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TRANSMISSION OF MALARIA IN DHEKIAJULI SUBDIVISION OF SONITPUR DISTRICT, ASSAM

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ABSTRACT

Epidemiological surveillance was made in Dhekiajuli sub-division of the Sonitpur district of Assam during 2004-2006. Two types of malaria parasites – *P. falciparum (Pf.),* and *P. vivax (Pv.)* were found. *Pv.* was observed through the year, while *Pf.* was not found in the winter months. On the yearly basis, SPR, SFR and *Pf* percentage were found in the ranges 15.8-33.3%, 10.3-28.2% and 50-100% respectively. API was found in the range of 31.6-75.2. Settlement category wise investigation revealed that the malariomatric indices were highest in forest villages (FV) followed by peripheral forest villages (PFV) and urban area (UA). Thus, the transmission of malaria gradually declined from forest villages to peripheral forest villages and then to the town area. FV suffered the most due to various reasons such as – more abundance of malaria vectors, more infectivity of malarial vectors and poor socioeconomic conditions. The seasonal variations of the malariomatric indices showed single peak model, the peak being in the monsoon season.Effect of malaria was found to be considerably low during winter and early summer. Thus, it has been observed that the monsoon environment is favourable for the multiplication and transmission of malaria in the study areas.

Key words: Malariomatric Indices, Dhekiajuli, API, Seasonal variation

INTRODUCTION

Human malaria is caused by the parasite *Plasmodium* and it is transmitted by the female mosquito vector *Anopheles*. The parasite entered into human blood at the time of biting by the infected vectors and the disease developed within few days in most of the cases. Sometimes, the parasite may be in dormant state in human blood, if the man has sufficient immunological resistance to the parasite.There are four types of human malaria, which are classified on the basis of the diseased caused due to infection of four different types of *Plasmodium parasites – P. falciparum (Pf.), P. vivax (Pv.), P. ovale (Po.)*and *P. malariae (Pm.).* Out of these four malarial types,the *Pf.* is the stable malaria in Northeast India, which causes 60-90% infection (Adhikari et al. 2013a). However, incidence of malaria due to *Po.* and *Pm.*, though few in numbers, have also been reported by Prakash et al. (2003) from Jorhat and Kamrup districts of Assam respectively. Preponderance and persistent transmission of *Pf.* make the region one of the hot-spots of malaria (Barkakati et al. 1992, Baruah et al. 2007). Focal outbreaks of malaria are common, especially in forest-fringed villages of Assam-Arunachal Pradesh border, which are occupied by new settlers. Outbreak of malaria in the Dhekiajuli subdivision of Sonitpur district was also reported time to time (Adhikari et al. 2013a).

The study area, Dhekiajuli subdivision of Sonitpur district of Assam belongs to Northeast India. The region is warm and wet having annual rainfall in the range 170-220 cm and temperature varying between 7^{o}C to 36^{o}C. Three categories of settlement areas - forest villages (FVs), peripheral forest villages (PFVs) and urban/ townarea (UA) are observed in the region. A mixed community including both ethnic and non-ethnic groups having diversified cultural habits and traits is observed in the region. The rural inhabitants are socio-economically poor and dependent on paddy cultivation and collection of forest produce for their survival. Most of the houses in the rural settlements are thatch or tin roofed and mud-plastered.

In this investigation, transmission of malaria was studied in three categories of settlement areas - forest villages(FVs), peripheral forest villages(PFVs) and urban/ townarea (UA). The FVs are well inside the forests and nearer to the Assam-Arunachal Pradesh border, while the urban area is towards the south and nearer to the river Brahmaputra. The PFVs are located in between the two categories of settlement area.

MATERIALS AND METHODS

Malaria data were generated by epidemiological surveyof the villages during 2004-2006. It was assumed that all malaria cases show fever. Blood smears were taken from people suspected of having malaria or those who were suffering from malaria. Active cases were detected by visiting house to house every two weeks and inquiring about fevers. Blood smears were prepared by pricing the finger (Sandra et al. 2014, Chotivanich et al. 2006).The tip of the ring finger of the left hand was first cleaned with a rectified swab and then pricked with the help of pricking needle. In case of toddlers, thumb of the foot was pricked for blood smears. For each person separate swab and needle was used.The first drop of blood was discarded and then the next two drops were collected on clean glass slides of sizes 75x25x1.2mm. Thesmears were collected about half an inch away from the edge of the slides and the smooth edge of another clean slide was used for their spreading. The thick smears were spread over an area of 50-90 mm^2, while the thin smearswere spread over an area of 250-450 mm^2. The slides were marked by code numbers and dried. Date of collection, name of the patient, age, sex, blood slide number, etc. wasrecorded simultaneously. The slides were taken to the laboratory for final examination.

