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REVIEW PAPER

Military Malaria in Northeast Region of India

Sunil Dhiman*, Indra Baruah, and Lokendra Singh

Defence Research Laboratory, Tezpur, Assam
**E-mail: dhiman_81@indiatimes.com*

ABSTRACT

Malaria has always been a pernicious problem of serious health hazard in the northeast region of India. The problem is worst for military and paramilitary forces deputed in all the states of this part of country. The forces are deployed for a short time generally from non malarious regions and thus become highly vulnerable to acquire the malaria infection. Several potential malaria vectors with very high vectorial capacity and high slide positivity rate in civil population manifold the chances of infection. In the present review, the incidence of malaria in the armed forces and paramilitary forces are discussed in detail and minimal measures for the control of malaria in northeastern region have been suggested.

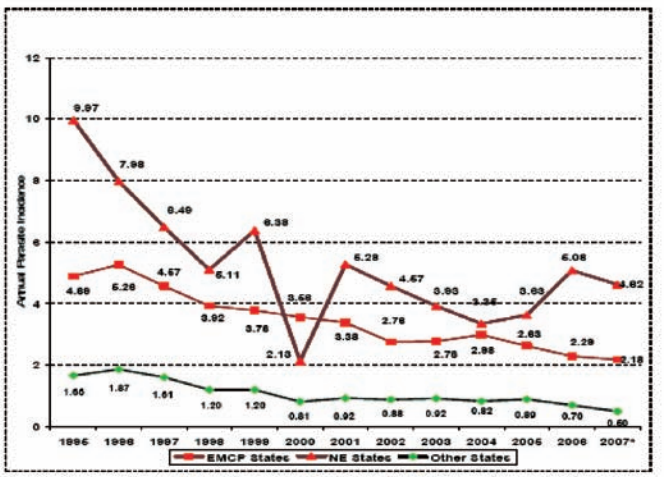
Keywords: Malaria, armed forces, paramilitary forces, *Plasmodium, Anopheles*

1. INTRODUCTION

"Battles have been won against malaria but the war against the disease is in danger of being lost."[1].

WHO

Malaria has been one of the most devastating diseases described since antiquity and its references can be found in the vedic writings of 1600 BC in India and by Hippocrates some 2500 years ago[2]. Malaria has become endemic and subject of intention in most part of the world as, currently, it kills 1.5 to 3 million people every year[3]. The situation is worst in sub-saharan Africa where about 90 per cent deaths are recorded annually due to malaria[4]. The Indian subcontinent is no more an exception as 1.84 million cases are recorded with more than thousand of deaths each year. However the figures might be different if all biasly reported cases and unrecorded or under recorded cases in the far flung areas with very less medical facility are visualised[5]. Around 95 per cent of the total population in India resides in malaria-endemic areas, but 80 per cent of malaria infections occur among 20 per cent of the population classified as 'high risk population' with high annual parasitic index (API) throughout the year (Fig. 1)[8]. The geographical areas where 'high-risk population' resides include seven north-east states and Sikkim. In these states, some 200 districts contribute most to the burden of the disease[6]. In northeastern states, there lives nearly 4 per cent of country's population but contribute 10 per cent to 12 per cent of total malaria cases every year[7]. This region has contributed 46 per cent of malaria deaths reported in the country in 2007 (Fig. 2)[8]. Focal outbreaks of the disease are frequent because the environment is conducive for vector survival and proliferation and hence lends to active transmission[9,10]. The Indian military and paramilitary forces are non immune to malaria and deployed along the highly malaria endemic but strategically important borders with neighbouring Bhutan, Myanmar, Bangladesh, and China, where the movement into infested area is a regular phenomenon which makes them subjected to the risk of acquiring infections[7]. The present review is an attempt to estimate the trends and frequency of malaria in and around the areas of forces deployment in north east and possible minimal control measures to minimise the malaria burden.



EMCP = Enhanced Malaria Control Programme.
Source: Malaria country profile 1995–2007[8].

Figure 1. North-eastern states showing very high annual parasitic index (API) in India.

