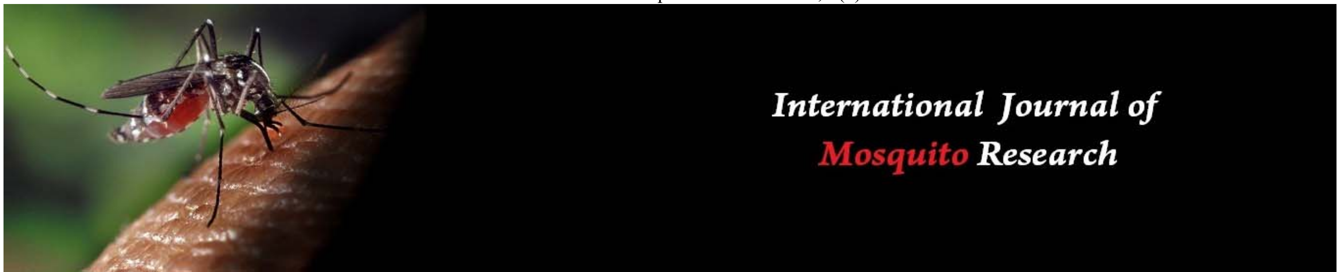

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Decline of malaria in Gadchiroli district of Maharashtra state, India

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Abstract
Globally, malaria is one of the most prevalent infectious diseases, with more than 216 million people at the risk of infection. India is the largest contributor of the disease among the Southeast Asian countries. This study was undertaken to assess the present situation of malaria and its severity, the prevalence of its vectors in Gadchiroli district of Maharashtra. The epidemiological as well as entomological investigations were carried out in 46 villages of three high malaria-endemic PHCs under the Gadchiroli district. Most of the villages are situated in deep forest and forest fringes remote areas of the district. Adult mosquitoes were collected from indoor and outdoor resting, and identified to species level as per the standard keys. A total of 841 blood slides were collected from the local population and examined; of which 227 slides were found positive for malaria parasites (87 for *Plasmodium falciparum*, 36 for *Plasmodium vivax* and 104 mixed infection. The mosquito identification revealed 12 mosquito species belonging to the genus *Anopheles*. In total, 2579 *Anopheles* mosquitoes were recorded; the average man hour density (MHD) lowest (9.02) for human dwellings and highest (46.98) for cattle sheds. The epidemiological data showed that the malaria transmission in the district occurs throughout the year. Month-wise analysis of malaria reported cases revealed rise in the number of cases from July onwards till attaining peaks in the months of November to January. After the month of February, there was a decline in number of malaria cases with very few cases reported during the months of May to June. Annual trend of malaria showed that the cases declined from 34206 in 2014 to 5484 cases in the year 2017. Therefore, there is a need to strengthen the surveillance in these highly malaria endemic PHCs for containment of malaria.

Keywords: Mosquitoes, *Parthenium hysterophorus,* bio-pesticides, percentage mortality, larvicidal agents, *Aedes aegypti*

Introduction
Despite substantial efforts towards achieving malaria elimination, the infection continues to be a significant public health burden across 87 countries of the world affecting almost half of the world's population. As per the latest World malaria report 2018, 4.35 lakhs people died from malaria globally [1]. Malaria is curable disease, if effective treatment is started early but delay in treatment may lead to serious health issues including death [2]. Malaria spreads through the bite of female *Anopheles* mosquitoes. There are six primary vectors of malaria in India namely, *Anopheles culicifacies, An. stephensi, An. fluviatilis, An. minimus, An. dirus* and *An. sundaicus* while *An. varuna, An. annularis, An. philippinensis* and *An. jeyporiensis* are the four secondary vectors [3-4]. *An. culicifacies* Giles alone contributes about 65% of the total cases of malaria annually and is the widespread malaria vector of rural and peri-urban areas. *Plasmodium vivax* and *P. falciparum* are the most prevalent malarial parasites in India [5, 6–8].
India, with about 0.84 million malaria cases and 194 deaths in 2017, still has very high mortality and morbidity rates due to this deadly disease [2]. Central part of the country is highly malaria endemic with more than 90% of the population at risk of infection [5]. In Maharashtra state, 17710 malaria cases and 20 deaths were reported in 2017 by the National Vector Borne Disease Control Programme (NVBDCP) [2].
Gadchiroli district of Maharashtra is one of the highest malaria endemic districts, where 11372 malaria cases were reported in the year 2008 and 5484 cases in 2017, of which *P. falciparum* accounted for 74.91%. Slide positivity rate (SPR) in the district has been ranging from 0.92% to 4.57% between the years 2008 and 2017. More than 67% malaria cases were from 12 PHCs including three rural hospitals out of 47 PHCs (data provided by the state health department). The main vectors of malaria in Gadchiroli are *An. culicifacies* and *An. fluviatilis* and their control depends on application of insecticides.