Microscopy is still the gold standard for malaria diagnosis.

In this method, diagnosis of malaria is performed by staining thick and thin blood films on a glass slide to visualize the malaria parasite (Gilles and warrell 1993). In the laboratory, the slides were first treated with Leishman's stain. After 2 minutes the slides were washed with tap water, dried and then examinedunder compound microscope using 10X eye piece and 100X oil objectives. Thick smears were the first to be examined for about 100 fields per slide. After that thin smears were examined for detection of the parasites. All the species of malaria can be diagnosed by microscopy**.** In a properly spread slide the parasites if present tend to accumulate towards the tail end that were recorded.

Data Presentation and Analysis

Data collected and generated for the study were tabulated into the following categories – the total population under surveillance, the number of blood slides examined (BSE), the number of blood slides found positive for malaria (Mal +ve),

the number of blood slides found positive for *Plasmodium falciparum (Pf.),* the percentage of positives cases of *Pf.*(*Pf*%), the annual parasitic index (API), parity status or slide positivity rate (SPR), and slide *Pf.*positivity rate (SFR). The following equations were used for their calculation -

$$SPR = \frac{\text{Number of slides found positive}}{\text{BSE}} \text{ X } 100$$

$$SFR = \frac{\text{Number of Plasmodium falciparum}}{\text{BSE}} \text{ X } 100$$

$$Pf\% = \frac{\text{Number of Plasmodium falciparum}}{\text{Number of positive cases}} \text{ X } 100$$

$$API = \frac{\text{Number of positive cases}}{\text{Population of the study area}} \text{ X } 1000 \quad (in\ a\ year)$$

The yearly parasitic load is depicted by the SPR. The percentage of *Pf.*and *Pv.* depicts the distribution of the parasitic species in the area (other *Plasmodium* species are not reported in this area). Neither API nor SPR is an exact measure of malaria prevalence and therefore, both are taken into consideration for the study of malaria rates (Reid 2000).

RESULTS

Epidemiological surveillance was made in twenty two forest villages, three peripheral forest villages and two wards of Dhekiajuli town during the period 2004-2006.The population distribution of the villages and the urban area under surveillance are presented in Table I. During the study period, the total numbers of households were found to be increased from 500 to 824 in forest villages, 498 to 726 in peripheral forest villages and 1004 to 1101 in the two wards of the town. Similarly, the total population were increased from 3922 to 5305, 3403 to 4260 and 5592 to 6166 in the respective three categories of settlement areas.

Table 1: Number of households and population of the villages and the wards under study

Category	Name of villages	2004		2005		2006	
		HH	Population	HH	Population	HH	Population
Forest Villages	Galil No. 1	24	187	35	245	43	271
	2. Galil No. 2	19	147	25	175	28	191
	3. Bariguri	22	160	28	196	31	214
	4. Bersorao Bari	24	165	28	191	29	208
	5. Milanpur	20	151	28	193	32	213
	6. Samajuli	18	150	27	186	33	203
	7. Dhubjuli	21	166	28	194	32	215
	8. Chandanapur	19	152	28	196	36	209
	9. Gwatartungguri	28	196	35	245	42	259
	10. Baisantipur	20	155	28	196	36	215
	11. Ragiajuli	16	113	22	154	28	172
	12. Ransaipur	13	92	19	133	24	156
	13. Pakricubba	31	462	35	595	82	643
	14. Adulbari	19	143	25	175	29	208
	15. Jiaguri	23	156	28	196	35	225
	16. Bwhiti	48	348	59	413	68	457
	17. Jwerama	21	175	28	196	32	218
	18. Talarbari	27	129	35	145	41	163
	19. Kantalbari	18	133	22	151	27	169
	20. Asrabari No.2	21	170	28	196	34	217
	21. Sanajuli	18	158	26	181	34	197
	21. Sanajuli	18	158	26	181	34	197
	22. Jamuguri	30	214	38	252	48	282
	Total	**500**	**3922**	**655**	**4804**	**824**	**5305**
Peripheral Forest Villages	1. Bhelaguri	192	1315	237	1424	247	1528
	2. Sopai Baligaon	183	1221	232	1328	273	1474
	3. Jhargaon	123	867	158	1069	206	1258
	Total	**498**	**3403**	**627**	**3821**	**726**	**4260**
Urban Area	Ward No.2	586	3062	602	3215	623	3376
	Ward No. 3	418	2530	447	2657	478	2790
	Total	**1004**	**5592**	**1049**	**5872**	**1101**	**6166**

