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Environmental Factors affecting the Bionomics of An. culicifacies and Malaria Endemicity

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Abstract

Objective: To study the effect of environmental parameters like humidity, rainfall and temperature on the dynamics of vectorial competence of An. culicifacies. **Methods:** Epidemiological data and climatological data were collected from state Govt. (Odisha). And the mosquito bionomics was studied in laboratory regression test of PMHD of An. culicifacies, SPR in relation to mean rainfall, mean humidity and mean temperature were done. **Applications/Improvements:** Linear regression test of the afore-mentioned and in addition to them mean humidity and SPR, mean humidity and PMHD showed positive correlation. Linear regression test of PMHD An. culicifacies and SPR of the study districts showed positive correlation with correlation coefficient value r^2 = 0.88 and p value = 0.0006. **Conclusion:** The results proved the effect of the above mentioned parameters in malaria transmission by favoring vector biology and thus malaria endemicity.

Keywords: Anopheles Culicifacies, Climatic Factors, Malaria Endemicity, Vector Bionomics, Vectorial Competence

1. Introduction

Malaria is a public health problem in India and creates severe roadblocks to its development[1]. An. culicifacies is a known rural malaria vector in India[2,3]. India's contribution to the global total of 2-3 million malaria every year is about 60-70%[4]. Irrespective of climatic variation An. culicifacies is widely distributed in most states of India and has been recorded in all mainland zones including Kashmir and high elevations in the Himalayas (up to 3000 meters) except islands of Lakshadweep and Andaman and Nicobar. It also extends beyond India's boundaries to Pakistan, Afghanistan, Iran, Yemen and Ethiopia to the west; to Bangladesh, Thailand, Myanmar, Laos and upto Vietnam to the East; to Nepal and Southern China in the North and upto Sri Lanka in the South[5–7]. It is the most important vector in plains of rural India contributing 60-70% of reported cases annually[7,8]. It is recognized as a primary vector of malaria, a disease of great socio-economic significance, in different areas of the world[9]. Bionomics is that part of biology which deals with the relationships of a given species and its environment. The bionomics of Anophelines include the development of immature stages i.e. eggs, larvae and pupae as well as the life of the adults under the influences exercised by the environmental conditions. Behavior is the result of the interaction of genetic factors, which govern the basic lines of behavior and ecological factors which may produce different types of reaction in a population having the same genetic characteristics.

Among the ecological factors, the phonological (study of seasonal periodic biological events) one is of considerable importance. For example, the ability of mosquitoes to breed in fresh or salt water or both is controlled by genetic factors. Host preference seems to be governed by genetic factors also, but the intensity of feeding on a certain host may vary from place to place and even from day to day, not only with the availability of hosts, but also with the changes in meteorological conditions. The speed of the development of the mosquitoes is dependent mainly on climatic factors.

Climatic change may be natural and human caused and it includes regional weather variations, temperature, precipitation and humidity. These changes influence

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longevity development of the vector, pathogen development, distribution and abundance of natural vertebrate hosts, duration of the aquatic stages, the speed of blood digestion and maturation of the ovaries, the frequency of feeding, vector habitat and naturally the disease transmission dynamics and ultimately influencing the vectorial capacity of the vector.

The Anopheline species is regarded as endophilic when largely found resting indoors or exophilic when largely found resting outdoors, although partial exophily has also been observed. Selection of the resting habitats is much influenced by the temperature and humidity of favorable resting places and human habitats.

Humidity is the limiting factor in the distribution and longevity. Forest species are more susceptible to humidity changes than those living in areas with a dry climate. During dry weather, indoor mosquitoes will concentrate in those housed or other indoor resting places where the microclimate offers a favorable humidity. Outdoor-resting mosquitoes will rest in the vegetation near the ground when it is dry. During the day mosquitoes rest inactive in cooler places. At dusk, when the temperature drops and the humidity increases, the mosquitoes suddenly become activated.

The effect of rainfall varies according to its amount and the features of the terrain. Repeated rains cause severe flooding, resulting in temporary flushing out of the breeding places. Consequently, the breeding of a vector population is greatly reduced but it will soon be re-established when normal conditions are restored. Moderately frequent rainfall but with fairly long periods of sunshine will increase the opportunity of prolific breeding.

Though a lot of work is available on the effect of climatic factors on transmission of malaria in other countries, very little is available about the same in India[10–18]. Thus, the environmental factors like rainfall, temperature and humidity are of great importance for the study of dynamics of An. culicifacies and its vectorial competence.

2. Methodology

2.1 Climatological Data

The data on relative humidity, rainfall and temperature of the relevant study districts were obtained from metrological department, Government of India.

