J Vector Borne Dis 52, June 2015, pp. 178–181

Declining trend of malaria in Car Nicobar Island, inhabited by the Nicobarese tribe: Plausible factors

I.P. Sunish, Zahid Ali Khan, A.N. Shriram & P. Vijayachari

Regional Medical Research Centre (ICMR), Port Blair, India

Key words *Anopheles sundaicus*; Car Nicobar; larvivorous fish; malaria

The Andaman and Nicobar Islands have been historically known to be endemic for malaria[1]. However, during the past few years, its prevalence has been declining in three districts of the union territory, *viz*. (i) Nicobar; (ii) South Andaman; and (iii) Middle & North Andaman (Table 1). This is due to the strengthening of vector control activities (indoor residual spraying, weekly application of larvicides, *etc*) by local malaria department. Various health campaigns focused on adopting preventive measures against mosquito bites (repellents and bednets), enhanced the disease awareness among the community and helped in the early treatment seeking behaviour. Among the three districts, disease prevalence was highest in the Nicobar. This district accounts for only 9% of the population of Andaman and Nicobar Islands (36,842/ 3,80,581 census 2011), but contributed to 76% of malaria cases as per Department of Health Services, Port Blair, Andaman and Nicobar Islands. Both *Plasmodium vivax* and *P. falciparum* malaria are reported, and 17% of total cases were due to the later. However, the disease prevalence was found to reduce drastically during the past few years. The annual parasite incidence (API) declined from 92.28 in 2009 to 10.36 in 2014 (Table 1). This drastic decline was due to better hygienic measures adopted by the Nicobarese tribal population, improved living conditions by the post-tsunami developmental activities of the Nicobar administration and also the control measures undertaken by the malaria department. Each district consists of three tehsils, and the tehsils of Nicobar district, *viz.* Car Nicobar, Nancowry and Great Nicobar, have diverse topographies. Car Nicobar tehsil is a plain land, while Nancowry is a hilly terrain with dense forest tracts, and Great Nicobar has an admixture of both terrains.

Anopheles sundaicus (Diptera: Culicidae) has been reported to be the most predominant mosquito species transmitting *Plasmodium* causing malaria[2]. In-depth studies on the bioecology of *An. sundaicus* have been undertaken in creek and non-creek areas of Car Nicobar Island.

Table 1. Malaria cases in the three districts of Andaman and Nicobar Islands (2009–2014)

District	Variables	2009	2010	2011	2012	2013	2014
South Andaman	Population	318486	282587	306865	306865	280498	281708
	Blood smear examined	57791	60456	43227	42343	38697	34854
	Number positive	452	792	330	326	279	107
	SPR (%)	0.78	1.31	0.76	0.77	0.72	0.31
	ABER (%)	18.15	21.39	14.09	13.80	13.80	12.37
	API	1.42	2.80	1.08	1.06	0.99	0.38
North & Middle Andaman	Population	107248	112248	142526	142526	141648	140715
	Blood smear examined	19287	28724	24990	26313	19654	20432
	Number positive	212	346	263	162	81	25
	SPR (%)	1.10	1.20	1.05	0.62	0.41	0.12
	ABER (%)	17.98	25.59	17.53	18.46	13.88	14.52
	API	1.98	3.08	1.85	1.14	0.57	0.18
Nicobar	Population	55223	55163	41368	41368	40375	41011
	Blood smear examined	56420	46109	29011	26694	19777	19589
	Number positive	5096	1581	1325	1045	649	425
	SPR (%)	9.03	3.43	4.57	3.91	3.28	2.17
	ABER (%)	102.17	83.59	70.13	64.53	48.98	47.77
	API	92.28	28.66	32.03	25.26	16.07	10.36

SPR–Slide positive rate; ABER–Annual blood smear examination rate; API–Annual parasite incidence.

This vector mosquito species is primarily zoophagic (prefers to feed more on animals)[3], exophilic (prefers to rest outdoors) and exophagic (prefers to feed outdoors). It is an opportunistic feeder and exhibits peak biting activity from 2000 to 0300 hrs. The species breeds mainly in lagoons and creeks. The rDNA sequence of *An. sundaicus* breeding in two distinct water bodies (freshwater and brackish water) from the islands of Nicobar district indicates the existence of only single species, *i.e. An. sundaicus* D[4].

The Car Nicobar (located at 9.16°N, 92.75°E) spanning over 127 km^2 area is a flat terrain, except small hilly areas in the interior. The climate is tropical due to its equatorial proximity. The average annual rainfall is 2380 mm with >100 rainy days. The decadal meteorological data show that the mean relative humidity in the Island is 79%, and the mean maximum and minimum temperatures are 30.2 and 23°C, respectively. Native aboriginal Nicobari tribal community belonging to the mongoloid race, inhabit all the 15 villages of this island. The breeding habitats of the vector were cesspools, road-side ditches, mangrove swamps and rain water drain (Fig. 1). The total population is 17,125 (census 2011), with an average of 279 households per village.