Indoor residual spray (IRS) and use of insecticide-treated bed nets (ITBNs) are effective strategies to control malaria [5]. The vector control is a major part of the strategy for malaria control to stop transmission of parasite through interventions targeting adult *Anopheles* vector mosquitoes. For control of malaria, the district has been receiving two rounds of spray with a synthetic pyrethroid alpha-cypermethrin insecticide every year and regular use of ITBNs [9]. The district is covered by the enhanced malaria control project (EMCP) programme supported by the WHO. Vector borne disease control programme of the state was benefited from the EMCP funded by the World Bank from 1997 [10]. More than 11000 malaria cases were reported annually during the years 2008–2010 which further increased significantly from 2011 onwards. Maximum malaria cases were reported in 2014 (n = 24469) and 2015 (n = 34206). Though there was decline in the reporting for the year 2017 (n = 5484).

There is a wide gap of 68 to 98% between reported malaria cases and the actual incidence of malaria in India [3]. Gupta *et al*. (2009) have also reported that several malaria cases managed at private healthcare facilities with self-diagnosis are not included in the official statistics or national malaria data reported by NVBDCP, thereby resulting in under estimation of the malaria burden [11]. Therefore, assessment of malaria situation in Gadchiroli may depict the real picture of malaria situation in the district. Study was undertaken to assess the current malaria situation and prevalence of the different malaria vectors in Gadchiroli, with an emphasis to highlight the foci of its severity. The information generated could be useful in finalizing the strategy of malaria prevention and its elimination from Gadchiroli district of Maharashtra state.

Materials and Methods

Study site

Gadchiroli district is highly dense forested district of Maharashtra. Majority of the villages are situated in deep forest and forest fringe remote areas of the district. Most of the houses have mud-plastered walls with thatched/tiled roofs. The number of rooms per family range between 2–5 and all the cattle sheds are mostly attached with human dwellings. The detailed topography, health infrastructure etc. of the district [12] is shown in Table 1.

Collection and analysis of malaria epidemiological data

The primary health centre (PHC) wise malaria epidemiological data for the last ten years, *i.e.* from 2008–2017 was collected from the District Malaria Officer (DMO), Gadchiroli (Figs. 1–3 & Table 2). The data was analyzed to gather information on various parameters, like prevailing malaria situation and its trend, peak months of malaria transmission, and vulnerable PHCs of the district using MS Excel 2007 programme. Different malaria epidemiological parameters such as parasite species, annual blood examination rate (ABER), slide positivity rate (SPR), slide falciparum rate (SFR), *P. falciparum* percent, annual parasite incidence (API) including deaths were also analyzed.

Entomological survey

The entomological investigations were carried out in 46 villages of highly malaria endemic PHCs, namely Murumgaon, Godalwahi and Karwafa for the years 2012–2018 to estimate the prevalence of anopheline mosquito vector in these areas. Adult mosquito collection was carried out from indoor human dwellings and outdoor cattle sheds for determining average man hour density (MHD) by using an aspirator and flash light in the early morning (0500 to 0800h). One man each in human dwellings and in cattle dwellings spent 15 minutes for collection adopting standard WHO recommended hand capture technique. Mosquito larval collection were also done from different breeding habitats and reared till emergence for proper identification. Collected adults were brought to the field laboratory and then transferred to central laboratory established at district level and PHCs level. All the adult mosquitoes were identified (Table 3) as per standard keys [13-14]. In addition, 60 specimens of malaria vectors, *i.e. An. culicifacies* (20), *An. fluviatilis* (20) and *An. annularis* (20) were dissected during the study for gut and gland infection to know the main vector from the district.