Village/Ward wise variation of Malariomatric Indices

During the epidemiological surveillance, 934 blood slides were collected from the inhabitants of forest villages during 2004. Among these blood slides, 183 were found to be malaria positive of which 58 were *Pv.* and 125 were *Pf.* In the year 2005, 1082 blood slides were collected from the same area out of which 249 slides were found to be malaria positive – 48 *Pv.* and 201 *Pf*. In 2006, 275 blood slides were found to be malaria positive out of 1256. Among them 57 were *Pv.* and 218 were *Pf*. Thus, only two types of malaria were observed in the forest villages of Dhekiajuli sub-division of the Sonitpur district of Assam.

The malariomatric indices were calculated for all the forestvillages and their range of variation are depicted in Table II. The names of the villages showing the maximum and the minimum values of the malariomatric indices are also shown in the table. During the three years of study period, the minimum and the maximum values of the indices were not observed in the same village except API. The minimum values of API were observed in Bwhiti village in all the three years, while the maximum values of API were observed in the villages Chandanpur,Ransaipur and Adulbari respectively. The range of variation of SPR, SFR and API was the highest during 2005, while the range of variation of *Pf*.% was the largest in 2004. All the four indices showed larger values during 2005 compared to other two years. API values indicate that the village Bwhiti was the least sufferer.

Table 2:Minimum and maximum values of malariomatric indices in the forest villages.

Malario-matric Indices	2004		2005		2006	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
SPR in %	15.8 (Adulbari)	23.5 (Jwrema)	19.4 (Samajuli)	33.3 (Dhubjuli)	18.6 (Milanpur)	25.5 (Dhubjuli)
SFR in %	10.3 (Ragiyajuli)	17.7 (Dhubjuli)	15.6 (Ransaipur)	28.2 (Dhubjuli)	15.2 (Galil No.2)	20.0 (Baisantipur, Dhubjuli)
Pf. in %	50.0 (Jwrema)	85.7 (Milanpur, Dhubjuli)	70.0 (Ransaipur)	100.0 (Samajuli)	70.0 (Galil No.2)	90.0 (Baisantipur)
API in %	31.6 (Bwhiti)	72.4 (Chandanpur)	33.9 (Bwhiti)	75.2 (Ransaipur)	32.8 (Bwhiti)	72.1 (Adulbari)

Village wise variations of the malariomatric indices in the forest villages for the study period as a whole are presented in Fig.1. It was found that SPR were in the range of 19-27% with highest transmission in Dhubjuli followed by Bariguri, Jwerama, Galil No.1, Bersorao Bari, Baisantipur, Jamuguri, etc. The lowest value of SPR was found for village Adulbari. Slide falciparum rate (SFR) ranged from 15% to 22%. The lowest and the highest were found for the village Bwhiti and Dhubjuli respectively. Milanpur and Samajuli had the highest *Pf*. (85%). API was found within the range of 30-70. It was found to be the highest for the village Adulbari followed by the villages Chanadanapur, Ransaipur, Talrbari, Kantalbari, Dhubjuli, etc. The lowest value of API was found for the village Bwhiti. Analysis of variance of API reveals that there were significant variations of API among the forest villages.

In the peripheral forest villages, blood slides collectedwere677, 916 and 1006 in the year 2004, 2005 and 2006 respectively, out of which 118, 176 and 177 were found to be malaria positive. *Pf.* cases were found to be 75, 133 and 126 in the three years respectively, while 43 *Pv.* cases were found in each of the year 2004 and 2005. The number of *Pv.* cases was 51 in the year 2006.

In the year 2004, a total of 1050 blood slides were collected from the two wards of Dhekiajuli town. 43 blood slides were found to be malaria positive. Among them 29 were *Pv*. and 14 were *Pf.* cases. A total of 1405 blood slides were collected in the year 2005, out of which 82 were found to be malaria positive. The *Pv.*and*Pf.* caseswere49 and 33 respectively. Out of 1412 blood slides, 87 were found to be positive in the year 2006. Among them 59 were *Pv.* and 28 were *Pf.* cases.

