Review of Vectorial Capacity of Anophelines in Odisha

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Abstract

The natural transmission of malaria depends on the presence and relationship between the three basic epidemiological factors: the agent, the host, and the environment. While the malaria parasite is the true infectious agent, the female *Anopheles* mosquito is the transmitting agent. The environment is viewed from three aspects; physical, biological and socioeconomic. There are four types of parasites of human malaria, *Plasmodium vivax, falciparum, malariae* and *oval*. In India, 60-65% of infections are caused by *P. vivax* and 35-40% by *P. falciparum*. Only a few cases of *P. malariae* have been reported in Odisha and Karnataka. Among *P. falciparum* blood stage antigens, there is a great diversity both between geographical areas and in the same area. In a single infection, antigenic variations of *P. falciparum* were detected, indicating a high diversity rate in the same strain. Virulence is expressed as the severity of an acute disease in non-immune individuals. Virulence is very different between the species.

Keyword: Plasmodium vivax, falciparum, Odisha

Introduction

While the malaria parasite is the true agent of infection, the female Anopheles mosquito is the agent of transmission. The environment of malaria occurrence is considered from three aspects - physical, biological and socioeconomic conditions. Movements of people in a variety of forms and at a variety of scales play an important role in the malaria equation of parasites—vectors—people (Prothero, 2001). He discussed about the transmission of malaria, spreading infection and exposing non-immune people to risk of infection. Mundada et al. 2012, have underline the various factors influenced by human activities and natural calamity that have great bearing on mosquitogenic conditions leading to increased potential for malaria transmission. They highlighted that natural transmission of malaria depends on the presence of, and relationship between the three basic epidemiological factors: the agent, the host and the environment.

Anopheles minimus, an important malaria vector of South East Asia has reappeared in the Singhbum hills, Odisha where deforestation and DDT residual spraying had reportedly eliminated it during the Malaria Eradication Programme. The study carried out by Jambulingam et al. (2005) shows that the environmental conditions favour the existence of the species and was one of the possible reasons for its reappearance.

Ecological changes due to canal irrigation for agriculture, increased water logging due to seepage from canals and inadequate drainage have resulted in creation of extensive mosquitogenic condition. Further, deforestation, rapid urbanization, industrialization and extensive use of insecticides in agriculture and public health may also have contributed towards changes in the ecosystem and in the prevalence of mosquito vectors. Research suggests that irrigation for rice cultivation increases the production of *Anopheles gambiae*, the main vector of malaria in Mali and their abundance is highly variable across villages and seasons (Duik-Wasser et al. 2007).

Factorial Analysis

A multi-factorial risk factor analysis study was designed by Kirby et al. (2008) to highlight important spatial, compound and mosquito control-related parameters that affect house entry of malaria vectors in Gambia. The study demonstrated that the risk of malaria transmission was greatest in rural areas, where large numbers of people sleep in houses made of mud blocks, where the eaves (lower edge of a roof) were open.

Education status of a mother in a family is an important aspect in determining malaria cases. In a study in rural Kenya by Noor et al. (2006), stress was given on mother's education determining children malaria cases. Children's use of nets purchased from the retail sector was shown to be closely correlated with mother's education, with only 14.4% of children of uneducated mothers using nets compared with 32.7% of those whose mothers had education up to secondary level and above.

The investments of billions of dollars in policies worldwide have been made to slowdown deforestation, eradicate malaria, and foster economic development. About one third of the world's population live in malaria-infected areas related to deforestation. Deforestation continued at the rate of 16 million hectares annually throughout the last decade, and about half the world's population lives on less than US$2 per day (Pattanayak et al. 2006).

Sibling species and their role in malaria transmission

The undestanding of the transmission of malaria is further complicated by the existence of species complex of cryptic species or sibling species or isomorphic species in this taxon and also in other malaria vectors. Species that are virtually identical in their morphology but reproductively isolated are termed as sibling species or cryptic species. Sibling species are morphologically identical but differ in other traits such as they share different ecological niches, host ranges or host preferences, vectorial capacities, resistance status to various insecticides and mating behavior.Except for *An. stephensi* all other malaria vectors exict as species complexes comporising several cryptic species. Studies have clearly indicated difference among sibling species that result in considerable impact on the transmission of malaria including susceptibility to commonly used insecticide in public health program.

