

Susceptibility of malaria vectors to insecticides in Gumla district, Jharkhand state, India

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Development of resistance to DDT in malaria vectors is being reported from various parts of India. Jharkhand state in India is one of the high malaria endemic states with *Plasmodium falciparum* accounting for 44% of the cases¹. In order to find out the rationale of using DDT in vector control, this study was carried out on insecticide susceptibility of malaria vectors in 12 endemic villages of six PHCs, namely Gumla, Sisai, Raidih, Basia, Palkot and Bharno, in Gumla district of Jharkhand state. The Gumla district has uneven terrain with hills, valleys and forests at different altitudes and having a population of 0.7 million² is highly malarious and situated close to the border of Simdega, a highly malarious district with a SPR of 14% in 2005³. Slide positivity rate (SPR) in Gumla district in 2005 was 3.4% but had been substantially higher in the recent past, ranging from as low as 10% to as high as 19.7% between 1997 and 2003 in Jharkhand¹. In Jharkhand state, indoor residual spray with DDT and insecticide-treated bed nets (ITBNs) are being used under vector control. There are 11 PHC's in the district and all the areas have been receiving two rounds of DDT spray every year from 1958 onwards. In spite of control measures, malaria remains a major health problem in these areas. The main vectors of malaria in Gumla district are *Anopheles culicifacies* and *An. fluviatilis* (Diptera: Culicidae)^{4–5}.

Insecticide susceptibility tests were carried out from March 2007 to September 2008 by using the WHO standard test kits against various insecticides during the

high prevalence period of respective vectors. *Anopheles culicifacies*, *An. fluviatilis* and *An. annularis* were collected from cattlesheds, human dwellings and mixed dwellings of different villages of each PHC during 0600–0800 hrs with the help of suction tube and flash light. The collected female mosquitoes were provided 10% glucose solution soaked in cotton pads and transported in caged cloth to the nearby field laboratory of the respective PHC. Insecticide susceptibility status of vector mosquitoes was determined using WHO specified insecticide impregnated papers with diagnostic concentrations of DDT (4.0%), malathion (5.0%), deltamethrin (0.05%) and cyfluthrin (0.15%) as per standard WHO technique⁶. After exposure for one hour the percent mortalities were calculated by scoring the dead and alive mosquitoes after 24 h of recovery period and corrected % mortality was determined using Abbott's formula⁷.

Results of susceptibility tests on *An. culicifacies*, *An. fluviatilis* and *An. annularis* against different insecticides tested are given in Table 1. The results revealed that *An. culicifacies*, *An. fluviatilis* and *An. annularis* were resistant to DDT and susceptible to deltamethrin, malathion and cyfluthrin. Statistical analysis revealed that there were no significant differences in mortalities among the mosquito species against malathion ($\chi^2 = 45.3$; $p < 0.001$), against deltamethrin ($\chi^2 = 9.92$; $p < 0.05$) and cyfluthrin ($p < 0.001$) while between DDT and pyrethroids and malathion there is a vast difference ($\chi^2 = 127$; $p < 0.0001$).

Table 1. Susceptibility of malaria vectors to insecticides in Gumla district (Jharkhand), India

Malaria vector	Insecticide papers used (%)	No. of mosquitoes exposed		No. of mosquitoes dead		Corrected % mortality	Susceptibility status
		Test	Control	Test	Control		
<i>An. culicifacies</i>	DDT (4.0)	664	60	255	2	38.4	Resistant
	Malathion (5.0)	611	60	583	1	95.42	Ver. required
	Deltamethrin (0.05)	566	60	559	2	98.78	Susceptible
	Cyfluthrin (0.15)	535	60	535	2	100	Susceptible
<i>An. fluviatilis</i>	DDT (4.0)	619	56	428	3	67.7	Resistant
	Malathion (5.0)	542	40	542	2	100	Susceptible
	Deltamethrin (0.05)	438	60	438	2	100	Susceptible
	Cyfluthrin (0.15)	435	60	435	2	100	Susceptible
<i>An. annularis</i>	DDT (4.0)	335	60	154	2	45.9	Resistant
	Malathion (5.0)	438	42	428	1	97.7	Susceptible
	Deltamethrin (0.05)	360	60	360	1	100	Susceptible
	Cyfluthrin (0.15)	335	60	335	3	100	Susceptible