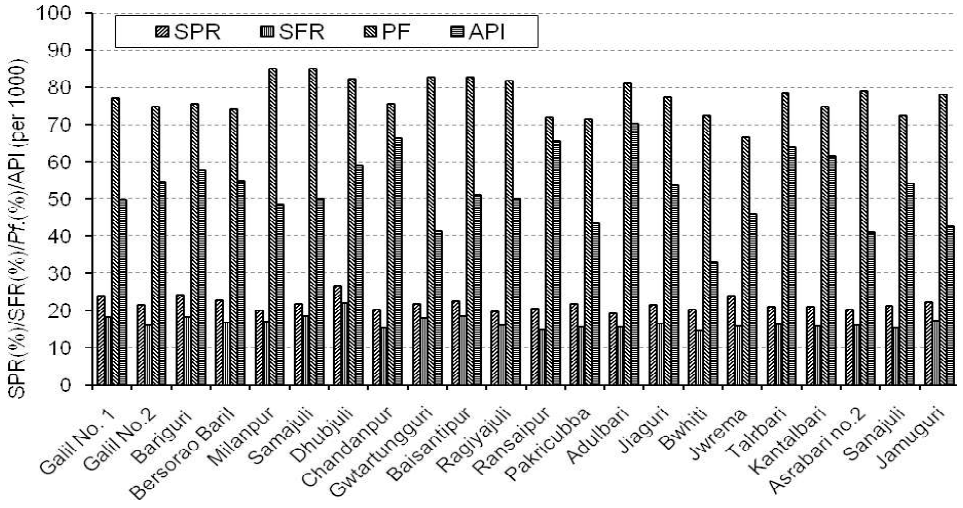

Fig.1: Village wise variation of SPR, SFR, Pf. and API in Forest villages (2004 - 2006)

Table-3 shows the village/ward wise variation of SPR, SFR, *Pf*.% and API in the peripheral forest villages and town area. There were no much variations of these parameters among the peripheral forest villages. However, API was found to be higher in Jhargaon compared to the other two villages. In the two wards of Dhekiajuli town, the values of the malariomatric indices were found to be significantly low compared to the peripheral and forest villages. Ward No.3 showed higher values of all the indices compared to Ward No.2.

Table 3: Values of malariomatric indices in the Peripheral Forest villages and in the Wards of Dhekiajuli town (2004 - 2006)

Village/Ward	SPRin %	SFRin %	*Pf*.in %	API(per 1000)
Bhelaguri	17.8	12.4	69.5	39.1
Sopai Baligaon	18.1	13.3	73.4	39.3
Jhargaon	18.5	12.9	69.9	45.7
Ward No.2	5.2	1.8	35.2	11.2
Ward No.3	5.8	2.1	35.6	13.0

Fig.2 shows the comparative accounts of variation of SPR, SFR, *Pf.* and API in forest villages (FV), peripheral forest villages (PFV) and Dhekiajuli town. Blood slides positivity rate clearly indicates that malaria transmission was highest in FV followed by PFV and the town area. SFR, *Pf*. and API also showed the same trend. Therefore, it can be concluded that the transmission of malaria gradually declined from forest villages to the peripheral forest villages and then to the town area. Thus, FV suffered the most due to various reasons such as abundance of vectors, more infectivity of malarial vectors and socioeconomic conditions. Adhikari et al.(2013a). observed that the percentage of anopheles mosquitoes were more in the forest and peripheral forest villages compared to urban area of the district. Species diversity and man-hour-density were also found to be higher inthe forest and peripheral forest villagescompared to the urban area. Infectivity study of the malaria vectors also revealed that more anopheles species were infected by malaria parasite in the forest and peripheral forest villages compared to the town area Adhikari et al.(2013a). Socioeconomic survey revealed that the people living in the forest and peripheral

forest villages had poor standard of living mostly with thatch houses, minimum clothing and without mosquito net giving more exposure to mosquitoes.

