INTRODUCTION
Among the tropical diseases, malaria continues to be a major tropical disease of public health importance. Realizing malaria as a global problem, the eighth World Health Assembly in 1955 adopted Global Malaria Eradication Campaign. In the ensuing years widespread spraying of DDT to kill adult mosquitoes, use of larvicides against mosquito immatures and of antimalarial drug against malaria led to a considerable reduction in malaria morbidity in several countries. To boost the global malaria eradication efforts, in 1960 the World Health Day theme was "Malaria eradication-a world challenge". Although malaria morbidity and mortality declined substantially as a result of these efforts, during 1980s and 1990s the disease resurged in many parts of the world. In the beginning of 1990s it was estimated that 300 to 500 million people suffered clinically with malaria and 1.5 to 2.7 million people died from the disease (Trigg and Kondrachine, 1998). In 1991 about 5.8 million cases of malaria were reported in the world excluding Africa, of which South-east Asian countries contributed about 3 million cases.

In India the scourge of malaria is known since time immemorial. *Atharva-veda* dating back to 1500 B.C. clearly mentioned about seasonal periodicity of fevers. Charaka and Susruta, the sages in Ayurvedic period, noted down different kinds of intermittent fevers.

After the epoch making discovery of the life cycle of malaria parasite by Ronald Ross in 1897 in Secundrabad (India), systematic experiments were conducted to control malaria, which of course met with failures due to lack of understanding of the vector biology and the dynamics of malaria transmission. Malaria, therefore continued to kill enormously through periodic epidemics. Disastrous epidemics occurred in Punjab and Uttar Pradesh in 1908 (Yacob and Satya Swaroop, 1945; White, 1929). Regional epidemics used to break out in Northern Sind and Punjab at intervals of about 10 to 12 years (Covell and Bailly, 1935). Mortality due to malaria used to increase enormously during the epidemics. Sinton (1935) estimated that at...
least 100 million people suffered from malaria in India and about one million died every year. In 1947 when India's population was 344 million there were 75 million cases of clinical malaria and 0.8 million deaths (Sharma, 1984).

Malaria prevented the development and harnessing of natural resources and destroyed the economy of the country (Sharma, 1995). Most of the industrial undertakings in India are located in areas with moderate to high risk of malaria and the disease is adversely affecting the industrial growth of the country (Sharma et al., 1987). The mineral wealth lies mostly in forested hills, foothills and difficult terrain which are traditionally known for high malaria (Ray, 1979). Malaria in India is endemic and its control has become a challenge due to technical, financial and operational problems (Sharma and Mehrotra, 1986).

Systematic efforts have been made since long to control malaria. As early as 1901, the Royal Society of London in consultation with the military authorities conducted an experiment in Mian-Mir, a cantonment near Lahore. After the epidemics in 1908, the Government convened an imperial malaria conference in Simla in 1909 and established Malaria Bureau in 1910. This was ultimately converted into Malaria Survey of India in 1927 and then to Malaria Institute of India in 1938.

In the beginning, malaria control measures were taken mainly by anti-larval measures like use of larvicidal oil, paris green and minor engineering works. Pyrethrum spraying against adult mosquitoes was tried during 1936-45. With the advent of DDT and its introduction for residual spraying in 1944, demonstration projects were taken up in 1946 with the help of the World Health Organization (WHO). Later other pilot projects were undertaken in many States of India. Successful large scale indoor residual spraying of DDT was done in rural areas between 1946 and 1953. These field trials showed technical, operational and administrative feasibility of malaria control with DDT and because of the spectacular results, the National Malaria Control Programme (NMCP) was started in 1953.
In the first year about 70 million population was brought under NMCP which went up to 230 million by 1957-58. During this period there was a steep decline in malaria cases. The child parasite rate and child spleen rate decreased from 3.9% to 0.8% and 15.7% to 4.2% respectively (Sharma, 1984). Encouraged by these results, within a short span of five years the control programme was converted into the National Malaria Eradication Programme (NMEP) in 1958. Malaria surveillance to detect and treat malaria cases was introduced in 1960-61. Based on this system the lowest number of confirmed malaria cases, that is 99,667 were reported in 1965 of which *Plasmodium falciparum* accounted for 26%. Thereafter the malaria cases went up gradually due to resurgence to 6.4 million with 59 deaths in 1976.

