STUDIES ON DISPERSAL OF MALARIA VECTORS IN A HILLY TRACT OF KORAPUT DISTRICT, ORISSA STATE, INDIA

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Abstract. Dispersal of malaria vectors was studied in a hilltop village in Koraput, a highly malarious district of Orissa. Immatures from terraced stream beds and day-time resting adults from artificially dug pit shelters, distributed centrifugally at different distances from the village were sampled. Breeding of *Anopheles fluviatilis*, *An. annularis* and *An. culicifacies* was found up to a distance of 1,700 m. Immature density of *An. fluviatilis* and *An. culicifacies* showed a negative correlation with the distance, but they were not statistically significant. The maximum distance at which *An. fluviatilis* adult females collected was 1,500 m. A significantly negative correlation was observed between *An. fluviatilis* resting females and distance. *An. culicifacies* adults were collected in low numbers even in the nearest pit shelters. No *An. annularis* was recorded from the pit shelters. The present record on the dispersal range of *An. fluviatilis* is estimated to be higher than that reported elsewhere in India.

INTRODUCTION

Dispersal of anophelines is an important phenomenon in malaria epidemiology as it has direct bearing on designing control strategy. It is necessary in assessing the extent and source of infiltration of mosquitos into operational areas from outside. While some information on this aspect is available on *Anopheles culicifacies* through the classical studies of Rao (1984), only limited information is available on *An. fluviatilis,* one of the major malaria vectors in stable malarious areas in India.

Therefore, a year-round study was undertaken in May 1989 in Jeypore hill tract, which is highly endemic for malaria transmitted by *An. fluviatilis,* the major vector, *An. annularis* and *An culicifacies* being the secondary vectors (Parida *et al,* 1991). For various reasons, indoor residual spraying of DDT/BHC has not made a marked impact in containing malaria in this area and studies are being conducted with a view of formulating alternate control strategies. Knowledge of mosquito dispersal will therefore be useful while rationalizing the applicability of different control methods.

MATERIALS AND METHODS

Study area

The geographical location and salient features of Koraput District of Orissa have been described earlier (Rajagopalan *et al,* 1990). A hilltop village, Champapodar (600 m above sea level) which is separated from other villages by a distance of at least 3 km, was selected for the study. The village is bordered in the east and west by hills and a perennial stream, which originates about 1,700 m away in the south, runs towards the village in between mountain barriers (Fig 1).

Larval and adult sampling

Malaria is endemic in the village and therefore the mark-release-recapture method was not practicable due to ethical considerations. Instead, the immature population in the breeding habitats were monitored at various points away from human habitations in order to have an indirect measure of the flight range of gravid females. Such an indirect method had been used earlier to study dispersal (Adisubramaniam and Vedamanickam, 1943; Bhombore *et al,* 1956; Rao and Philip, 1947). This method assumes that all vectors come for their blood meal to the village. Since the village is the major source of blood meals it is fairly reasonable to assume that the distribution of immatures is a good indication of dispersal of gravid females.

Paddy fields in the terraced stream beds which are the major breeding sources, were selected at 50, 500, 1,000, 1,500 and 1,700 m away in the