Epidemiological survey

Fever survey was carried out in the selected 46 villages by visiting the houses. Blood smears were taken from subjects having fever after obtaining informed consents. Collected blood slides were stained with Giemsa stain and examined for malaria parasite under the microscope and the fever cases were screened with the help of Paracheck rapid diagnostic kits (RDKs). All the positive cases were treated with Blister Packs of ACT as per NBVDCP schedule to prevent further transmission of malaria. The various epidemiological parameters *e.g.* SPR, SFR, *Pf* percent were also analyzed for active surveillance (Table 4).

Susceptibility of malaria vectors against various insecticides

The insecticide susceptibility of malaria vectors was determined in the villages that were selected on the basis of high malaria cases. Susceptibility tests were carried out at diagnostic concentrations of various insecticides such as deltamethrin (0.05%), malathion (5.0%) and DDT (4.0%) against *An. culicifacies* and *An. fluviatilis* (Table 5). In addition, cone bioassay tests were also conducted to assess the quality of IRS on surface wall of houses sprayed with Lambdacyhalothrin and cyfluthrin insecticide after 1 to 4 weeks of spray in 13 villages of the three PHCs.

Results

The entomological studies carried out for determining the mosquito fauna with reference to anopheline mosquitoes showed that 12 mosquito species (belonging to genus *Anopheles*) were prevalent in the study area. In total 2579 *Anopheles* mosquitoes were recorded from the study villages. The overall average MHD of mosquitoes in human dwellings and in cattle sheds ranged from 9.02–46.99. Lowest MHD range (0.00–4.17) was observed for human dwellings while highest MHD range (0.04-21.21) was for cattle sheds which indicates the zoophilic nature of the vector species (Table 3). Maximum number of *An. fluviatilis* were recorded in cattle sheds and found to breed in stream and stream pools in the forest area. *Anopheles annularis* mosquitoes were caught from cattle sheds and human dwellings and were found to breed in paddy field, ponds, ditches, drains, ground pools and pits. *Anopheles culicifacies* captured from the houses of the surveyed villages was found responsible for round the year malaria transmission. Results of additional study on the mosquito gut and gland infection revealed that none of the

Anopheles species was found positive for malaria parasite in the study area.

The results of insecticides susceptibility of malaria vectors showed that the populations of *An. culicifacies* and *An. fluviatilis* were fully susceptible to deltamethrin, partial resistant/tolerant to malathion and highly resistant against DDT (Table 5). The results of cone bioassay tests revealed that the spray was satisfactory for only five villages out of the 13 villages surveyed. Mostly the IRS was not uniform on the wall of the houses in all villages. The spray was found incomplete, patchy, of poor quality and mostly the spraying covered only the outer wall surfaces. The range of *An. culicifacies* mortality decreased significantly with time with 56.6–61.0% mortality after one week and 11.6 –19.0% after four weeks.

Under epidemiological studies, a total of 841 blood slides were collected and examined, out of which 227 slides were found positive for malaria parasites [87 positive for *P. falciparum* (*Pf*), 36 for *P. vivax* (*Pv*) and 104 were mixed infection (*Pv+Pf*)].The village-wise examination of blood slides revealed an average SPR of 26.99%. *Plasmodium falciparum* was the most dominant parasite accounting for 38.32% of the total infections (Table 4). The high SPR and mixed infection rate indicates poor functioning of the health workers and high malaria positivity in the selected area.

The malaria epidemiological data showed that the malaria transmission occurs throughout the year in Gadchiroli district of Maharashtra state. The data revealed that API showed decreasing trend with 20.23 in 2014 to 4.54 in 2017. Though for the year 2015, it was 28.40. Annual blood examination rate (ABER) was good and above 10% as per NVBDCP guidelines for all these years as shown in Table 4. Maximum malaria cases (n = 34206) were reported for the year 2014 with 18 deaths, followed by 24469 cases with 11 deaths for 2015, 9163 cases with three deaths for 2016 and minimum cases (n = 5484) with three deaths were reported for year 2017 (Figs. 1– 3 &Table 2).