2. VECTORS AND PARASITE PREVALENCE

The climate window of northeastern states offers rich mosquito fauna with diverse and vast breeding habitats throughout the year. Out of the six recognised primary

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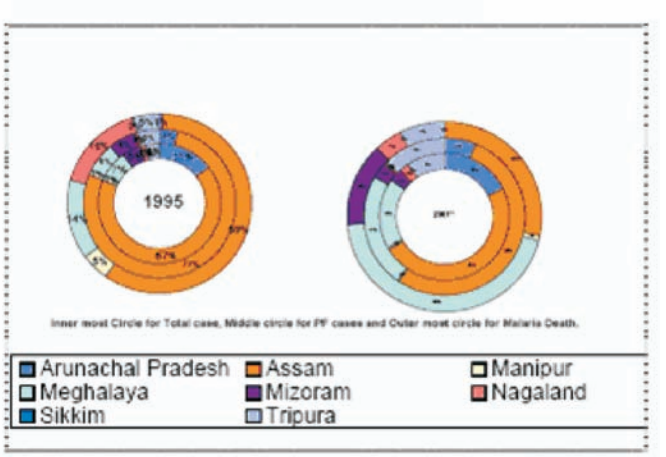


Figure 2. Contribution (%) of malaria cases, Pf cases and deaths amongst northeast states[8].

vectors of malaria in India, namely, *Anopheles culicifacies*, *An. stephensi*, *An. dirus*, *An.fluviatilis*, *An. minimus* and *An. sundaicus*[11] the three major vectors, viz., *An. minimus*, *An. fluviatilis* and *An. dirus* have been reported to be responsible for uninterrupted malaria transmission in the north east[12]. These have exophagic and exophilic behavior and high efficiency which further aggravate the situation[13]. However a total 23 Anopheles species has been described[9] which include four vectors of secondary importance namely *An. annularis, An. varuna, An. jeyporiensis* and *An. philippinensis*[14]. The abundance of Anopheles species biting on human host elucidates their anthropophilic behaviour (Table 1). The vector species in most areas are widely present during the wet season however their prevalence in low number during winter season can not be overruled, confirming the malaria transmission profile round the year[8]. The military personnel being highly mobile and having odd working hours are vulnerable to the bites of infected mosquito and therefore become infected. *Plasmodium falciparum* also referred as 'The Killer Parasite' elsewhere is the predominant malaria parasite contributing 60 per cent of total infections whereas the remaining cases are shared by *Plasmodium vivax*[15]. However, a few countable cases of *Plasmodium malariae*[16] and *Plasmodium ovale*[17] infection have been diagnosed in NE but still their contribution towards the malaria scenario as a whole seems to be negligible.

Table 1. Anophelines and their abundance in cattle sheds (evening collections), house dwellings (day resting) and human bait (night biting) collections in Assam[9]

Species	Density per person per hour		Biting rates per person per night
	Evening collections	Day resting	Night biting
An. aconitus	0.87	0.12	3.47
An. annularis	1.48	0.24	1.15
An. barbirostris	0.38	0.00	0.15
An. culicifacies	0.08	0.01	0.03
An. dirus	0.003	0.002	0.53
An. fluviatilis	0.00	0.68	0.00
An. hyrcanus group	6.25	0.01	0.35
An. jamesii	0.12	0.00	0.00
An. jeyporiensis	0.18	0.24	0.24
An. karwari	0.08	0.00	0.00
An. kochi	1.70	0.01	1.29
An. maculatus	0.24	0.06	0.18
An. majidi	0.02	0.00	0.00
An. minimus	0.12	6.58	5.82
An. pallidus	0.30	0.00	0.12
An. Ohilippinensis/ nivipes	13.80	0.04	2.59
An. ramsayi	0.06	0.00	0.00
An. splendidus	0.20	0.01	1.32
An. subpictus	0.06	0.00	0.06
An. tessellates	0.17	0.00	0.12
An. theobaldi	0.01	0.00	0.00
An. vagus	4.79	6.15	0.88
An. varuna	0.22	1.52	1.74

3. MALARIA VERSUS MILITARY

Malaria has shaped the course of history for millennia and has always been part of the ups and downs of nations and kingdoms; of wars and of upheavals. Many kings and military leaders were struck down in their prime by malaria and many other great warriors succumbed to malaria after returning from the warfront. In many conflicts, more troops were killed by malaria than in combat. The activities of the armed forces would create thousands of breeding places for the vector mosquitoes and thus greatly increase the transmission. Even in recent years, extensive movement of non-immune soldiers, night vigils and other activities like cine-viewing, inadequate use of mosquito nets, and other protection methods, failure to take chemoprophylaxis or even in chemoprophylaxis[18] and its adverse effects has contributed to the rising cases of malaria in war time as well as in peace. During the World War II, many troops had to suffer casualties by inflicted malaria. Gen Douglas MacArthur's of US Army was not at all worried about defeating the Japanese, but was greatly concerned about the failure to defeat the Anopheles mosquito which killed 60,000 US troops in Africa and the South Pacific from malaria. US Forces could succeed only after organising a successful attack on malaria[19]. Therefore in recent the military research centres of various countries are continuously engaged in research and development of newer antimalarial drugs, vaccines, and effective vector management protocols.