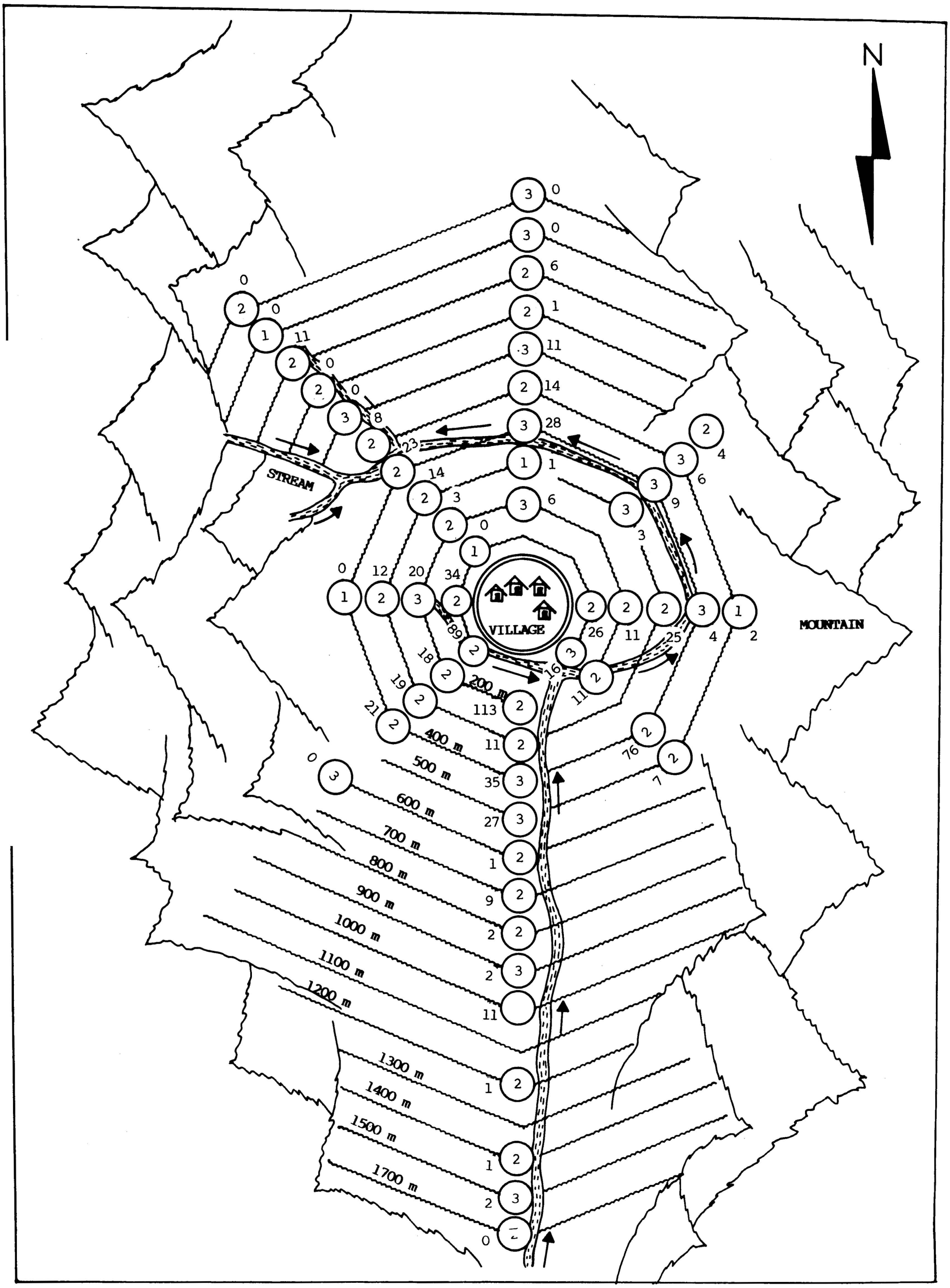

Fig 1—Schematic diagram showing sites of pit of shelters (0). Figure between the concentric circles refers to radious in meters. Figure within the circle refers to number of pit shelters searched. Figure outside the circle refers to number of *An. fluviatilis* females collected.

southern direction from the village. Dipper samples were taken along the edges and one meter interior of the paddy fields. The number of dips in each plot ranged from 60 - 100 depending on the available water filled surface area. Per dip density (no. of larvae/dip) was used to compare the density in different paddyfields. Immatures collected were reared and identified at adult stage. Sampling could not be done in other directions due to the mountain barrier.

The outdoor resting habit of the vector *An. fluviatilis,* was also exploited to study the dispersal based on distribution of adults in the outdoor habitats. One to three artificial pit shelters were made at every 100 m distance away from the periphery of the village in eight directions. Pit shelters were made upto a distance of 1,600 m in the southern direction, 1,100 m in the north, 1,000 m in the northeast and 500 m in other directions. Due to mountain barriers uniform distance could not be maintained in all the directions. Each pit shelter was 45 - 60 cm deep, 30 - 45 cm wide and was dug on the sides of the well shaded mound of earth. The resting females were collected during morning hours (06.00 hours to 08.00 hours) from these shelters at fortnightly/ weekly intervals and shelter-wise collections were recorded separately. Anophelines were identified and grouped according to gonotrophic status. Blood samples were collected from full fed ones and the source of blood meal was identified using Agar-gel diffusion technique (Crans, 1969).

The villagers visit nearby jungle in day-time for cultivation, wood cutting, collecting forest produces and take cattle for grazing. In order to find out day biting behavior of anophelines, outdoor man and cattle biting mosquitos were also sampled.

RESULTS AND DISCUSSION

Dispersal based on immature population

The per dip larval density of 16 anopheline species in rice-fields at different distances is given in Table 1. The average immature density of *An. fluviatilis* was 0.055, 0.03, 0.05, 0.02 and 0.02 larvae per dip at 50 m, 500 m, 1,000 m, 1,500 m, and 1,700 m, respectively. The immature density

Table 1

Per dip density (no. of larvae collected/dip) of anopheline immatures collected from rice fields at different distances.

Distance of fields no. of dips taken	50 m 2,246	500 m 1,526	1,000 m 1,865	1,500 m 1,669	1,700 m 1,658
Species			Per dip	density	
01 *An. fluviatilis*	0.045	0.028	0.045	0.015	0.024
02 *An. culicifacies*	0.014	0.001	0.002	0	0.001
03 *An. aconitus*	0	0	0.001	0	0
04 *An. jeyporiensis*	0.155	0.148	0.237	0.144	0.178
05 *An. subpictus*	0.017	0	0.004	0.001	0.001
06 *An. vagus*	0.084	0.007	0.007	0.005	0.003
07 *An. annularis*	0.004	0	0.002	0	0.003
08 *An. maculatus*	0.004	0.004	0.008	0.002	0.004
09 *An. pallidus*	0	0	0	0	0.001
10 *An. splendidus*	0.076	0.035	0.068	0.087	0.122
11 *An. jamesi*	0.004	0.003	0.001	0.002	0.002
12 *An. theobaldi*	0.005	0.004	0.005	0.004	0.008
13 *An. tessellatus*	0	0	0	0.001	0
14 *An. peditaeniatus*	0	0	0.005	0	0
15 *An. barbirostris*	0	0	0	0	0.001
16 *An. nigerrimus*	0.004	0.007	0.001	0.001	0.001