2.2 Mosquito Collection

An entomological survey was done in the district including both forested and non forested areas. In the morning hours between 06.00 am and 9.00 am, indoor resting mosquito samples were collected from houses using mouth aspirators. Identification of species was done according to Christophers' taxonomic keys[19]. The entomological data were taken for calculation of the entomological indices. The PMHD of An. culicifacies was then calculated as the number of mosquitoes per man per hour.

Thus PMHD = Number of mosquitoes collected (particular species)/(number of persons involved in collection) x (actual time spent in collection).

2.3 Epidemiological Data

The epidemiological data of the study districts were duly collected from the State Government for analysis.

2.4 Study Period

Study was performed from 2006 to 2008.

2.5 Statistical Analysis

A linear regression test was done of An. culicifacies PMHD and SPR, mean rainfall and PMHD and SPR, mean humidity PMHD and SPR as also mean temperature PMHD and SPR were done.

3. Results

The data on PMHD and the SPR of the An. culicifacies in the study districts are depicted in the following table. Highest PMHD was found in Dhenkanal followed by Angul, Keonjhar, Ganjam, Nayagarh, Khurda, Puri, Jagatsingpur (Table 1). However, in forested districts higher PMHD of An. culicifacies is found. The correlation of PMHD of An. culicifacies and SPR of the respective study areas showed directly proportional relationship ($P < 0.05$) i.e. larger the PMHD of the species more is the SPR.

The mean rainfall, mean maximum temp, mean minimum temp and the mean humidity of 2006, 2007 and 2008 are depicted in the Table 2. There is an increase in all three parameters from 2006 to 2008 in majority of the study districts.

The SPR data of coastal and forested districts are shown in Figure 1. Low SPR is noted in the coastal districts as compared to the forested districts. However, among the forested districts higher SPR was seen in Angul, Dhenkanal and Keonjhar; intermediate values of SPR were observed in Ganjam, Nayagarhand Khurda.

The comparative PMHD data showed that it is low in the coastal districts as compared to the forested districts. However, among the forested districts higher PMHD was seen in forested districts (Keonjhar, Anugul and Dhenkanal). Intermediate PMHD was observed in the coastal districts (Nayagarh, Ganjam and Khurda) (Figure 2).

The SPR and respective PMHD of An. culicifacies for three consecutive years 2004, 2005, 2006 are given in the Table 3, which showed a direct positive correlation between PMHD of An. Culicifacies with higher SPR of all the districts. The mean of the climatic factors are compared with the PMHD and SPR in Table 3 to see if these environmental factors affecting the vector bionomics and malaria endemicity of the study area.

Table 1. PMHD of An. culicifacies and SPR of the study areas (2008)

Study areas	PMHD of An. culicifacies	SPR of the study districts
Khurda	3	3.86
Dhenkanal	7.16	12.84
Nayagarh	5.43	6.31
Puri	3	0.4
Ganjam	5.92	6.12
Jagatsingpur	2.46	0.8
Angul	6.8	12.5
Keonjhar	6.56	10

Table 2. Meteorological data recorded in eight endemic districts of Odisha

Area	Mean rainfall			Mean of max temp			Mean of min temp			Mean of humidity		
	2006	2007	2008	2006	2007	2008	2006	2007	2008	2006	2007	2008
Coastal district												
Jagatsingpur	129.7	147.2	169.7	37.08	36.81	35.2	19.71	18.44	20.9	72	71.96	79.88
Puri	86.82	98.96	161	36.75	39.71	33.9	14.75	16.78	20.43	63.96	61.13	78.17
Forested districts												
Dhenkanal	87.33	145.1	116.4	36.75	39.7	38.1	18.45	16.78	15.9	63.96	61.125	58.25
Nayagarh	102.1	145.9	115	37.1	36.6	37.1	14.45	19.3	19.49	71.13	74.41	72.46
Ganjam	71.96	94.62	103.3	34.93	33.68	34.6	19.43	20.65	20.23	78.25	78.13	77.75
Angul	111.7	141.9	112	36.75	39.71	38.1	14.45	16.78	15.9	63.96	61.13	58.25
Keonjhar	90.5	134.9	129.3	35.4	34.73	35.2	15.32	15.58	15.93	59.1	64.83	65.5
Khurda	91.66	119.7	140.4	37.1	36.6	37.1	18.45	19.3	19.49	71.13	74.41	72.46

Table 3. Mean rainfall, temperature, humidity and respective SPR of the study districts

Area	Average rainfall temperature and humidity of 2004-2006			Mean SPR	PMHD
	Mean rainfall/ month	Mean Temperature	Mean humidity		
Khurda	117.23	25.3	72.67	3.86	2.8
Dhenkanal	116.28	23.6	61.11	12.84	6.4
Nayagarh	121	25.3	72.67	6.31	5.2
Puri	115.6	23.7	67.75	0.4	2
Ganjam	89.94	25.2	78.04	6.12	5.98
Jagatsingpur	148.88	24.84	74.61	0.8	2.9
Angul	121.89	23.6	61.11	12.5	6.5
Keonjhar	118.21	22.2	63.14	10	6.32