3.1 Malaria in Army and General Reserve Engneering Force

The personnel of road construction company (RCC) of General Reserve Engineering Force (GREF) located in northeast and infantry soldiers patrolling to give the security cover in the farmost areas of the region have been investigated for malaria[13]. The incidence of malaria among army soldiers and GREF personnel are mainly due to *Plasmodium falciparum* (Table 2). The GREF personnel have significantly more malaria ($x^2 = 8$, $df = 1$, $p = 0.0045$, OR = 0.26, 95 % CI = 0.09 – 0.75) than army because of better discipline in army. Moreover, GREF deploy local labour for rapid road work, which have high slide positivity rate[20] and may serve as a reservoir of malaria parasite to the susceptible GREF. The *Plasmodium vivax* infections have also been reported in army[21]. In an another study[22] data from five consecutive years (2002 – 2006) indicated that the disease burden due to malaria ranged from 3.6 % to 7 % in different army units located in Assam.

Table 2. Incidence of malaria in Army and GREF personnel[13].

Category	Attacked	Not attacked	Total
Army	9 (17.65%)	42 (82.35%)	51 (100%)
GREF	18 (45%)	22 (55%)	40 (100%)

3.2 Malaria in Central Reserve Police Force and Boarder Security Force

The Central Reserve Police Force (CRPF) personnel like other forces are highly mobile and operate in highly malaria prone areas. They are mostly non immune population and hence the acquired infections are often associated with severe clinical manifestations. The three consecutive years (2001-2003) data of malaria[7] revealed that > 7 % of total indoor cases of all diseases are due to malaria whereas the death contribution due to malaria is > 13 % (Table 3). Based on the CRPF Base Hospital records, it was concluded that *P. falciparum* was predominant to *P. vivax* (> 80 % of cases, $t = 18.9$, $df = 4$, $p < 0.001$) among the total malaria cases, and was responsible for considerable mortality associated with cerebral complications. The difference in slide positivity rate (SPR) among the three study years was highly significant ($x^2 = 22.53$, $df = 2$, $p < 0.001$). Border Security Force (BSF) is another force which faces tremendous morbidity due to malaria. The force has been deployed along the Bangladesh border in NE sector. Their routine duty involves patrolling on the border in night hours and thus fall prey to the dreadful disease. In most of the cases, the affected personnel are given treatment at local health centers. The ailing soldiers recover, but the illness recurs. Out of over 8,000 BSF soldiers hit by malaria this year (2008-09), eight soldiers died[23].

3.3 Malaria in Sashtra Seema Bal and Indo Tibeten Border Police

Sashastra Seema Bal (SSB) is the other paramilitary force in NE region to safeguard the people and prevent illegal activities on malaria sensitive Indo Bhutan Border. These forces face heavy constraints due to mosquito nuisance and malaria. To understand the malaria in SSB, 257 blood smears were collected and examined in two SSB units/ outposts at Bhairabhkund, Udalguri district near Bhutan border in 2005 (Table 4). 26 slides (> 10 %) were diagnosed for *Plasmodium* infection with 19 (> 73 %) shared by P. falciparum and 5 (>19%) by *P. vivax*. The unit I was newly set and had very high malaria rate than the other ($x^2 = 27.57$ $df = 1$, $p < 0.001$). The Indo Tibetan Border Police (ITBP) is deputed to safeguard the Sino-Indian border in Arunachal Pradesh. These forces are also vulnerable to malaria incidences as many lives are thrived due to malaria every year in the state. Recently, deaths have been reported from an area where ITBP is having base camp for border operations[24]. However much data about incidence of malaria in ITBP is not available as now.

3.4 Malaria in Tripura State Rifle

Tripura State Rifle (TSR) is the main paramilitary force of Tripura, which is responsible for providing security to

Table 3. Relative disease burden due to malaria in CRPF based on records of Base Hospital III, Guwahati, Assam[7]

Year	No of indoor cases (all diseases)	No. of admissions/ referral cases due to malaria (%)	No. of positive cases		No. of cases with cerebral involvement	No of deaths due to *P. falciparum* (%)	Total deaths (all diseases)
			P. falciparum (%)	*P. vivax* (%)			
2001	945	90 (9.5)	84 (93.3)	06 (6.7)	16	2 (13.3)	15
2002	1064	43 (4.0)	40 (93.0)	03 (7.0)	06	2 (8.0)	25
2003	1177	89 (7.6)	75 (84.3)	14 (15.7)	18	4 (21.0)	19
Total	3186	222 (7.0)	199 (89.6)	23 (10.4)	40	8 (13.6)	59