The factors responsible for resurgence of malaria have been critically analysed (Ray, 1977; Kalra, 1980; Sharma and Mehrotra, 1986; Sharma, 1988). These inter alia include- emergence of resistance among main malaria vector species, *Anopheles culicifacies* and *An. stephensi* to the commonly used insecticides DDT and BHC, exophily and exophagy among vectors, precipitation of resistance in *P. falciparum* to chloroquine, shortage and untimely supply of DDT during the attack phase of NMEP, inadequate infrastructure in general health services, poor laboratory facilities and lack of funds, refusal or poor acceptance for residual spraying by the community, periodic mud-plastering of walls and population migration.

In view of the worsening situation of malaria, the Government of India implemented the Modified Plan of Operation (MPO) in 1977, thus converting the eradication programme to containment, with the main objectives to prevent deaths due to malaria, reduce malaria morbidity, maintain the gains against malaria in industrial and green revolution areas and to consolidate the achievements already made (Pattanayak and Roy, 1980). To tackle the increase of *P. falciparum* cases and to prevent the spread of chloroquine resistant *P. falciparum* to other vulnerable areas, a special programme known as *Plasmodium falciparum* Containment Programme.
(PFCP) was also launched in 1977 in 55 districts which was later extended to 79 districts (Ray, 1979; Choudhury, 1985).

Following the implementation of MPO and PFCP, the number of malaria cases went down gradually to about 1.66 million in 1987, but thereafter there has been an increase in malaria cases. Serious malaria epidemics were reported from northern and north-western parts of India and in 1995 there were about 3 million cases (population >950 million), one third of which were due to *P. falciparum* and over 1200 deaths (NMEP, unpublished data).

When NMEP was launched in 1958 it was envisaged that the eradication of malaria would be achieved by 1966-67 in most parts of the country (Sharma, 1984), but the setback to NMEP was a typical case of near victory to calamity (Sharma, 1988). Residual spraying, though successful in some places, miserably failed in other places.

Now it is amply clear that indoor residual spraying with insecticides is not the only answer for malaria control. Since there are social, economic and entomological problems with the conventional spraying of insecticides (Curtis, 1994), a judicious amalgamation of different control techniques acceptable to the community need to be adopted. In recent years renewed interest has been generated in Integrated Disease Vector Control methods, popularly known as bio-environmental control, in which vector control involves the use of larvivorous fishes, larvicidal bacteria, elimination and management of breeding sites and health education. Though the strategy was successful in some places (Sharma, 1986; Sharma and Sharma, 1986; Rajagopalan *et al.*, 1989), in view of its limited scope in forested areas with extensive and at times inaccessible breeding habitats, a need for appropriate alternative measures has been felt.

Among the potential alternatives to prevent man-vector contact use of bednets (mosquito nets) hold good promise. Use of bednets as a personal protection measure
against blood sucking or nuisance insects is known to man for a long time. Since mosquitoes could bite through or enter a badly arranged or damaged net, attempts were made to treat netting with repellents. Recently impregnation of bednets with pyrethroid insecticides has been found to be an effective technology to prevent man-mosquito contact. Pyrethroids have been reported to be effective at low dosage against mosquitoes and are safe to human at the target doses (WHO, 1989). Impregnated bednets have been successfully tried in many parts of the world against malaria (WHO, 1989; Rozendaal and Curtis, 1989; Li Zuzi et al., 1989; Graves et al., 1987). The collateral benefits of using treated nets such as reduction of other nuisance insects, make them more attractive and acceptable to the community (Charlwood and Dagoro, 1989).

In Assam State, India, bednets impregnated with deltamethrin (Jana, 1991) or lambdacyhalothrin (Bhaskar Rao, 1993) were successfully tried against malaria transmitted by *An. minimus*. Since 70% of rural malaria in India is transmitted by *An. culicifacies* (Subbarao et al., 1988), it was pertinent to evaluate the efficacy of bednets in an area where *An. culicifacies* is the main malaria vector. Thus, the present trial was undertaken in forested villages with tribal population of Sundargarh district, Orissa where *An. culicifacies* is the main vector along with *An. fluviatilis* which plays a minor role in malaria transmission.

**Objectives of the study**

- To test relative bio-efficacy of available synthetic pyrethroids on different nettings in the laboratory against mosquitoes for evaluation of optimum pyrethroid/net combination.

- To evaluate impact of pyrethroid treated bednets on malaria morbidity and other clinical measures in a tribal population.
• To assess possible effect of treated bednets on vector population such as density, human biting pattern, parity rate and host specificity.

• To study the residual efficacy of the impregnated bednets in order to determine the frequency of re-impregnation of bednets.

• To study the community acceptability and feasibility of the bednet trial and the socio-cultural aspects of bednet usage.

• To measure the collateral benefits and adverse effects (side effects), if any, of the intervention.