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Anopheline mosquitoes in District Ramgarh (Jharkhand), India

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ABSTRACT

Background & objectives: Jharkhand is one of the highly malaria endemic states in India and experiencing vast ecological and human-induced changes over the years. These changes have provided more favourable conditions for malaria transmission in the region. The present study was carried out to find out the distribution and prevalence of anopheline vector and non-vector species in District Ramgarh of Jharkhand state.

Methods: Daytime indoor resting adult female anopheline mosquitoes were collected from four subcentres comprising of eight study villages in District Ramgarh. The collections were made from fixed as well as random human dwellings and cattlesheds on fortnightly basis using manual aspiration method from January to December 2012. Mosquito identification was done by using standard identification keys.

Results: A total of 18,875 anophelines belonging to 19 species were collected. Of these, 61.87% were vector species (*An. culicifacies, An. fluviatilis* and *An. annularis*). Of total vector collection, 57.44% was observed in Gola block and 42.55% in Ramgarh. *An. culicifacies* was predominant species followed by *An. fluviatilis* and *An. annularis* in the study area. Out of 19, eight anopheline species exhibited successional changes in their composition over the period of years. Statistical analysis revealed positive correlation between meteorological variables and man hour density in case of *An. culicifacies*, whereas these were negatively correlated in case of *An. fluviatilis* and *An. annularis*.

Interpretation & conclusion: The study revealed the prevalence of three recognised malaria vector species (*An. culicifacies, An. fluviatilis* and *An. annularis*) in high density throughout the year in this area, which indicates possibility of widening of malaria transmission window in the presence of malaria parasites. The shifting of anopheline species in Ramgarh also indicate alteration in ecological, environmental and sociological conditions, which necessitate routine monitoring on ecology and successional changes of vector species as well as malariological survey for management and adoption of appropriate vector control strategies in this area.

Key words Anophelines; malaria; rainfall; temperature; vector

INTRODUCTION

In Jharkhand, the District Ramgarh, characterized by hilly terrain and rich deposits of coal is highly endemic for malaria. Most of the tribal population reside in these hilly areas which are difficult to reach and have limited access and availability of health services. Low acceptance of health services by tribal populations further magnifies the problem. As per the data obtained from District Malaria Office, Ramgarh, the slide positivity rate was 2.37, 1.39, 1.08 and 1.28% in 2009, 2010, 2011 and 2012 respectively. Besides, the continuous introduction of labourers from different places for coal mining operations in the district further increases its vulnerability to malaria. Such non-immune immigrant labourers at mining sites act as mobile reservoirs of malaria by continuously carrying malarial infection with them, and thus add to the malaria problem. Christophers *et al*[1] reported that the aggregation of labourers contributed to high malaria transmission among new immigrant workers in an industrial site.

In Hazaribagh range, Ramgarh is also the centre of two Indian army regiments (Sikh and Punjab), where the soldiers remain outdoor for most of the time and thus are vulnerable to malarial infection. The district has also been facing extensive deforestation due to excessive anthropogenic activities such as construction of dams, roads, industry, coal mining; and large areas of natural forest have been replaced by plantations over the years. Such land transformations due to deforestation have caused vast ecological changes in this area which has affected both breeding and resting habitats of anophelines, their prevalence, density and composition of malaria vectors; which in turn modifies the transmission pattern of the disease[2-3]. Recent study by Saxena *et al*[4] also reported that *An. culicifacies s.l.* replaced *An. minimus s.l.*, in the

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deforested areas of Assam, India. The earliest surveys on anophelines were carried out by Senior-White[5] in Hazaribagh range including Ranchi plateau, who incriminated *An. culicifacies* and *An. fluviatilis* as malaria vectors in this region. A study conducted by Roy[6] recorded only two anopheline species, *An. annularis* and *An. culicifacies* from Hazaribagh town. Survey by Singh and Raziuddin[7] recorded 10 anophelines in Hazaribagh district. More recent study by Qamar *et al*[8] reported 13 anophelines from the district. Since 1958, the vector control intervention in this area is undertaken by two rounds of indoor residual spray with dichloro-diphenyl-trichloro ethane (DDT) every year, which led to decrease in malaria incidence, but malaria vectors have now become resistant to DDT[9]. Since long, no entomological survey and vector susceptibility tests against insecticides have been carried out in Ramgarh district to assess malaria vector prevalence and their distribution, which is witnessing altered landuse changes due to deforestation, agriculture, road construction, infrastructure development and coal mining, *etc*.