Table 4. Malaria situation in SSB

Unit/outpost	BSE	Positive (SPR)	Pf (%Pf)	Pv (%Pv)	Mixed (%)
I	70	19 (27.1)	12 (63.2)	5 (26.3)	2 (10.5)
II	187	7 (3.7)	7 (100)	Nil	Nil
Total	257	26 (10.1)	19 (73.1)	5 (19.2)	2 (7.7)

BSE = Blood smears examined; SPR = Slide positivity rate
Source: Defence Research Laboratory Record, 2005.

the inside dense forest areas of state. These forces are highly mobile due to regular patrolling duties and frequent movement into the malaria endemic patches along the Bangladesh border, and thus are subject to risk of acquiring malaria infections[7]. A year long study (July 2007 to April 2008) was carried out in 8th Battalion HQs and two of its outposts under a project (DRL-24) sanctioned by DRDO. The TSR jawans of the units and civil people inhabiting the force area were actively surveyed for malaria parasite. A total of 556 cases suspected for malaria were examined by both rapid detection kit (RDK) and microscopic methods, which confirmed 204 malaria positives (Table 5) having 179 infections due to *P. falciparum* and rest contributed by *P. vivax*. High SPR (> 36 %) significantly encompassed the role of malaria in hampering the insurgency operations of the force. There was no difference between SPR of two study years (x^2 = 3.33, df = 1, p > 0.05), however the SPR in TSR personnel during the study was very low as compared to civil (x^2= 19.98, df = 1, p< 0.001).

3.5 Malaria in Biological War

Easy replication, storing and quite devastating properties of malaria parasite make it suitable candidate as biological warfare agent. The thought of using malaria as bio-weapon is not novel as French emperor, Napoleon, has used it in 1809 against British armed force of 39,000 men in Walcheren expedition in the Low countries, when the British were conquered by malaria before a battle could be fought. Napoleon reportedly flooded the Holland countryside to allow malaria to become rampant. He reportedly stated, "We must oppose the English with nothing but fever, which will soon devour them all." The British estimated that in all of wars between 1793 and 1815, the total human life losses were 2,40,000 with probably less than 30,000 of those deaths being caused by war wounds[25].

4. SUCCESS STORIES

Various efforts were made to control malaria. The DDT spraying was spectacular success in reducing malaria-related morbidity[26]. The result of malaria eradication programme was so overwhelming that malaria was considered a disease of the past which led malaria to be a neglected disease. However malaria emerged, multiplied, and became the 'king of diseases'. The DDT yielded relief, in the beginning its efficacy was overestimated and use was done non judiciously, which might have been one reason for the setback suffered on controlling malaria. However, there have been some encouraging results of efforts to control malaria at small scale, which may serve as models to nationwide application.

4.1 Malaria Free Cantonment

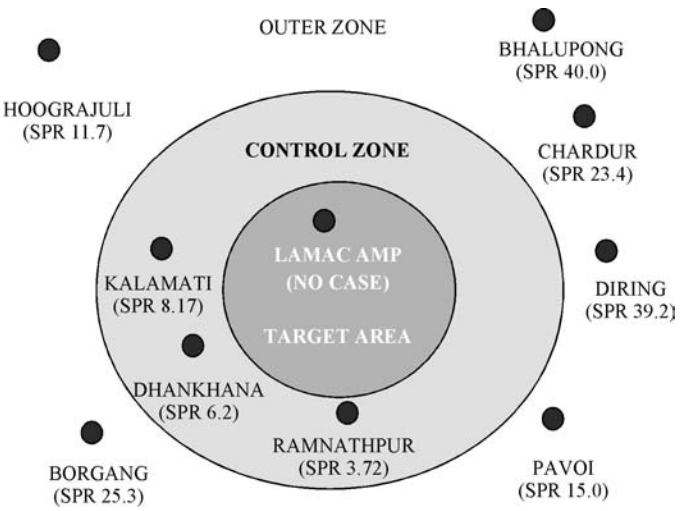
Missamari area of Sonitpur district, Assam, is regarded as high endemic area for malaria with perennial prevalence and transmission. Missamari cantonment (diameter >1 km) is important in strategic point of view. A detailed study was carried out in nine villages surrounding the cantonment