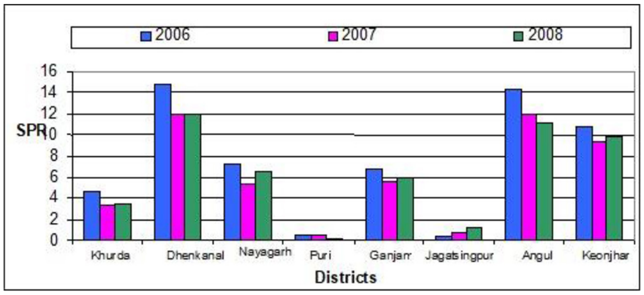

Figure 1. SPR in three different years in the study districts.

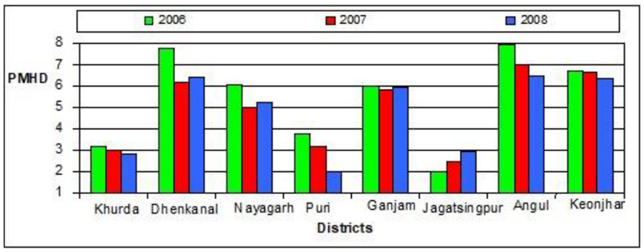

Figure 2. PMHD of An. culicifacies in three different years in the study districts.

3.1 Statistical Analysis

Linear regression test of PMHD An. culicifacies and SPR, mean rainfall PMHD and SPR, mean humidity SPR and PMHD, mean temperature PMHD and SPR, showed positive correlation. Linear regression test of PMHD An. culicifacies and SPR of the study districts has positive correlation with correlation coefficient value $r^2 = 0.88$, p value = 0.0006. Other parameters did not show significant association in this study.

4. Discussion

There has been a prolonged duration study of the positive correlation between rainfall and malaria[20–23] and in some other studies there was no strong correlation visible[24,25]. The role of climatic factors in malaria endemicity in high land areas shows that transmission of malaria involves complicated interactions among the different Plasmodium stratins, anopheline mosquitoes and humanoid hosts[26]. It is observed that the transmission fails to occur if the vector life span is less than the time required for the development of the pathogen to its virulent stage[16].

In addition to changes in the amount and the rate of transmission of vectors and parasites that are already there in a certain area, change of climate of the area can allow the introduction of different vectors and parasites that may be more efficient. Since P. malariae and P. ovale have longer extrinsic cycles, some mosquitoes have not the life span to transmit them. However, if environmental conditions change in ways that would increase the survival time of those mosquitoes, then they can transmit other species of malaria that were not present in that area before. The seasonal malaria peak is directly related to the rainfall peaks[27].

A study in Quetta indicated that An. culicifacies appears mostly in April and May and increases greatly in June and July and then the decline starts mostly in September[28]. This indicates that An. culicifacies is not resistant to low temperatures. Its density has been correlated to temperature and also to humidity and rainfall, which played a positive role in the rising of the vector prevalence. The density of An. culicifacies was the maximum during summer, but incidence of malaria was at its lowest level during this season[29].

Yet another study in Southern districts of Odisha State revealed that the high density could play a major role in transmission of malaria. Through infection rate was low (1.39%) and it has poor anthropophagy but its high density was compensating towards its contribution towards malaria transmission[30].

In the current study, the density of An. culicifacies is seen to be high in forest areas, but shows variations with climatic factors. Similar observation of increase of An. Culicifacies density was found in Mandala district, Madhya Pradesh, India[31].

However, in Southern districts of Odisha, it was found that the density of An. culicifacies did not indicate any association with incidence of malaria[30]. However, they found higher density of An. culicifacies in some study districts with comparatively low incidence of malaria parasite where density of An. fluviatilis was high. A study in a malaria-prevalent area Sistanva Baluchestan province, south-east Islamic Republic of Iran has revealed low activity of An. culicifacies during cold winter and hot summer periods[32].

However the other functional aspects (Anthropophilic nature, gonotropic cycle, sporozoite rate, biting habit, resting habit, breeding habit etc.) of bionomics of An. culicifacies with regard to the changes in climatic factors have not been touched upon. A detailed document to this by the author is in pipeline which will correlate the above aspects of vector bionomics (An. culicifacies) as climate is one of the major factors which affect the incidence of malaria. With rise of global temperature in twenty first century changes in distribution of vector and of prevalence are sure to occure[9].

5. Conclusion

Climatic factors are found to have an impact on malaria transmission through their effect on the life span, capacity and virulence of the vector. An understanding of such effects is sure to help us design the eradication program in a more efficient manner in Odisha in particular and in general at other similar places also having similar climatic variations and geographic features.

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