showed a negative correlation with the distance, but it was not statistically significant ($r = 0.6756$; $p = 0.21$; $df = 3$). The median flight range, which is the distance up to which 50% of the total larvae were collected, was a little over 500 m. There is a general agreement that *An. fluviatillis* does not fly far from the place of feeding if suitable breeding place is available close by (Rao, 1984). The maximum dispersal range of *An. fluviatills* observed in this area was 1,700 m. This was higher than that reported by others [Adisubramaniam and Vedamanikkam, 1943 (300 m); Rao and Philip, 1974 (800 m); Bhombore *et al*, 1956 (400 m); Rao, 1984 (600 m)].

The immatures of *An. annularis* were collected upto 1,700 m. The density was very low in all rice plots and hence no statistical analysis was done to see if there is any difference between rice plots. *An. annularis* has been reported to fly long distances (Christophers, 1933).

Breeding of *An. culicifacies* was also observed upto 1,700 m but the immature density was higher in the nearest rice fields and decreased with distance ($r = 0.7596$; $df = 3$; $p = 0.14$). There are several observations on dispersal of *An. culicifacies* in different parts of India. When preferential breeding habitats of this species were at hand they did not appear to pass over them (Rao, 1984). *An. subpictus* also showed a similar pattern though it is generally regarded as a strong flier compared to *An. culicifacies* (Rao, 1984).

As the upstream water flows with a downward gradient towards the village, the possibility of immatures drifting away from the village was remote. Therefore, the distance at which immatures were collected has been considered as the distance travelled by the adults for egg laying.

Dispersal based on adult sampling

Out of the total 1,668 anophelines collected in outdoor shelters, *An. fluviatilis* was the predominant species (45%), followed by *An. jeyporiensis* (24%) and *An. tessellatus* (16%). *An. culicifacies* and *An. annularis* were rare in these collections which may be due to their endophilic behavior (Das *et al*, 1990).

The maximum distance at which *An. fluviatilis* could be collected was 1,500 m and the median flight range was 300 m. When the mean density per shelter was analysed, it was found to be higher, up to 500 m. Beyond this, the density was reduced with the increased distance. Statistical analysis showed a significant linear negative correlation between per shelter density of *An. fluviatilis* and distance ($r = 0.795$, $df = 12$, $p = 0.0007$). But this linear relationship could predict only 63.3% variability in the per shelter density, which means that dispersal is not adequately described by this relationship. Hence, regression was done after transforming the distance variable to a logarithmic scale, which explained 86.9% variability ($r = 0.932$, $df = 12$, $p = 0.0001$) in the observed per shelter density indicating an exponential decline in density with distance (Fig 2). Calculations of average flight range, however, cannot be validated since the area available for resting of adults becomes wider with increase in distance and density of adults gets diluted due to increase in area. *An. fluviatilis* was collected almost in all directions up to a distance of 500 m. Density was higher in south, southeast and southwest directions when compared to others, probably because of the presence of perennial steams which might provide favorable microclimate or their flight was oriented towards the breeding sites. Beyond 500m, comparison was not possible as pit shelters could not be made in some directions due to the mountain barrier.

The blood meal analysis showed that 14% of the 141 *An. fluviatilis* tested had taken human blood and the remainder bovine. Out of 564 mosquitos dissected 34% were fully fed and 23% semigravids. Only 17.2% of the total was unfed in a nulliparous condition. The day-time biting collection yielded only species of *Aedes, Haemagogus* and *Mansonioides*. Therefore, it has been presumed that incidence of day biting by anopheline species was rare in this locality. The vector feeds on man/cattle at night time when the hosts are available in the village, and those collected from pit shelters dispersed from the village after feeding either for resting or oviposition.

Information obtained in the study indicates the constraints in incorporating anti larval measures against *An. fluviatilis* in malaria control operations in this area. The outdoor adulticidal spray is also impracticable considering the range of dispersal. Though the major vector is still susceptible to DDT and it rests inside or outside of the dwellings in the night before and after feeding (VCRC unpublished data) residual spraying is ineffective, partly because of the mudplastering habit of the

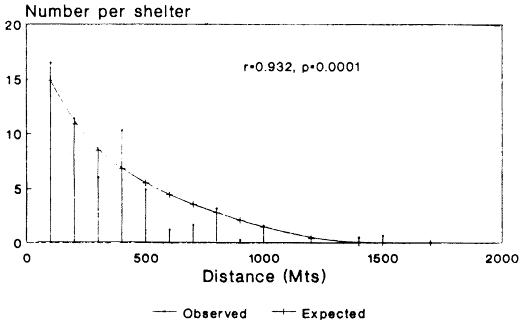

Fig 2—Relationship between distance and no. of *An. fluviatilis* collected.

people. Under such circumstances, personal protection measures can be considered as an alternative malaria control measure.

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