Year-wise analysis of reported malaria cases during the decade 2008–17 in different Talukas of Gadchiroli district indicated that cases were higher for 2008–2011; thereafter there was a decline in malaria cases during 2012 and 2013. However, in 2014 and 2015 a major outbreak of malaria was reported. Malaria cases declined after 2015 and there were 5484 cases in 2017 (Figs. 1–3 & Table 2).

Month-wise analysis of malaria reported cases revealed that number of cases starts to rise from the month of July onwards reaching to peak in the months of November to January. After the month of February, there was a decline in number of malaria cases and very few cases were found during the months of May to June.

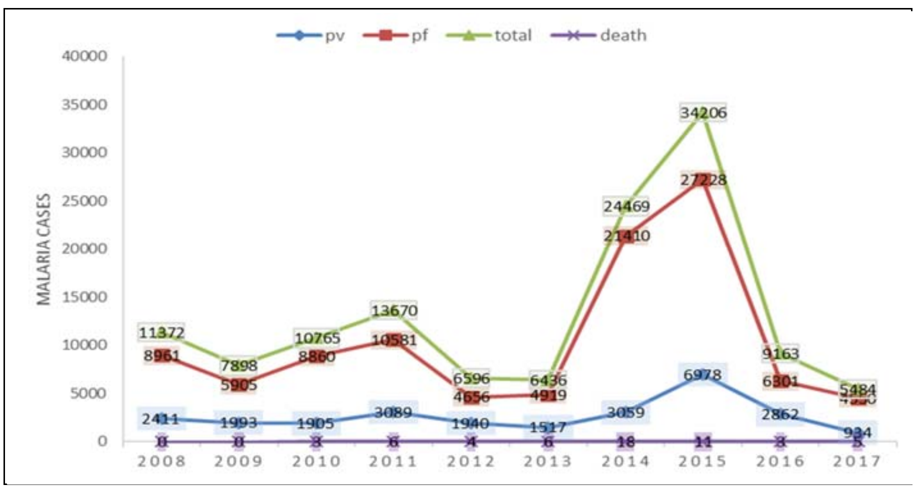

Fig 1: Malaria cases with deaths in Gadchiroli district of Maharashtra State, India (2008-2017)

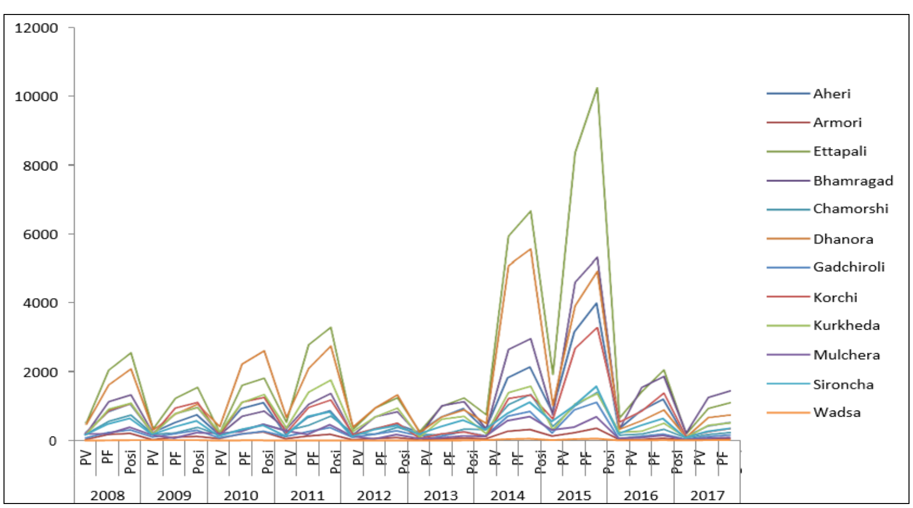

Fig 2: Annual trend of malaria cases with death in different Talukas of Gadchiroli district, Maharashtra (2008–17).