Table 5. Malaria in TSR

Year	BSE (n)		Malaria (m)		Pf (f)		Pv (v)		Total = n/m 'f, v'	SPR	SFR	%Pf
	TSR	Civil	TSR	Civil	TSR	Civil	TSR	Civil				
2007	256	149	63	74	50	64	13	10	405/137 '114,23'	33.8	28.1	83.2
2008	90	61	33	34	31	34	2	0	151/67 '65,2'	44.4	43.0	97.0
Total	346	210	96	108	81	98	15	10	556/204 '179,25'	36.7	32.2	87.7

Source: Defence Research Laboratory Record, 2008.

area with regular monitoring of vector and parasite (Fig. 3). Minimal effective measures were taken which included: active surveillance, radical treatment, indoor residual spray(IRS), insecticide-treated bed nets (ITBN) and repellents as personal protection measures (PPM) and biolarvicides. Malaria awareness camps for soldiers and civil were organised in regular intervals. After one year of monitoring, no malaria case could be detected among the soldiers of the target area (Lama Camp), however low SPR was recorded in the neighbouring villages kept as control.



Control Zone: Diameter 1.5 kms

Source: Defence Research Laboratory Record 1997.

Figure 3. Malaria free cantonment in Assam.

4.2 Malaria Control in Jorajan Forest Camp

A retrospective analysis of month-wise malaria cases among the Jorajan Central Industrial Security Force (CISF) camp inmates revealed an increasing trend of malaria since 1996–97 and a malaria control strategy was formulated which included: reduction of man–vector contact, chemoprophylaxis, and epidemiological and entomological monitoring. After strict implementation of the strategy only five malaria cases (all *P. falciparum*) were reported from the Jorajan camp between June 2000 and May 2001 and therefore reducing the malaria load significantly (> 90 %)[27].

4.3 Malaria Control in Sonapur

In Sonapur area of Assam the 'insecticide-impregnated nets' tested by Malaria Research Centre (MRC), Sonapur, could reduce the malaria incidence in intervention villages by 70 % in two years (1988–90) as compared to the baseline year 1987. This simple and economical control strategy emphasised largely on the reduction of man-mosquito contact and resulted marked reduction in malaria cases[28].

5. CONCLUSIONS

Malaria has become a byproduct of infrastructural development and soaring exponentially, still the control can be achieved after proper understanding of local epidemiology pattern. The health agencies have always been determined to eradicate malaria but the emergence of drug resistance, widespread resistance to available insecticides, wars, massive population movements, and lack of community participation have made the long-term maintenance of the effort untenable.

Malaria episodes have been reported from the armed forces all around the world as the troops are not able to take precautions during operation and duty hours[29,30]. In malaria hyper endemic areas such as north eastern region of India, the military forces have always been at the risk of malaria infection probably due to duty demand and sometimes movement of susceptible soldiers from the non endemic zone. The malaria statistics in forces changes every year in the adjacently located units and even in the same unit. This may be associated with the number of fresh soldiers moved into the unit or a new unit raised/ moved in from other regions. The troops are normally on chemoprophylaxis but malaria is still recorded due to potential burden of parasite in highly malarious ecosystem. In such situation, the demand of extra investment in case detection, warning or forecasting system, emergency responses by government or non governmental organisations may not be the most appropriate and cost-effective method for control. However investment in sustainable approaches to vector control (spraying households with residual insecticide, i.e., IRS), promoting individual protection (ITBN and repellents, i.e., PPM) and effective case management are more useful. Health education among soldiers at grass root level is of paramount importance for effective translation and implementation of the designed technology[31]. In addition, the use of indigenous and eco-friendly chemicals[32] and insecticide pre-treated patches applies on uniform[33] could be able to provide the better malaria solution to the troops in malarious zones.

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Contributors

Mr Sunil Dhiman obtained his MSc and MPhil from Dr Bhim Rao Ambedkar University, Agra, during 2003 and 2005, respectively. He is presently working at Medical Entomology Division, Defence Research Laboratory (DRL), Tezpur, on xenomonitoring of malaria parasite, development of herbal products for mosquito control and repellent impregnation of military uniform.

Dr Indra Baruah obtained his PhD from Gauhati University, Guwahati. Presently, he is working as Scientist 'D' and Head, Medical Entomology at DRL has isolated a potential entomopathogenic *Bs* strain from northeast. His area of work includes taxonomy of vector mosquitoes and their biological control.

Dr Lokendra Singh obtained his PhD from Punjab Agricultural University, Presently, he is Scientist G and Director, DRL. He was deputed to Antarctica during 1994-95. He has made outstanding contribution in the development of bioremediation system for human waste at extreme low temperature.