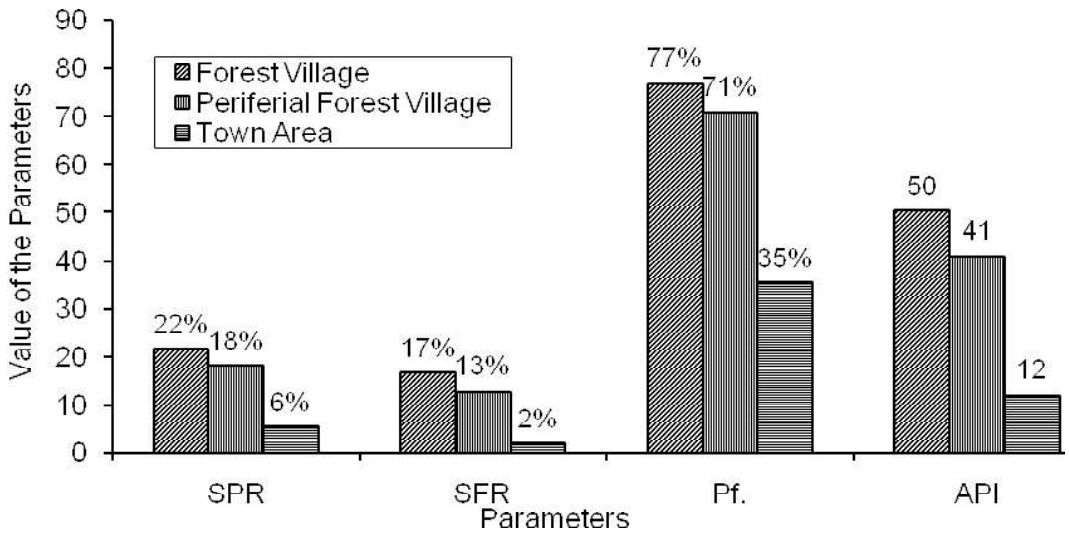

Fig.2: Variation of SPR, SFR, PF and API in Forest Villages, Peripheral Forest Villages and Dhekiajuli Town (2004-2006)

Seasonal variation of Malariomatric Indices

The seasonal variations of SFR, SPR, *Pf.*% and monthly parasitic index (MPI) were investigated. MPI was calculated in the analogy of API. Monthly values of these indices are shown in Table IV for all the three categories of settlement areas. It has been observed that the patterns of variation of all the indices are the same for all the three types of settlement areas. Therefore, the results are combined for all the three categories and the seasonal variation patterns of the indices are presented in Fig.3. It has been observed that all the indices show similar pattern, the peak being in the monsoon months June-July. The dominance of malaria has been observed for the period April to September.

Table 4: Monthly values of SPR, SFR, Pf % and MPI for FV, PFV and UA.

Month	SPR in %			SFR in %			*Pf.* in %			MPI		
	FV	PFV	UA	FV	PFV	UA	FV	PFV	UA	FV	PFV	UA
Jan	2.5	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.4	0.0
Feb	4.9	7.5	3.1	0.0	0.0	0.0	0.0	0.0	0.0	0.8	1.0	0.4
Mar	13.2	15.3	2.2	1.3	5.8	0.6	10.0	37.9	28.6	2.2	2.4	0.4
Apr	19.6	19.4	4.4	8.9	9.0	1.5	45.7	46.3	33.3	3.2	3.5	0.8
May	24.9	21.7	8.7	19.5	15.8	2.5	78.4	72.9	28.6	5.2	4.1	1.6
Jun	43.0	34.3	11.7	42.2	32.9	5.6	98.2	95.7	48.0	11.9	8.2	2.8
Jul	38.0	30.7	11.8	37.7	30.1	6.4	99.4	98.0	53.9	11.7	8.6	2.9
Aug	26.1	24.5	7.1	24.5	20.9	1.9	93.9	85.3	25.9	7.0	6.0	1.5
Sept	23.1	16.7	3.3	13.1	8.1	0.3	56.7	48.8	10.0	4.7	3.5	0.6
Oct	11.6	13.0	2.4	1.3	2.2	0.0	11.5	16.7	0.0	1.9	2.1	0.4
Nov	6.4	3.7	1.8	0.0	0.5	0.0	0.0	14.3	0.0	0.9	0.5	0.3
Dec	3.2	3.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5	0.2