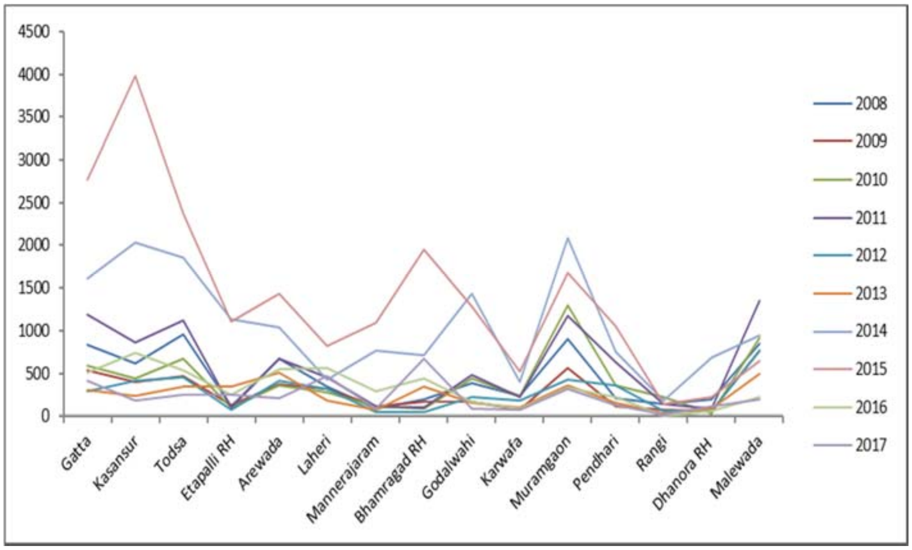

Fig 3: Malaria cases in different PHCs of Gadchiroli district, Maharashtra (2008–17).

Discussion

Malaria control in forest and hilly area is very difficult due to various socio-economical, geographical and ecological factors like presence of abundant water reservoirs with grassy margins, marshy land, streams, stream pools, drains and springs which act as the major sources of mosquito breeding. Water lodged in paddy fields in the downhill also contribute in breeding of mosquitoes. Many malaria vectors present in forest areas in the country are not studied and their respective role in malaria transmission is not clearly understood due to lack of entomological surveys and lack of knowledge of various ecological aspects of forest malaria. Some of the factors responsible for intense malaria transmission in such areas are presence of abundant mosquito breeding habitats, lack of disease awareness, nomadic lifestyle and tribal, cattle shades attached with human dwellings, houses with mud-plastered walls and thatched/tiled roofs (favors malaria vector biting and resting), migration of people, presence of asymptomatic carriers in the community, high man vector contact and probably under dosage of antimalarials.

The highest number of *An. culicifacies, An. fluviatilis* and *An. annularis* were found outdoors in cattle sheds. Dhiman *et al*. (2005) reported that *An. culicifacies*, *An. fluviatilis* and *An. annularis* as vectors of malaria from Dhanora taluka of Gadchiroli district and also observed that there was no evidence of outdoor resting of *An. culicifacies* except in one village of Dhanora PHC, where the vector was found in tree holes in the vicinity of human dwellings. *Anopheles culicifacies* could not be collected in light trap collections made during the survey [15]. Similar studies have been conducted in Godda district of Jharkhand and in Bihar states [16-19]. Earlier researchers have reported both *An. culicifacies* and *An. fluviatilis* as the vectors of malaria in the Gadchiroli district [20–21].

Insecticide susceptibility status of the anopheline vector in Gadchiroli showed that the the vectors, *An. culicifacies* and *An. fluviatilis* are resistant to DDT, tolerant to malathion and susceptible to synthetic pyrethroids. These are in confirmation with one of our previous study conducted in the same district during 2012 [20]. However, one recent study undertaken by Gyan Chad *et al* (2017) showed presence of resistance in *An. culicifacies* against synthetic pyrethroids [21]. Therefore, to confirm these findings, further in depth studies on insecticide susceptibility status of malaria vectors in Gadchiroli are necessary.

Results of epidemiological survey indicated the presence of high percentage of symptomatic carriers of malaria parasites in the local population with more *Pf* percentage than reported in data provided by the state health department. Other researchers have also conveyed under reporting of the malaria cases from other states of the country [5, 11]. Recently similar studies have been carried out by the earlier researchers working on under reporting of malaria cases in Delhi and other states including Gadchiroli district of Maharashtra [15, 20, 22–23].

