7. Summary

Studies on various aspects of ecology and behaviour of *A. fluviatilis*, the major vector of malaria were carried out in the Koraput district of Orissa, during the period April'88 to May '90. The salient findings of the study are summarized below.

Extensive surveys on immature and adult populations of anophelines showed the prevalence of 22 species and one variety and *A. fluviatilis* constituted 8.50% and 4.12% respectively of total anopheline immatures and adults collected.

Laboratory studies on *A. fluviatilis* revealed the average fecundity of 47.1 eggs, average incubation period of 1.5 days during rainy season and 2.8 days in cold season and hatchability of 91.58%. The average immature duration was 12.4±0.99 days in rainy season and 14.78±1.64 days in cold season. The pupal duration was 1.66 and 1.87 days respectively for the corresponding seasons. The total immature duration was significantly longer in cold season. The larval growth pattern in successive instars followed a geometric progression. The male to female sex ratio was 1.0:0.96.

Streams, rivers, ponds and wells were perennial, and borrow pits and paddy fields were seasonal breeding habitats of *A. fluviatilis*. Though the incidence of anopheline breeding was highest in borrow
pits, the intensity of breeding of this species was significantly higher in streams.

*A. fluviatilis* was found to be closely associated with *A. culicifacies* in streams and with *A. annularis* in ponds. In wells this species did not show any positive association with any of the anophelines. Breeding of *A. fluviatilis* occurred in streams throughout the year with a peak in cold season. In rivers the immature density registered two peaks, a major one during hot and a minor one during cold season. In ponds, the peak in immature density was observed during cooler months and the breeding was perennial in this habitat. Wells recorded the peak in cold season and considerable breeding was noticed in rainy season also, when other habitats were subjected to flooding.

Life tables were constructed to summarize mortality and survival rate of immature population. Natural survival of immatures of *A. fluviatilis* showed that the probability of survival through different developmental stages was maximum in ponds and borrow pits. Generally, in all the breeding habitats the number and proportion of late instars and pupae were very less indicating a high mortality during development.

Phenotypic variations were detected in the adult population of *A. fluviatilis* collected from forested hilly areas and most of such
variations were observed for the first time.

A total of 483 *A. fluviatilis* females was obtained from various resting collections. The density varied from 0 to 10.67 indoors and from 0 to 35.0 outdoors during hot and cold seasons respectively. The density of day time resting population of *A. fluviatilis* recorded from outdoors was significantly higher than that of indoors and this trend was similar in all seasons. Top-hill village recorded maximum density followed by foot-hill, riverine and plain village.

The analysis of abdominal condition of indoor and outdoor resting populations confirmed the exophilic behaviour of this species. It also suggested that a large proportion of mosquitoes leave indoors before completing the gonotrophic cycle. The ratio of *A. fluviatilis* resting in human dwelling to cattle shed was 0.7:1.0. This was compared with earlier observations and found that there was an evidence of increase in the proportion of mosquitoes resting in cattle sheds and a change in the resting behaviour of this species from human dwelling to cattle shed.

The proportion of *A. fluviatilis* resting in different sites in human dwellings was found to be significantly different. Significantly a higher proportion of mosquitoes was collected from walls followed by roof, hanging objects and objects kept on floor. Further analysis on the day-time resting population in relation to
different height of the wall clearly suggests its association with height of the wall. Maximum number of mosquitoes (50.23%) was collected from 4 feet and above. Similar results were also obtained from night resting collections. Among the outdoor resting habitat, pit shelters were found to be the most preferred habitats followed by tree-holes. Seasonal shift in the preference has also been observed and discussed with environmental conditions.

The man biting rate of *A. fluviatilis* was fluctuated between 1.0 and 16.0 indoors and 0.5 and 3.0 outdoors in different months. This species was observed to be predominantly endophagic. Biting mosquitoes were collected throughout the night in all the seasons and maximum biting was seen between 22.00 and 02.00 hr. A seasonal shift in the peak biting activity was noticed. The biting activity showed a relationship with temperature. The parous females in the biting collections were found to predominate in all the months and its proportion deflected between 40-100% in different hours and there was no correlation with hour of biting.

Observations on the pre- and post-feeding activities suggested that *A. fluviatilis* enters the house from their day time shelters and rest indoors before feeding. Night resting collections at different hours indicated that this species rest indoors after feeding. Semi-gravid females were also encountered in man biting collections indicating the occurrence of re-feeding phenomenon in this species.
Simultaneous biting collections on man and cattle yielded 20.8% and 79.2% on the two hosts respectively.

Blood meal identification showed an overall Human Blood Index (HBI) of 0.26. While none of the specimens collected from cattle shed showed positive for human blood, 72.7% of the samples from human dwellings showed positive for human blood. Of the total samples collected from outdoor resting shelters, 19.5% showed positive reaction with human antiserum. Maxillary index of both cattle and man biting population of *A. fluviatilis* showed no characteristic difference.

The number of *A. fluviatilis* collected from light traps in cattle sheds was significantly higher than in human dwellings. The mosquitoes trapped in light traps were quantitatively and qualitatively similar to day time resting collections but not to man biting collections.

Physiological age of *A. fluviatilis* was calculated to be 17.0-24.5 days in different seasons. Estimation of calendar age showed that 4.5% of females attained the dangerous age of 10 days and more. Lowest natural survival of adult population was observed in hot season (March-June) and the highest in cold season (November-February).
The net reproductive rate ($R$) estimated for cold season was 3.0200 and it was 0.6486 for rainy season. The mean generation time ($T$) was found to be slightly longer in cold season than in rainy season. Both the intrinsic rate of increase ($r$) and finite rate of increase ($\lambda$) of this species were found to be higher during cold season. The finite rate of increase of the natural population showed a decreasing trend in hot and increasing trend in cold seasons respectively. Observed values of finite rate of increase ($\lambda$) did not show any deviation from that of estimated values.

As many as 19,769 anophelines belonging to nine species were dissected for natural infection with malarial parasites. Maximum number of infections was noticed in $A.\ fluviatilis$, with a sporozoite rate of 0.16%.

Vectorial capacity of $A.\ fluviatilis$ was estimated to be the highest value for $P.\ vivax$ followed by $P.\ falciparum$ and $P.\ malariae$. The difference in the estimated values of sporogonic period was the reason for such variation as other parameters were assumed to be similar. Season-wise analysis showed that the vectorial capacity was higher in rainy season followed by hot and cold seasons. There was an increase in the number of malaria cases with the vectorial capacity in different seasons and the relationship suggests the validity of the vectorial capacity as an indicator of transmission potential in this area. Observations on dispersal based on the presence of
immatures and adults at different sites from the human habitations suggests that *A. fluviatilis* population can disperse to a maximum distance of 1700 m for oviposition and 1000 m for resting.

*A. fluviatilis* females were found to be susceptible to DDT, HCH, Malathion and Deltamethrin.

Vector control perspectives in the study area were discussed in the light of present observations. Due to the vastness of breeding habitats antilarval treatment with insecticides is not practicable. Some of the naturalistic methods such as keeping the streams free from vegetations near the villages and use of fishes in ponds and wells could be revived. Though *A. fluviatilis* is predominantly an exophilic mosquito, its pre- and post-feeding activities facilitate the contact with sprayed surface area, suggesting that residual insecticidal spraying can be continued. Personal protection methods will also be useful with proper community motivation.