Need for sibling species studies

Most of the anophelines that are involved in the transmission of malaria in the South and South- East Asian countries have been identified as species complexes. Vector control is very important part of global as well as the regional malaria control strategy for disease management. The success of this strategy would entirely depend on a systematic review of the available information on vector species, their identification and also the knowledge of their biology. Differences in the biological characteristics of members of the complexes have an important bearing on malaria transmission dynamics. It is, therefore, imperative to determine sibling species composition and their bionomics as well as their roles in the transmission of malaria. If identification of sibling species is to be done routinely in malaria control activities, techniques which are simple, accurate and affordable need to be developed.

Vectorial capacity

The vectorial capacity of An. *fluviatilis* remained estimated using the formula of Macdonald as modified by Garrett-Jones: Vectorial capacity (C) = $ma^2p^n/-\log_e p$; Where, ma = human landing density, a = human feeding habit, p = probability of daily survival, n = duration of sporogony, and $-\log_e p$ = expectation of life.
Human landing collections, where the bait (human volunteer) was protected by a bed-net, were carried out simultaneously indoors and outdoors at monthly intervals, at one site, in each of the three selected villages between 1800 and 0600 h for a period of 15 months from September 2016 to December 2017 (six months in summer, five months in rainy and four months in winter season). In total, 45 each of indoor and outdoor collections were made. Ethical clearance was obtained for engaging human volunteers as baits from the Institutional Ethical Committee of Vector Control Research Centre. Mosquitoes that landed on the net were collected using oral aspirators and flashlights. Human landing density was calculated from the number of female mosquitoes landed on the net or attempted to bite per bait per night. In the following morning, the mosquitoes were identified, grouped according to their gonotrophic conditions and dissected out to determine the parity status using ovariolar dilatation method.

Since the human landing density indoors and outdoors was low, the human landing density was obtained averaging indoor and outdoor results. Man feeding habit of the vector species was estimated by multiplying the human blood index (HBI) (proportion of blood meals taken on man) with feeding frequency, which was obtained on daily basis from the duration of one gonotrophic cycle (the interval in days between two consecutive blood meals). The gonotrophic cycle of *An. fluviatilis* was assumed to be two days for summer and three days for rainy and winter seasons based on the earlier study in Koraput district, Odisha.

The probability of survival through one day was computed by taking the g^{th} root of PP (where PP is the proportion of parous females in man-landing collections and 'g' is the duration of gonotrophic cycle). The proportion parous was determined by dissecting out ovaries of the female mosquitoes collected on human baits and looking for dilatations in pedicel part of the ovarioles that were separated from the ovaries. The time (in days) taken by malaria parasite to complete its development in vector mosquitoes [sporogonic cycle (n)] was estimated as a function of temperature using the formula $n = T/t\text{-}t_{min}$ where, n is the duration of sporogony, T = total degree days required for completion of sporogony, (105 °C for *P. vivax* and 111 °C for *P. falciparum*), t is the actual mean diurnal temperature and t_{min} is the threshold temperature (14.5 °C for *P. vivax* and 16.0 °C for *P. falciparum*) required for development of malaria parasite. Data on temperature during the study period were collected from the Research Station of the Odisha University of Agriculture and Technology located about 10 km from the study sites and used for estimating the duration of sporogonic cycle. Using the values of both probability of survival through one day (p) and the duration of sporogonic cycle (n), the probability of survival through extrinsic incubation cycle (p^n) was calculated.

***Malaria incidence*:** Incidence of malaria in the study villages was recorded through fortnightly door to door active case detection method. From all fever cases as well as persons suffering from fever within last 15 days from the date of earlier survey, blood smears were collected and the patients were treated presumptively with chloroquine. The microscopically proved malaria positive persons were administered with radical treatment (chloroquine and primaquine) as per the guidelines of National Drug Policy on Malaria.

Conclusion

The spatial and temporal patterns of distribution of species are the key factors required for monitoring of vector control programmes. Outcome of the results on seasonal abundance of malaria vectors in four different geographical areas of Keonjhar district, Odisha would improve our understanding of the patterns of malaria transmission and the role of vector species in malaria transmission. The information on the seasonal prevalence of malaria vectors might pave the way for designing appropriate vector control strategies. Thus, monitoring the population of a geographical area from time-to-time can be successfully achieved with this method.

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