Under reporting of malaria cases might be a barrier to achieve the goal of eliminating malaria from India by 2030. Underreporting of malaria cases is due to miss-detection/misdiagnosis by RDT kits and microscopic methods or due to human error. Misdiagnosis of malaria parasite might be the cause of development of immunity and asymptomatic carriers in the community [24]. For accurate estimation, improved microscopic diagnosis of malaria parasite and PCR method may be included for examination especially for negative slides of malaria parasite. The PCR methodology is very reliable and fast method to detect malarial infection [25].

The district is receiving two rounds of IRS with a synthetic pyrethroid alpha-cypermethrin. The use of insecticide-treated bednets (ITBNs) is the most effective method to control and prevent malaria [26]. In spite of these control measures, malaria remains a serious public health problem in Gadchiroli district of Maharashtra. Though, in the year 2017, the malaria cases declined in comparison to the year 2008. There may be chances of outdoor transmission of malaria parasite in Gadchiroli as most of the tribal population goes to forest for their earnings and livelihood. Therefore, to minimize the outdoor biting of mosquitoes, use of suitable mosquito repellent should be encouraged in the community. It may play a great role for controlling malaria in the district. The study necessitates improve the quality of insecticides spraying strategy for control of malaria vectors in the district.

Most of the malaria cases are being reported from rural and remote areas of Gadchiroli. However, in the year 2017 malaria cases declined significantly which might be due to increased awareness regarding malaria in Gadchiroli. High percentage of *P. falciparum* has also been reported from Dhanora taluka of Gadchiroli and Gumla districts by Dhiman and Singh *et al*. [15–16]. The presence of high percentage of symptomatic carriers in the local population act as perennial reservoirs, and indicate that the people are not using personal protection measures, making them more vulnerable to contact malaria. However, repeated infections and no clearance of parasite from the blood due to under-dosage of anti-malarial drugs might be the cause of development of immunity and asymptomatic carriers in the community [16].

Odisha showed >80% decline in malaria cases which is significantly higher against the overall decline in the country *i.e.* 24%. It was mainly possible due to enhanced LLIN distribution, intensified health awareness campaigns for up scaling use of LLIN and enhancement of health seeking behaviour. In addition, launch of a programme called DAMaN, which included killing of the malaria-parasites from the entire population of remote and inaccessible pockets through mass screening and treating all positive cases helped in reducing the occurrence of cases [27]. As witnessed in Odisha, an extensive programme for malaria control is required in district Gadchiroli, to achieve the target of malaria elimination by 2030 in the district and the country.

Table 1: District profile of Gadchiroli district, Maharashtra State.

Parameter	Information
Created in	1982 from Chandrapur district
Area	14412 km2
Population	1072942(census 2011) and 1209223(as per the website of Gadchiroli district, 2018)
Tribes	Madia, Gond and Gowari
Rivers	10
Altitude	217 m
North latitude	18.43' to 21.50'
East longitude	79.45' to 80.53'
Topography	77.9% hilly, forested, valley
Temperature	11.3–47.7 °C
Average rainfall in 2011	840.7mm
Civil hospitals/ District hospitals	1
Total PHCs	47
Public Heath Units	34
Rural Heath Hospitals	10
Sub District Hospital	3
Tribal PHCs	44
High risk PHCs	25
Sub Centres	376
Ashram schools	86
Anganwadi centers	1285
Asha workers	Sanctioned 1453; Filled 1431
Drug distribution centers	2085
Fever treatment depots	542
Malaria clinics	Sanctioned 48; Filled 43
Villages	1661

Table 2: Epidemiological data of malaria in Gadchiroli district of Maharashtra State (2008–2017).