Malaria was rampant in the Car Nicobar Island before and subsequently after the tsunami in 2004, which devastated the island rendering the inhabitants homeless. Subsequent to 2006, malaria prevalence gradually declined. Currently, the API during the year 2014 was 1.21 in Car Nicobar, while its value was >25 in the other tehsils of the district (Fig. 2). One of the reasons for the negligible number of cases in Car Nicobar was large-scale release of larvivorous fish, *Gambusia affinis,* in the stagnated water bodies of the island[5]. During mid-1980s, National Institute of Malaria Research, erstwhile Malaria Research Centre under the *aegis* of Indian Council of Medical Research, India, demonstrated the use of larvivorous fish as part of an integrated vector control strategy for the control of malaria. The strategy included earth levelling works, release of *G. affinis* fishes, biweekly application of *Bacillus sphaericus* in marshy areas and installation of one-way sluice gates. It was reported that over the years, with a better understanding of the transmission dynamics of malaria and introduction of bioenvironmental control strategy, the API declined from 19.4/1000 in 1989 to 4.3/1000 in 2002[6]. Large-scale production and release of *G. affinis* was carried out, and hatcheries were established in Andaman (Port Blair) and Nicobar (Car Nicobar, Katchal, Nancowry and Campbell Bay) group of islands. These fishes were released in the habitats that support breeding of *An. sundaicus.* This proved to be effective in bringing down the vector population/abundance, thereby decreasing the transmission levels[6]. The API in this island reached a lowest value of 0.6/1000 in the year 2013 (Fig. 2)

Fig. 1(a-d): Breeding habitats of vector mosquitoes– (a) Cesspool; (b) Road-side ditch; (c) Mangrove swamps; and (d) Drain.

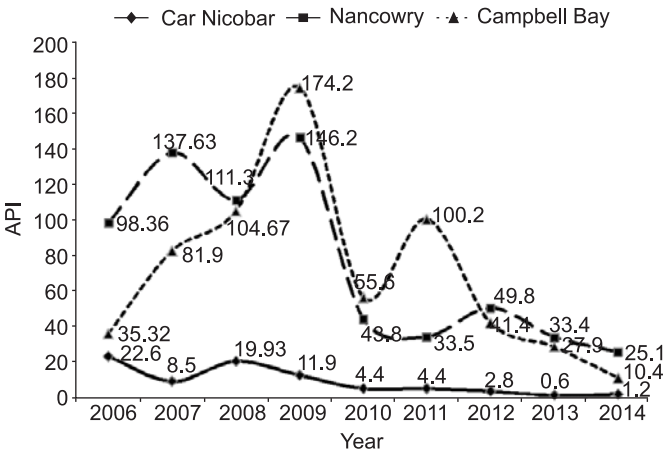

Fig. 2. Annual parasite incidence (API) in the three tehsils of Nicobar district.

In order to investigate plausible reasons for malaria decline in Car Nicobar Island, vector mosquito survey and case incidence details were analyzed. To determine the extent of anopheline prevalence, survey of mosquito immatures in the stagnated ground water bodies was carried out, by employing a standard long handled dipper. A sample of the immatures was brought to the laboratory for rearing and was identified to species level, following

standard taxonomic keys. Most of the large water bodies were found to be inhabited by fishes, and therefore, did not support breeding of mosquito immatures of any species. Anopheline immatures were collected from the water bodies formed along the roadside ditches, and also from the water pools created along the sides of rivulets flowing through the villages, which were draining out into the sea. The anophelines were also collected from the water bodies of mangrove swamps along the southern part of the Island (Kimious village). The immature survey in five villages of Car Nicobar, *viz*. Perka, Kakana, Kinmai, Small Lapathy and Arong revealed that out of 199 dips, 11 were positive for anophelines, and the per dip density with respect to anophelines was 0.57 (114/199 dips).

The adult anophelines were collected through all night landing catches (ANLC) in the five villages. Collections were made throughout the night from 1730 hrs to the next day 0530 hrs, to determine the human landing rates of the vector mosquito. Survey was carried out for two nights in each village and the mosquitoes landing on a human volunteer were collected (before the act of biting), using an oral aspirator and a torch light. The study was cleared by the Institutional Ethical Committee. A total of ten whole night landing collections were made. Collections from the five villages revealed negligible number of anophelines. The anophelines obtained from the immature and adult collections (human landing) were identified as *An. sundaicus*. The other predominant mosquito species were *Culex bitaeniorhynchus, Cx. quinquefasciatus,* and other *Culex* sp. The average per night landing collection per bait for all the mosquitoes caught was 348.5, and for anophelines it was 24.7. Comparatively, more number of anophelines was collected from Kakana village (Fig. 3), which could be due to its proximity to the coastal line.