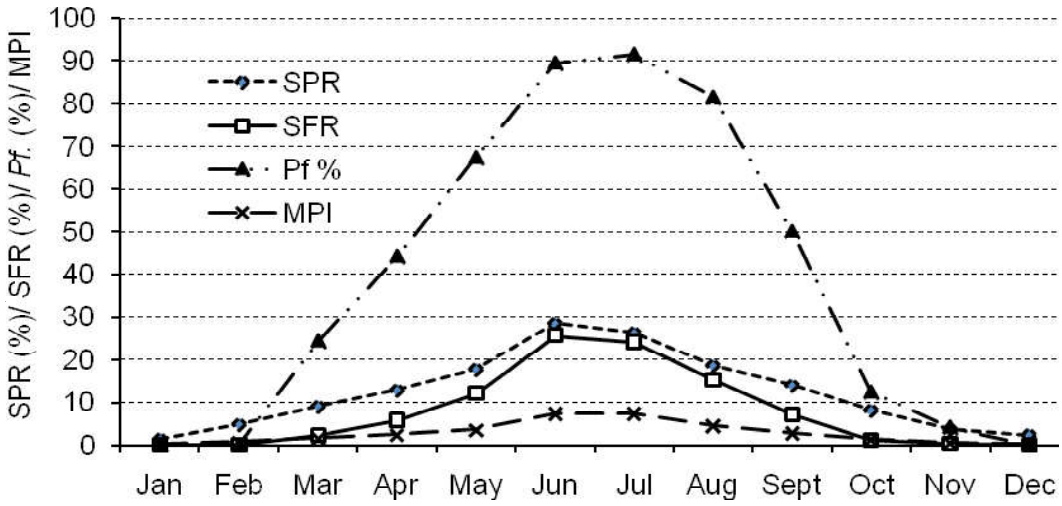

Fig.3: Monthly variation of malariomatric indices in Dhekiajuli sub-division of Sonitpur district.

DISCUSSION

Several workers studied the transmission of malaria in different parts of Northeast India. Das et al. (2004) detected *Pv.* and *Pf.*cases equally (50% each) with SPR ranging between 33.7% and 55.9% in Sonitpur district of Assam. However, Baruah et al. (2005) detected *Pf.* ranging from 96% to100% and SPR from 25% to54.4% in 2005. Gogoi et al. (1995) reported that there were twenty deaths and mostly due to *Pf*. in Tarajuli T.E., Assam during the period 1990-1993. Das et al. (1997) found *Pf*.% in the range of 86.7-100.0% in Tamulpur area of Kamrup district of Assam. In Darrang district, Kamal and Das (2001) observed *Pf*. to be the dominant parasite i.e., >80%. Das et al. (2002) observed *Pf*.>60% and *Pv*.>40%in forest-fringed villages of Lakhimpur district. Das et al. (2003) reported high percentage of *Pf.* (44.4-100%) and malaria incidence ranging from 9.2- 52.2%. Baruah et al. (2004) reported 76.5% of *Pf*. and 30.2% of SPR in Dimapur. Bhatnagar et al. (1982), Jana-Kara et al.(1995), Prakash et al. (1996) and Das et al.(1997) had similar observation of high incidence of *Pf.* in the northeast regionof India. Singh et al.(1997), and Singh and Khere (1999) also reported high percentage of *Pf*.from different parts of Chattisgarh (Madhya Pradesh). According to National Anti-malaria Programme 1999, among the northeast states, API was highest in Arunachal Pradesh (62.56%) followed by Mizoram (19.28%) and lowest in Manipur (1.20). Das et al. (2000) detected 25.1% SPR and *Pf*.% in the range of 40-100 %in Rajmahal range, Bihar.

In the present study, it has been observed that the malaria transmission was prevalent in forest and peripheral forest villages throughout the study period (2004-2006). In forest villages, SPR was found within the range of 15.8-33.3%, the highest being for Dhubjuli village in 2005.The percentage of *Pf.*ranged from 50% to100% with maximum in the village Samajuli in 2005 and the mean for all the forest villages for the study period as a whole was found to be 77%. API ranged from 31.6 to 75.2, which means that there were considerable numbers of asymptomatic carriers in the area.In the peripheral forest villages *Pf*.% ranged from 59.0% to 78.0%. API ranged from 29.7 to 52.4 and SPR ranged from 15.4% to 20.2%. In town area *Pf*.% was from 30.0% to 41.7%, API from 7.5 to 17.3 and SPR ranged from 4.0%to 7.1%. The study revealed that *Pv.* cases were there, but in less number compared to *Pf.* cases. This finding is in conformity with those who reported earlier that initially most of the malaria cases were due to *Pv.,* but during the last few

years *Pf.* has increased considerably (Dutta and Bhattacharya 1990, Deva and Sarma 1995, Malhotra et al. 1985).

Though a good number of workers studied the transmission of malaria in different parts of the region, only a few have taken seasonality into account. Dutta et al. (1993) found higher range of API and *Pf*. percentage in Arunachal Pradesh during May to December. Dev et al. (2004) observed high *Pf.*% in Sonapur during the month of August and then it declined during the winter months. The *Pv*. cases were present throughout the year. In this study also *Pv*. cases were observed throughout the year. Vanderwal and Paulton(2000) observed bimodal peak one in Dec-Jan and another in June-July in northern Haiti. However, single peak was observed in this study, the peak being in the months of April to September which is in conformity of the results obtained by Dev et al.(2001). The *Pf*. cases were absent during the period November to February except for November, 2005.