Keeping this in view, the present survey was undertaken to determine the successional changes in anopheline species composition, their distribution and prevalence particularly malaria vector species in this area, for guiding the strategy for vector/malaria control.

MATERIAL & METHODS

Study area

The district Ramgarh located at N 23° 38', E 85° 34' was carved out from Hazaribagh district of Jharkhand state on 12 September 2007. It covers an area of 1360.08 km^2, including 487.93 km^2 of forest area; with a population of 9,49,159 (census 2011). The climate of the district is subhumid. The temperature rises up to ~ 41°C during the summers and drops down to around 10°C during the winters. The maximum (333.6 mm) and minimum (9.5 mm) rainfall occurred in July and December respectively, in 2012.

Anopheline mosquito survey was carried out in two primary health centres (PHCs), namely Ramgarh and Gola which are low and high risk malarious areas respectively, in District Ramgarh. Further, under Ramgarh PHC, Garke and Harhatkander subcentres were selected while from Gola PHC, Sangrampur and Maganpur subcentres were selected. From each subcentre two villages were selected for entomological survey. The villages are situated in the forested terrain and surrounded with perennial streams, rivers, rivulets, wells, and natural springs which are congenial for mosquitoes breeding. The human dwellings (HD) in study villages were characterized by mud-plastered wall with tiled or thatched roofs, open wide windows adjacent to cattlesheds (CS). The inhabitants are mainly tribes of Birhor, Munda, Mahto, Linda, Oraon, Bediya and Triki; having low socioeconomic status and solely depend on agriculture and forest produce for their livelihood.

Entomological survey

In each village, entomological survey was conducted on fortnightly basis from January to December 2012. Indoor resting adult female anopheline mosquitoes were collected from fixed and randomly selected HD as well as CS by manual aspiration method during morning hours between 0500 and 0700 hrs as per WHO manual[10]. The mosquito collections were made from two HD and two CS (for 15 min each) by an insect collector. The collected mosquitoes were kept in cage, labelled properly and brought to the laboratory. The mosquitoes were anesthetized with ether, and identified morphologically at project site Ranchi using standard keys[11-16] and cross checked at National Institute of Malaria Research (Field Unit), Ranchi. Density of anopheline mosquito is expressed as man hour density (MHD). MHD is the number of anophelines collected by one person for one hour and is calculated by taking into account the total number of anopheline (n), time spent in minutes (t) and number of person/s involved in the collection (p).

$$MHD = n \times 60/t \times p$$

Meteorological data collection

The monthly maximum-minimum average temperature and total rainfall data of the district, for the study period was obtained from Department of Geography, Ramgarh College, Ramgarh, Jharkhand.

Statistical analysis

Spearman's correlation was used to examine association between meteorological variables (monthly maximum temperature, monthly minimum temperature, monthly average temperature and monthly rainfall) and MHD of vectors using Microsoft-Excel 2007 and significance of correlation coefficient was verified at $p<0.001$, $p<0.01$ and $p<0.05$.

RESULTS

In total, 18,875 adult female anophelines were collected from different study sites during the survey out of which, 10,463 (57.44%) were collected in Gola and 8,412