The results emphasize that the three malaria vectors in Gumla district are resistant to DDT only and are susceptible to other insecticides tested. Resistance to DDT may be due to prolonged use of DDT in indoor residual spray since 1958 to till date. Krishnamurthy and Singh⁸ for the first time recorded resistance in *An. culicifacies* and *An. annularis* to DDT in a village of Uttar Pradesh in the year 1962 and Das⁹ and Sahu¹⁰ reported resistance in these vectors in Orissa. The present study confirms this finding in Gumla district of Jharkhand state. *Anopheles fluviatilis* has been reported as a primary vector of malaria in the forests of adjoining states of Jharkhand like Orissa and Chhattisgarh and is found to transmit malaria throughout the year in these areas, whereas *An. culicifacies* found to transmit malaria in post-monsoon months (July and August/September)⁵. *Anopheles fluviatilis* is mainly distributed in hilly tract villages¹¹ and the preferential breeding habitat is stream¹⁰, where the chances of exposure to the agriculture pesticides are relatively less. Azeez¹² and Rao¹³ reported unconfirmed resistance to DDT in *An. fluviatilis* and *An. annularis* in Dhanbad (Bihar). The present study confirmed that *An. culicifacies*, *An. fluviatilis* and *An. annularis* were resistant to DDT in Gumla district of Jharkhand state.

In view of presence of DDT resistance in all the three malaria vectors tested in this area, it is warranted that DDT use should be discontinued and district-wise susceptibility status of malaria vectors to the insecticides being used in the programme should be monitored for rational use of appropriate insecticides for malaria control in these areas.

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References

1. *Malaria Control Programme Annual Report*. Ranchi, Jharkhand: National Vector Borne Disease Control Programme, Directorate of Health Services 2007.
2. Districtwise population details, Jharkhand. Available from: <http://jharkhand.nic.in/districts.htm>.
3. Hamer DH, Singh MP, Wylie BJ, Yeboah-Antwi K, Tuchman J, Desai M, Udhayakumar V, Gupta P, Brooks

- MI, Shukla MM, Awasthy K, Sabin L, MacLeod WB, Dash AP, Singh N. Burden of malaria in pregnancy in Jharkhand State, India. *Malar J* 2009; 8: 210.
4. *Malaria and its control in India*. v. I. Delhi: Directorate of National Malaria Eradication Programme 1986; p. 254.
 5. Das NG, Bhuyan M, Das SC. Entomological and epidemiological studies on malaria in Rajmahal Range, Bihar. *Indian J Malariol* 2000; 37: 88–96.
 6. *Instructions for determining the susceptibility or resistance of adult mosquito to organochlorine organophosphate and carbonate insecticides—diagnostic test*. Geneva: World Health Organization 1981. WHO/VBC/1981.806.
 7. Abbott WS. A method of computing the effectiveness of an insecticide. *J Econ Entomol* 1925; 18: 265–7.
 8. Krishnamurthy BS, Singh NN. DDT resistance in *Anopheles culicifacies* Giles, 1901 and *Anopheles annularis* Van der Wulp 1814 in a village of Meerut district, U.P. *Indian J Malariol* 1962; 16: 375–7.
 9. Das M. A note on susceptibilities of some *Anopheles* to chlorinated hydrocarbon insecticides in Orissa. *Bull Indian Soc Malar Commun Dis* 1966; 3: 323–9.
 10. Sahu SS, Patra KP. A study on insecticides resistance in *Anopheles fluviatilis* and *An. culicifacies* to HCH and DDT in Malkangiri district of Orissa. *Indian J Malariol* 1995; 32(3): 112–8.
 11. Das PK, Gunasekaran K, Sahu SS, Sadanandane C, Jambulingam P. Seasonal prevalence and resting behaviour of malaria vectors in Koraput district of Orissa. *Indian J Malariol* 1990; 27: 173–81.
 12. Azeez SA. Susceptibility status of *Anopheles fluviatilis* and *Anopheles annularis* to DDT in an area near Dhanbad. *Bull Indian Soc Malar Commun Dis* 1964; 1: 53–4.
 13. Rao TR. *The Anophelines of India* (Rev. edn.). Delhi: Malaria Research Centre (ICMR) 1984; p. 154–8.

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