CONCLUSION

Epidemiological surveillance was made in twenty two forest villages, three peripheral forest villages and two wards of Dhekiajuli town during the period 2004-2006. Two malaria parasites – *P. falciparum (Pf.),* and *P. vivax (Pv.)* were found in the study area. *Pv*. was observed through the year, while *Pf*. was not found in the winter months. Analysis of the malariomatric indices revealed that the indices vary with location, month and year. On the yearly basis, SPR, SFR and *Pf*. percentage were found in the ranges of 15.8-33.3%, 10.3-28.2% and 50-100% respectively. API was found in the range of 31.6-75.2. Comparison of the indices with respect to settlementcategories showed that the values of the indices were the highest in the forest villages (FV) followed by the peripheral forest villages (PFV) and the urban area (UA). Therefore, it can be concluded that the transmission of malaria gradually declined from the forest villages to the peripheral forest villages and then to the town area.On the average, SPR, SFR, *Pf*. percentage and API were found to be 22%, 17%, 77% and 50 in the forest villages, 18%, 13%, 71% and 41 in the peripheral forest villages and 6%, 2%, 35% and 12 respectively in the urban area. Thus, FV suffered the most due to various reasons such as abundance of vectors, more infectivity of malarial vectors and socioeconomic conditions.

The seasonal variations of the malariomatric indices were found to follow the seasonal rhymes of the meteorological parameters – rainfall, temperature and

humidity in the region and showed single peak model, the peak being in the monsoon season. The dominance of malaria was observed for the period April to September. Effect of malaria was found to be considerably low during winter and early summer. Thus, it has been observed that the monsoon environment is favourable for the multiplication and transmission of malaria in the study areas.

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REFERENCES

1. Adhikari M., S. Kalita and T. C. Deka (2013a) Infectivity of malaria vectors in three different types of settlement areas in Dhekiajuli subdivision of Sonitpur District, Assam. *NeBIO* 4(5): 17-22
2. Adhikari M., S. Kalita and T. C. Deka (2013b)Diversity and Abundance of Malaria Vectors in Dhekiajuli Subdivision of Sonitpur District, Assam. *Asian Jour. Exp. Biological Sci* 4(1): 103-111
3. Barkakati B.N. and M.V.V.L.Narasiham (1992)A longitudinal study to monitor chloroquine resistance to P. falciparum malaria in Bokajan and Manja PHC of Karbi Anglong district, Assam. *Indian Jour. of Malariology* 29(3): 173-183
4. Baruah I., N. G. Das and J. Kalita (2007) Seasonal prevalence of malaria vectors in Sonitpur district of Assam, *Indian Jour.of Vector Borne Diseases* 44:149-153
5. Baruah I., N.G. Das, and S.C. Das (2004) Studies on anopheline fauna and malaria incidence in Dhansiripar PHC of Dimapur, Nagaland. *Indian Jour. of Vector Borne Diseases* 41:67-71
6. Baruah I., P.K. Talukdar and S.C. Das (2005)The drug sensitivities of *Plasmodium falciparum* in the Sonitpur District, Assam, India. *Southeast Asian Jour. of Trop. Med.&Public Health* 36(3):587–590
7. Bhatnagar V.N., S.R. Dwivedi, B.G.Misra and M.Das (1982)Detection and incrimination of *Anopheles minimus* Theobald. 1901 as malaria vector in the foothill areas of Nagaland, *India. Indian Jour. of Malariology* 19 (2):129-133
8. Chotivanich K., K. Silamut and N. P. J. Day (2006) Laboratory diagnosis of malaria infection – A short review of methods. *Australian Jour. of Medical Science* 27(1):11-15