(42.55%) in Ramgarh PHC. A total of 19 anopheline species, namely *An. culicifacies, An. fluviatilis, An. annularis, An. subpictus, An. pallidus, An. splendidus, An. vagus, An. jeyporiensis, An. nigerrimus, An. crawfordi, An. sergentii, An. aconitus, An. tessellatus, An. barbirostris, An. jamesii, An. kochi, An. varuna, An. theobaldi* and *An turkhudi* were recorded in adult mosquitoes collection (Table 1). *Anopheles culicifacies* was found to be the most prevalent species in the study area. Under Gola PHC, comparatively high number of anophelines was recorded in Sangrampur subcentre (5304) than Maganpur subcentre (5159). However, under Ramgarh PHC, more anophelines were collected in Harhatkander (4514) than Garke (3898) subcentre. As such, results revealed maximum anopheline collection in Sangrampur and minimum in Garke. Among 19 anopheline species, only three species (*An. culicifacies, An. fluviatilis* and *An. annularis*) have been incriminated as vectors[1, 17]. The total adult anopheline vectors collected in District Ramgarh were 11,678 (61.87%), out of which *An. culicifacies* (34.80%) was most abundant followed by *An. fluviatilis* (33.16%) and *An. annularis* (32.03%).

The vector distribution at PHC level revealed that vector collection varied from one geographical location to another. Of total vector collection, 57.44% were recorded in Gola PHC and 42.55% in Ramgarh PHC (Table 1). In Gola PHC, *An. annularis* was most abundant (40.14%) followed by *An. fluviatilis* (35.52%) and *An. culicifacies* (24.34%), whereas in Ramgarh PHC, *An. culicifacies* was most abundant. Vector (*An. culicifacies, An. fluviatilis, An. annularis*) distribution at subcentre level demonstrated that the higher vector collection was recorded in Sangrampur (3618) than Maganpur (3091) in Gola PHC. In Sangrampur, the highest vector collection was recorded for *An. annularis* followed by *An. fluviatilis* and *An. culicifacies* whereas in Maganpur *An. fluviatilis* showed highest collection followed by *An. annularis* and *An. culicifacies*. In case of Ramgarh PHC, the population of vector was higher in Harhatkander (3057) than Garke (1912). At both Harhatkander and Garke subcentres, collection of *An. culicifacies* was highest followed by *An. fluviatilis* and *An. annularis*.

Table 1. Anopheline mosquitoes collected from different study sites in Ramgarh during January to December 2012

Anopheline species	No. of mosquitoes collected				Total collection	MHD
	Ramgarh		Gola			
	Garke	Harhatkander	Sangrampur	Maganpur		
An. culicifacies Giles 1901	837	1594	870	763	4064 (21.53)	169.33
An. fluviatilis James 1902	685	805	1094	1289	3873 (20.52)	161.37
An. annularis Van der Wulp 1884	390	658	1654	1039	3741 (19.82)	155.87
An. splendidus Koidzumi 1920	124	56	132	341	653 (3.46)	27.21
An. nigerrimus Giles 1900	4	23	12	31	70 (0.37)	2.91
An. jeyporiensis James 1902, and var. *candidiensis* Koidzumi 1924	48	39	17	127	231 (1.22)	9.62
An. jamesii Theobald 1901	1	2	2	1	6 (0.03)	0.25
An. kochi Grassi 1899	0	1	1	3	5 (0.02)	0.21
An. tessellatus Theobald 1901	3	6	2	8	19 (0.1)	0.79
An. vagus Donitz 1902	113	152	130	75	470 (2.49)	19.58
An. subpictus Grassi 1899, and var. *vadakadiensis* Doraisamy 1963	1313	867	870	691	3741 (19.82)	155.87
An. sergentii Theobald 1907	2	1	8	27	38 (0.2)	1.58
An. turkhudi Liston 1901	0	0	0	2	2 (0.01)	0.08
An. barbirostris Van der Wulp 1884	1	4	2	3	10 (0.5)	0.41
An. pallidus Theobald 1901	358	301	464	723	1846 (9.78)	76.91
An. varuna Iyengar 1924	0	0	2	0	2 (0.01)	0.08
An. crawfordi Reid 1953	19	1	18	27	65 (0.34)	2.71
An. aconitus Donitz 1902	0	4	23	9	36 (0.19)	1.5
An. theobaldi Giles 1902	0	0	3	0	3 (0.01)	0.12
Total	3898	4514	5304	5159	18875	

The figures in parentheses indicate percent composition; MHD—Man hour density.