Year	Population	BSC & Exam	+VE	PF	PV	ABER	API	SPR%	SFR%	PF%	Death
2008	1104062	535213	11372	8961	2411	48.48	10.30	2.12	1.67	78.79	5
2009	1122357	529591	7898	5905	1993	48.19	7.04	1.49	1.11	74.76	1
2010	1140652	530602	10765	8860	1905	46.52	9.44	2.02	1.66	82.30	3
2011	1158947	529846	13670	10581	3089	45.72	11.80	2.57	1.99	77.40	6
2012	1177242	520258	6596	4656	1940	44.19	5.60	1.26	0.89	70.58	4
2013	1209496	536341	6436	4919	1517	44.34	5.32	1.19	0.91	76.42	6
2014	1187784	692277	24469	21410	3059	57.23	20.23	3.53	3.09	87.49	18
2015	1204101	74711	34206	27228	6978	62.-7	28.40	4.57	3.64	79.60	11
2016	1206217	914648	9163	6301	2862	75.82	7.57	1.00	0.68	68.76	4
2017	1209223	598160	5484	4550	934	49.47	4.54	0.92	0.76	52.97	5

Source: Office of District Malaria Office, Gadchiroli District of Maharashtra State

Table 3: Man hour density of mosquitoes in Gadchiroli district

Sr. No.	Mosquito species	Average man hour density and percentage of mosquitoes			
		Indoor/Human dwellings		Outdoor/Cattle sheds	
		No. of collected Mosquitoes (%)	MHD	No. of collected Mosquitoes (%)	MHD
1	*An. culicifacies*	192(7.44%)	4.17	976 (37.84%)	21.21
2	*An. fluviatilis*	46 (1.78%)	1.00	194 (7.52%)	4.21
3	*An. annularis*	95(3.68%)	2.06	513 (19.89%)	11.15
4	*An. nigerrimus*	0 (0.00%)	0.00	15 (0.58%)	0.33
5	*An. subpictus*	69 (2.67%)	1.50	372 (14.42%)	8.08
6	*An. barbirostris*	0 (0.00)	0.00	35 (1.36%)	0.76
7	*An. splendidus*	5 (0.19%)	0.11	23 (0.89%)	0.50
8	*An. aconitus*	3 (0.11%)	0.06	7 (0.27%)	0.15
9	*An. jeyporiensis*	2 (0.07%)	0.04	9(0.34%)	0.19
10	*An. vagus*	0 (0.00%)	0.00	2 (0.08%)	0.04
11	*An. varuna*	4 (0.15%)	0.08	13 (0.50%)	0.28
12	*An. pallidus*	0 (0.00%)	0.00	4 (0.15%)	0.08
		416 (16.13%)	9.02	2163(83.86%)	46.98

Table 4: Results of epidemiological surveyunder taken invariousvillages of PHCs of Gadchiroli district