9. Das N.G., I. Baruah and S.C. Das (2002) Situation of Malaria in Forest-fringed villages of North Lakhimpur district, Assam, *India. Indian Jour. of Malariology* 39:43-47
10. Das N.G., I. Baruah, S. Kamal, P.K. Sarkar, S.C. Das and K. Santhanam (1997) An epidemiological and entomological investigations on malaria outbreak at Tamulpur PHC, Assam. *Indian Jour. of Malariology* 34:64-170
11. Das N.G., M. Bhuyan and S.C. Das (2000) Entomological and epidemiological studies on malaria in Rajmahal Range, Bihar. *Indian Jour. of Malariology* 37(3):88-96
12. Das N.G., M. Bhuyan and S.C. Das (2003) Some observations on malaria in tribal areas of Bastar district, Chattisgarh. *Jour. Com. Diseases*, 35 (4), 300-305
13. Das N.G., P.K. Talukdar and S.C. Das (2004) Epidemiological and entomological aspects of malaria in forest-fringed villages of Sonitpur district, Assam. *Indian Jour. of Vector Borne Diseases* 41:5-9
14. Dev V., C.R. Hira and M.K. Rajkhowa (2001) Malaria-attributable morbidity in Assam, north-eastern India. *Annals of Trop. Med. & Parasitol* 95(8):789-796
15. Dev V., S. Phookan, V.P. Sharma and S.P. Anand (2004) Physiographic and entomologic risk factors of malaria in Assam, India. *Am. Jour. Trop. Med. Hyg.* 71(4):451-456
16. Dev V. and V.P. Sharma (1995) Persistent transmission of malaria in Sonapur PHC, Kamrup District, Assam. *Jour. Parasitic Diseases* 19:65-68
17. Dutta P. and D.R. Bhattacharya (1990) Malaria survey in some parts of Namsang circle of Tirap district, Arunachal Pradesh. *Jour. Com. Diseases* 22:92-97
18. Dutta P., V. Dev and D.R. Bhattacharya (1993) Anopheline fauna and malaria incidence in Changlang district (Arunachal Pradesh). *Indian Jour. of Malariology* 30:135-143
19. Gilles H.M., D.A. Warrell (1993) *Diagnostic methods in malaria*. In: Bruce-Chwatt's Essential Malariology, 3rd ed., Edward Arnold, 78-95
20. Gogoi S.C., V. Dev, B. Choudhury and S. Phookan (1995) Susceptibility of *Plasmodium falciparum* to chloroquine in tea garden tribes of Assam, India. *Southeast Asian Jour. of Trop. Med. & Public Health* 26(2):228-230
21. Jana Kara B.R., W.A. Wajihullah, B. Shahi, Vas Dev, C.F. Curtis and V.P. Sharma (1995) Deltamethrin impregnated bednets against *Anopheles minimus* transmitted malaria in Assam. *Indian Jour. Trop. Med. Hyg.* 98:73-83

22. Kamal S., and S.C. Das (2001) Epidemiological observations on malaria in some parts of Darrang district, Assam. *Indian Jour. of Malariology* 38:25-31
23. Malhotra M.S., R.P. Shukla and V.P. Sharma (1985) Studies on incidence of malaria in Gadarpur town of terrain, District Nainital (U.P.): *Indian Jour. of Malariology* 22:57-62
24. Prakash A., P.K. Mahapatra, V.K. Srivastava (1996): Vector incrimination in Tamulpur Primary Health Centre, District Nalbari, Lower Assam during malaria outbreak 1995. *Indian Jour. Med. Res.* 103 (2):146-149
25. Prakash A., P. K. Mohapatra, D. R. Bhattacharya, B. K. Goswami and J. Mahanta (2003)Plasmodium ovale: First case report from Assam, India. *Current Science* 84(9):1187-1188
26. Reid C. (2000) Implications of Climate Change on Malaria in Karnataka, India. A Senior Honors Thesis in Environmental Science submitted in Brown University.
27. Sandra I., J. Cunningham and N. Champouillon (2014) Methods Manual for Laboratory Quality Control Testing of Malaria Rapid Diagnostic Tests (version 7). WHO Global Malaria Programme (GMP), Geneva, Switzerland. PP. 299
28. Singh N. and K. K. Khare (1999) Forest malaria in Madhya Pradesh: Changing scenario of disease and its vectors. Indian Jour. *Parasitic Diseases* 23:105-112
29. Singh N., M.M. Shukla, S.K. Chand and V.P. Sharma (1997 b) Outbreak of *falciparum* malaria in submerged villages of Narayanganj PHC, district Mandladue to Narmada irrigation project Central India (Madhya Pradesh), *Current Science* 73:686-691
30. Vanderwal T. and R. Paulton (2000) Malaria in the Limbe River valley of northern Haiti: a hospital based retrospective study, 1975-1997. Rev Panam Salud Publica/ *Pan Am. Jour. Public Health* 7(3):162-167