The details of malaria case incidence were obtained from the Malaria Department, Directorate of Health Services, Port Blair. These data were consolidated and analysed to determine the trend in malaria incidence in the three districts of Andaman and Nicobar Islands. Tehsil- wise analysis was also carried out with special emphasis on Car Nicobar Island. During the years 2009–2014, the API was ≤2 in the two northern districts of the archipelago. In Nicobar district, the values were much higher, and during the year 2014 it was 10.36 (Table 1). However, the values were negligible in Car Nicobar tehsil of this district during the past five years (Fig. 2).

Larvivorous fishes in mosquito control have been successfully used for more than a century[7]. As compared to insecticides, fishes are shown to be more efficient and environment friendly. They are harmless to both humans

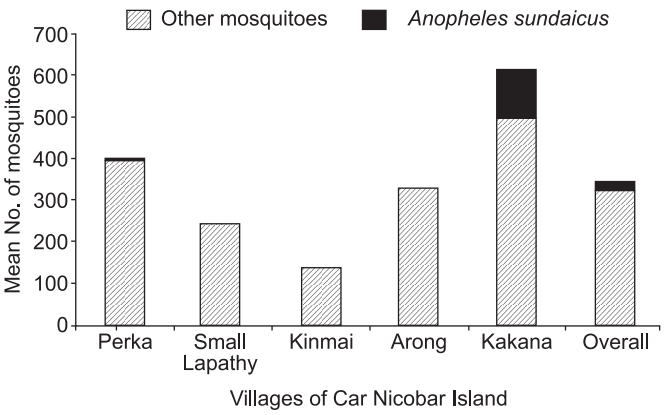

Fig. 3: Average number of mosquitoes landing on human bait in Car Nicobar Island

and other non-target organisms, economical and exhibit lower risk of resistance development in mosquitoes[8]. Although, larvivorous fishes were released in the major water bodies of all islands in the Nicobar group, they persisted mainly in the Car Nicobar island, probably due to its flat terrain when compared to other islands, *viz*. Nancowry and Campbell Bay. Larvivorous fishes were found to inhabit all the perennial water bodies of the Car Nicobar, and were identified as *G. affinis*. During heavy rains, when the water bodies overflowed, the water along with the fishes populated the newly formed transient water habitats. Thus, in the temporary pools also, these fishes were able to control the mosquito immature abundance. However, in the perennial water bodies, the fishes were observed to establish themselves very effectively.

Observations from the present study visibly highlight negligible breeding of vector mosquitoes and thereby minimal man landing anophelines in the Car Nicobar Island. Use of larvivorous fishes is a simple, cost-effective, and a site specific measure for vector control. Integrated vector management (IVM) efforts are now oriented towards controlling *Anopheles* either at the larval stages and/or at the adult stages by means of biological control agent[9], whereas various concerns at the ecological, environmental, social, and economical levels are carefully considered[10].

Additionally, the drug, azithromycin has been mass administered in Car Nicobar Island, in order to reduce the high prevalence of trachoma[11]. This could be a contributory factor in reducing malaria parasitaemia in this island. In Niger district, mass distribution of azithromycin during the dry, low-transmission season was associated with the reduced community prevalence of malaria and the parasite density, 4–5 months after drug administration[12]. However, this hypothesis needs to be validated in this island. A survey on the use of mosquito repellents showed that almost 97% of the households (N = 450)

were using the mosquito coils and/or vapourizers to prevent man-mosquito contact.

In view of the current prevailing situation in the Car Nicobar Island, there is a window of opportunity to move towards achieving the goal of malaria elimination in this island. We conclude on a positive note that a robust health infrastructure exists in this island, and that the vector control strategies are being implemented by the malaria department under the *aegis* of NVBDCP. Nevertheless, there is a need for further strengthening of these activities to reach the goal of elimination. For instance, monitoring of various potential breeding habitats needs to be carried out at regular intervals, in order to assess the presence/absence of fishes. Periodic surveys are needed for identifying new breeding sites of mosquito immatures and for their control using release of larvivorous fish. Better awareness on malaria and its prevention methods can be created among the inhabitants of Car Nicobar through information, education and communication (IEC) campaigns, *via* tribal council, the church priests and the village headmen, who are most revered. The traditional healers, whom most villagers approach for treatment, can be roped into the main stream, for malaria elimination strategy. Together, they wield enormous power over the Nicobari tribe residing in this island. Therefore, these elements need to be factored, for putting in place an appropriate strategy to hasten the process of malaria elimination in Car Nicobar Island.

ACKNOWLEDGEMENT

The authors greatfully thank to Sh Subroto Biswas, District Malaria Officer, Port Blair, for his help in obtaining malaria data of the island.

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Correspondence to: Dr I.P. Sunish, Regional Medical Research Centre, RMRC–ICMR Field Unit, Perka Village, Car Nicobar–744 301, India. E-mail: sunish67@yahoo.com

Received: 27 September 2014 *Accepted in revised form:* 10 March 2015