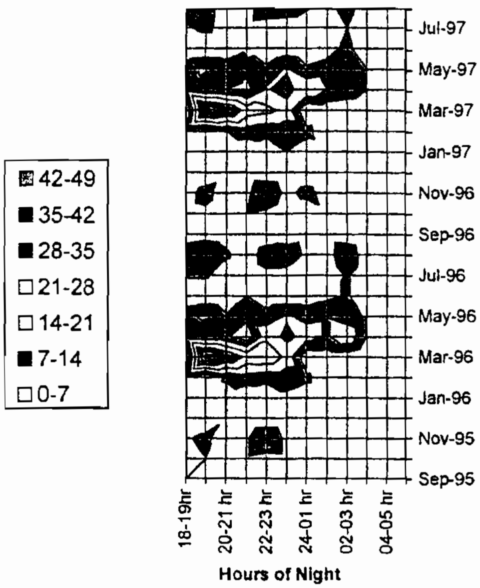

Fig 3–Contour map showing patterns of variations in biting density of *Culex quinquefasciatus* in different hours of night during different months of the 2-years' study period in the tea agro-ecosystem of Assam, India.

reach the peak around 22.00 to 23.00 hours and were sustained at a comparatively higher density till the third quarter of night. Mosquitos belonging to 1-parous and 2-parous were found in all quarters of the night. However, 3-parous were limited to the first three quarters of the night and the 4 parous were limited to the third quarter of the night.

DISCUSSION

Highest density of host-seeking *Cx. quinquefasciatus* was seen in the months of March, April and May [12.8, 9.41 and 9.37/man/hour respectively (pooled data of two years)] followed by a declining trend in biting density towards the end of the year. There were two minor peaks in the months of August and November. In Mysore and Karnataka, Gowda and Vijayan (1993) observed a maximum biting density of *Cx. quinquefasciatus* in March (12.3/man/hour) and a minimum in July (4.9/man/hour). However in contrast to their study the minimum biting density in the present study was found to be 0.8/man/hour in the month of December. Minimum temperature in our study was probably a limiting factor. In contrast to our study Rajagopalan *et al* (1981) recorded the highest biting density (9.9) of *Cx. quinquefasciatus* in October and December and the lowest (2.2) in June in Pondichery. Maximum temperature did not seem to influence monthly biting densities significantly. However, rainfall showed curvilinear type of relationship with it.

The present study has revealed that *Cx. quinquefasciatus* in Assam has two peak periods of early night biting activity and this is in contrast to a single mid-night peak reported for the same vector from South India (Vanamail and Ramaiah, 1991; Gowda and Vijayan, 1993). Vanamail and Ramaiah (1991) used the harmonic wave model to estimate periodicity index and peak biting time of *Cx. quinquefasciatus*. However in our study the distribution of biting mosquitos in the different hours of night was not unimodal, therefore using a harmonic model for quantifying biting rhythm of *Culex* mosquitos in Assam is not appropriate . The first peak showed 15.2% biting followed by the second peak with 13.6% biting. There was another minor upswing with 8.9% biting during 00.02 to 00.03 hours. The early night peak was more prominent during cooler months and the second peak was more prominent during summer. Biting activity of *Cx. quinquefasciatus* in the study gardens extended almost throughout the night only during pre-monsoon and post-monsoon periods. During the month of December the biting cycle was found to be mostly limited to the first and second quarters of night. By and large there was no biting in the last hour of the night. In the present study it was found that both parous and nulliparous mosquitos showed almost similar biting rhythms in the first two quarters of the night. In the later half of night nulliparous density in biting population goes down early as compared to parous. On the other hand Gowda and Vijayan (1993) observed that nulliparous mosquitos increased from dusk to dawn but the parous mosquitos showed a decreasing trend.

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