Further, temporal distribution of vector species at each study site also showed variation throughout the year (Fig. 1). In Sangrampur and Maganpur subcentres, *An. annularis* was prevalent throughout the year (temperature range 10–41°C, Fig. 2) with peak density in March (temperature range 18–36°C and rainfall 28.9 mm, Fig. 2); *An. culicifacies* showed peak density in August (temperature range 25–32°C and rainfall 321.7 mm, Fig. 2) and *An. fluviatilis* exhibited high density in colder months *i.e.* November to February (temperature range 10–30°C and rainfall 9.5–22.3 mm) (Figs. 1a & b). In Garke subcentre, *An. culicifacies* showed peak density in August and May (Fig. 1c), whereas in Harhatkander subcentre, its peak density was observed in June (Fig. 1d). *An. fluviatilis* exhibited highest density in December, whereas *An. annularis* in August, in both Garke and Harhatkander subcentres.

Correlation coefficient analysis between malaria vector species and meteorological parameters revealed that vector density is strongly influenced by environmental conditions prevailing in that area. In the present study, density of *An. culicifacies* was positively correlated with maximum temperature, minimum temperature, average

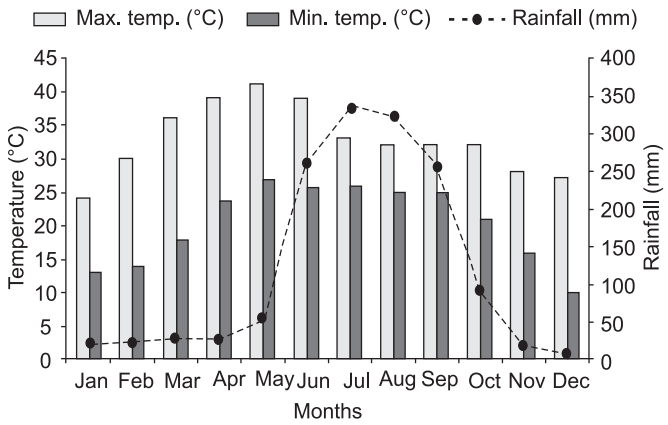

Fig. 2: Monthly meteorological (maximum–minimum temperature and rainfall) variables at district Ramgarh during January–December 2012.