Name of village	Name of PHC	BSCE	+ve	*Pf*	*Pv*	*Pf* + *Pv*	SPR%	SFR%	*Pf*%
1. Japtalayi	1. Godalwahi	7	5	4	0	1	71.42	57.14	80.00
2. Karwafa	2. Karwafa	20	3	1	0	2	15.00	5.00	33.33
3. Murumgaon	3. Murumgaon	418	58	21	14	23	13.87	5.02	36.20
4. Morchul		1	0	0	0	0	0.00	0.00	0.00
5. Savargaon		6	1	0	0	1	16.66	0.00	0.00
6. Gajamendi		11	6	3	1	2	54.54	27.27	50.00
7. Kangadi		5	1	1`	0	0	20.00	20.00	100.00
8. Kolarbodi		1	1	0	0	1	100.00	0.00	0.00
9. Sursundi		1	1	0	0	1	100.00	0.00	0.00
10. Kosami		3	2	1	0	1	66.66	33.33	50.00
11. Devsura		2	2	1	0	1	50.00	50.00	50.00
12. Charwahi		1	0	0	0	0	0.00	0.00	0.00
13. Kulbhatti		69	24	15	3	6	34.78	21.74	62.50
14. Kisneli		2	1	1	0	0	50.00	50.00	100.00
15. Fulkoda		6	5	3	1	1	83.33	50.00	60.00
16. Khedegaon		66	22	9	3	10	33.33	13.64	40.90
17. Rampur		10	4	1	1	2	40.00	10.00	25.00
18. Tumdikasa		50	14	4	2	8	28.00	8.00	28.57
19. Rengagaon		10	4	1	1	2	40.00	10.00	25.00
20. Pannemara		25	15	3	2	10	60.00	12.00	20,00
21. Ampyali		12	5	0	1	4	41.66	0.00	0.00
22. Tavetola		2	0	0	0	0	0.00	0.00	0.00
23. Sindesur		6	4	1	1	2	66.66	16.66	25.00
24. Sinsur		5	3	1	1	1	60.00	20.00	33.33
25. Muska		3	2	1	0	1	66.66	33.33	50.00
26. Khamkheda		1	1	0	0	1	100.00	0.00	0.00
27. Marartola		2	2	1	0	1	100.00	50.00	50.00
28. Belgaon		24	12	5	1	6	50.00	20.83	41.66
29. Umarpal		9	4	1	1	2	44.44	11.11	25.00
30. Hoitola		1	1	1	0	0	100.00	100.00	100.00
31. Aamatola		1	0	0	0	0	0.00	0.00	0.00
32. Masadkehaka		2	2	1	0	1	100.00	50.00	50.00
33. Yegalkheda		1	0	0	0	0	0.00	0.00	0.00
34. Ridwahi		15	2	1	0	1	13.33	6.66	50.00
35. Bandur		2	1	0	1	0	50.00	0.00	0.00
36. Bodankheda		12	6	2	1	3	50.00	16.66	33.33
37. Kahkawahi		5	3	1	1	1	60.00	20.00	33.33
38. Gurkasa		1	1	1	0	0	100.00	100.00	100.00
39. Kawdikasa		1	1	0	0	1	100.00	0.00	0.00
40. Gotatola		11	4	0	0	4	36.36	0.00	0.00
41. Gopitpla		1	1	0	0	1	100.00	0.00	0.00
42. Khairwahi		1	1	1	0	0	100.00	100.00	100.00
43. Hirange		5	2	0	0	2	40.00	0.00	0.00
44. Chandgad		1	0	0	0	0	0.00	0.00	0.00
45. Aundhi		2	0	0	0	0	0.00	0.00	0.00
46. Jarawandi		1	0	0	0	0	0.00	0.00	0.00
Total		841	227	87	36	104	26.99	10.34	38.32

BSCE-Blood slides collected and examined

Table 5: Susceptibility of malaria vectors against various insecticides in Gadchiroli district.

Mosquito species	Insecticides (%)	Mosquito exposed		Mosquito dead		Mortality in mosquitoes		Corrected mortality (%)
		Test	Control	Test	Control	Test	Control	
An. culicifacies	DDT (4.0)	200	50	28	2	14.0	4.0	14.0
An. culicifacies	Malathion (5.0)	200	50	179	0	89.5	0.0	89.5
An. culicifacies	Deltamethrin (0.05)	200	50	191	1	95.5	2.0	95.5
An. fluviatilis	DDT (4.0)	150	50	72	2	36.00	4.0	36.00
An. fluviatilis	Malathion (5.0)	150	50	132	0	88.00	0.0	88.00
An. fluviatilis	Deltamethrin (0.05)	150	50	148	1	98.66	2.0	98.66

Conclusion

The study indicates that malaria cases are under-reported and actual number of malaria cases is much higher than the reported. As India is moving forward to achieve the goal of malaria elimination, proper reporting of malaria cases is absolutely essential for the identification and eradication of malaria foci. The study demands regular and effective mass surveillance, and proper implementation of malaria control measures in the endemic study areas, which contribute to most of the malaria cases with special emphasis on entomological surveillance in high risk PHCs of Gadchiroli. The use of IRS alone is not enough for malaria control, rather it should be complemented with use of ITBNs and mosquito repellents for enhanced efficacy, specifically in the tribal areas of the country. IEC activities should be taken up to increase community's knowledge and awareness in local language at the individual and community level, to enhance the IRS coverage and use of ITBNs for eliminating the disease from the state and to achieve the goal of malaria elimination by 2030.

The reports of resistance against synthetic pyrethroids in the study area suggests that there is an urgent need for further evaluation of new insecticide molecules for improved control of malaria vectors. Further studies on insecticide susceptibility status of malaria vectors in the region are necessary to confirm the findings. As studies on fauna survey and vector incrimination are lacking in this district, future research studies should focus on fauna survey including vector incrimination.

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