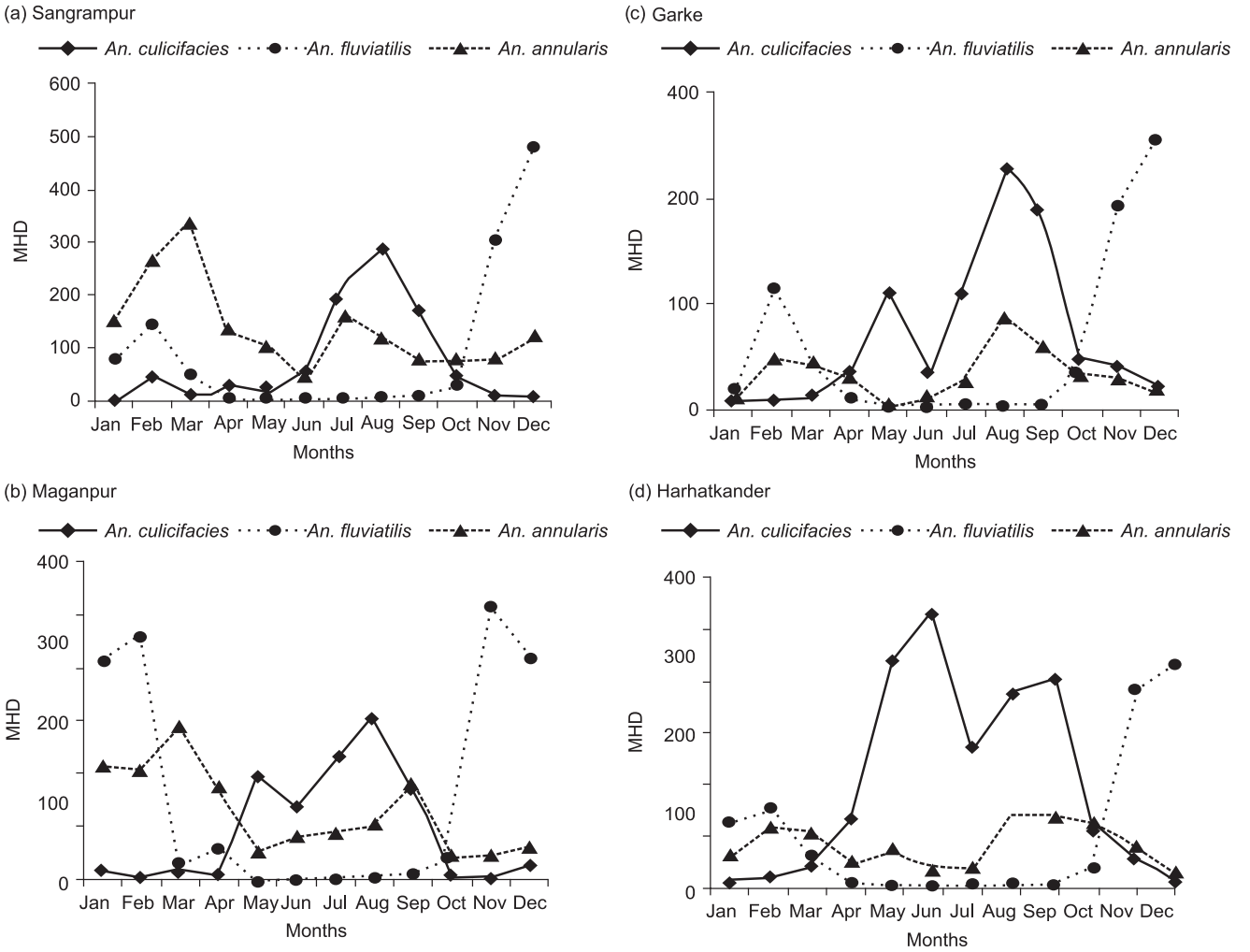

Fig. 1: Monthly variation in man hour density (MHD) of *An. culicifacies*, *An. fluviatilis* and *An. annularis* at (a) Sangrampur; (b) Maganpur; (c) Garke; and (d) Harhatkander subcentres during January to December 2012.

Table 2. Correlation between meteorological variables and anopheline vector species at different subcentres under Ramgarh PHC

Subcentres/ Species	Maximum temperature (°C)	Minimum temperature (°C)	Average temperature (°C)	Average rainfall (mm)
Garke				
An. culicifacies	0.17	0.63*	0.43	0.62*
An. fluviatilis	– 0.54	– 0.76**	– 0.70**	– 0.43
An. annularis	0.11	0.16	0.04	0.28
Harhatkander				
An. culicifacies	0.62*	0.87***	0.80**	0.56
An. fluviatilis	– 0.64*	– 0.80**	– 0.77**	– 0.43
An. annularis	– 0.11	0.05	– 0.02	– 0.04
Sangrampur				
An. culicifacies	0.02	0.54	0.31	0.85***
An. fluviatilis	– 0.59*	– 0.77**	– 0.73**	– 0.40
An. annularis	– 0.03	– 0.37	– 0.22	– 0.26
Maganpur				
An. culicifacies	0.32	0.72**	0.56	0.77**
An. fluviatilis	– 0.76**	– 0.89***	– 0.88***	– 0.50
An. annularis	– 0.05	– 0.24	– 0.16	– 0.22

Significant correlation at *$p<0.05$; **$p<0.01$; ***$p<0.001$.

temperature and rainfall at each subcentre (Table 2). *An. culicifacies*' density showed significant positive correlation with minimum temperature (r = 0.87, $p<0.001$) and average temperature (r = 0.80, $p<0.01$) at Harhatkander, whereas it showed highly significant positive correlation with rainfall (r = 0.85, $p<0.001$) at Sangrampur. However, *An. fluviatilis*' density exhibited negative correlation with each meteorological parameter at each subcentre (Table 2). There was statistically significant ($p<0.01$) strong negative correlation between density of *An. fluviatilis* and minimum temperature as well as average monthly temperature. *An. annularis* showed an insignificant negative correlation with each meteorological parameter except Garke subcentre, where insignificant positive correlation between *An. annularis*' density and meteorological variables was observed.

DISCUSSION

It is evident from the present survey that District Ramgarh having rich anopheline fauna density, has undergone some successional changes in species composition. Four species, namely *An. karwari, An. moghulensis, An. ramsayi* and *An. stephensi*, not observed in the present study, were already reported by Senior-White[5], which indicates shifting of these species from this area, due to continuously changing ecological, environmental and sociological conditions. However, four more species, namely *An. crawfordi, An. sergentii*, *An. turkhdi* and *An. kochi*, recorded in present study, were not reported by Senior-White[5] suggesting ecological succession of anopheline species. Further, species composition observed in present study is an updated information as compared with previous studies by Roy[6] who recorded only *An. annularis* and *An. culicifacies* from Hazaribagh town; Singh and Raziuddin[7], recorded 10 anopheline species in four blocks of Hazaribagh and Qamar *et al*[8], reported 13 anopheline species from Hazaribagh district.

The spatio-temporal variation in vector density reflected their specific environmental and ecological preferences. The highest abundance of *An. culicifacies* at each site during rainy season (June to September) was due to favourable temperature (25–39°C) and rainfall (254.8–333.6 mm) during that period. The results are in conformity with the findings of Shukla *et al*[18] and Baruah *et al*[19]. The study has also been supported by the fact that the daily survival of vector species is about 90% at 16–36°C temperature[20]. Moreover, the rice cultivation during monsoon period is more conducive for breeding and proliferation of *An. culicifacies*. Further, high density of *An. fluviatilis* at each site especially during winter months may be possibly due to preferred temperature (10–30°C), rainfall (9.5–22.3 mm)[19] and suitable breeding sites[21].

The prevalence of *An. annularis* throughout the year may be attributed to its broad ecological and environmental adaptability of breeding in biannual rice cropping, ponds, ditches, stray fallow, wells, pools, river margins and irrigation channels associated with algal growth and vegetation supporting its prevalence throughout the year. Similar findings were recorded by Baghel *et al*[22], Yadav *et al*[23] and Sahu *et al*[24]. As such, the high abundance of *An. culicifacies* during rainy season, *An. fluviatilis* during winter and *An. annularis* throughout the year indicated maintenance of perennial transmission of malaria.

Besides meteorological parameters, some industrial activities such as opencast coal mining and anthropological activities such as deforestation in the vicinity of Ramgarh might also have influenced anopheline density in the area. Opencast coal mining results in borrow pits left after road construction, drains and abandoned excavated areas which often increases breeding sites for malaria vector[25]. Deforestation caused by mining activities leads to subsequent change in landuse and human settlement also alters the local ecosystem, vector ecology and disease prevalence[25-26]. Additionally, the resting habitats also play an important role in influencing vector density at a particular place[27]. Therefore, mud-plastered houses with open wide windows, mud tiled and thatched roofs,

adjacent cattlesheds, and closer proximity to breeding sites at different study sites can not be ignored while dealing with vector control. Therefore, prompt actions are needed to control vector population by adopting appropriate vector control strategy for tribal areas, which could help in reducing malaria vectors *vis-à-vis* malaria in this region.

CONCLUSION

The study revealed the prevalence of 19 anopheline species including three recognized malaria vectors (*An. culicifacies*, *An. fluviatilis* and *An. annularis*) in Ramgarh district of Jharkhand, India. The high density of *An. culicifacies* during rainy season, *An. fluviatilis* during winter season and *An. annularis* throughout the year with peak density in summer season may prolong the transmission period and cause perennial malaria transmission in the presence of parasite. Therefore, each vector species should be targeted at appropriate time by adopting suitable vector control measures and implementing integrated vector management (IVM) strategy in order to control malaria in the area.

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