7.0 SUMMARY & CONCLUSION
Malaria is endemic in Calcutta. For the last few decades, investigators have been referring *Anopheles stephensi* as the only vector in Calcutta, despite the presence of few other *Anopheles* species. Some of these species, namely, *Anopheles subpictus* and *Anopheles annularis* are the vectors of the disease in other parts of India. The later species is also one of the important vectors of malaria in West Bengal. In Calcutta, *Plasmodium vivax* is the predominant malarial parasite and the resurgence of *Plasmodium falciparum* since the early 1980s has made the maliariogenic situations more complex. The bionomics of *Anopheles stephensi* is very complex and requires a study under the present ecological condition, which have changed drastically due to rapid urbanization and various development activities. There are lacunae in the epidemiology of malaria in relation to vector. Owing to the existence of some malaria vectors, viz, *Anopheles annularis*, *Anopheles subpictus* in Calcuta and the adjoining areas, apprehension has been raised in certain quarters that besides *Anopheles stephensi*, these species may have some role in the epidemiology of malaria.

The salient observations made by the study are being summarized below:

1. Altogether 9 species of mosquitoes belonging to the genera *Culex*, *Anopheles*, *Aedes* and *Armigeres* were obtained from the human habitation during the study period.

2. The total number of mosquitoes obtained in two years from six study sites was 41185. Among the *Anopheline species*, *Anopheles subpictus* topped the list (876, 21.13%), followed by *Anopheles vagus* (427, 1.03%), *Anopheles stephensi* (171, 0.41%), *Anopheles barbirostris* (45, 0.11%), *Anopheles annularis* (39, 0.09%) and *Anopheles hyrcanus* (4, 0.009%).

3. The names of the *Anopheline species* and their total numbers in two years were, *Anopheles subpictus* (876), *Anopheles vagus* (427), *Anopheles stephensi* (171), *Anopheles barbirostris* (45), *Anopheles annularis* (39) and *Anopheles hyrcanus* (4).

4. Besides six study sites 40 brick-built rooms, 30 shanties and 25 slum-rooms were also searched for *Anopheles stephensi*. The total number of *Anopheles stephensi* collected was 76. The total number of *Anopheles stephensi* collection was significantly higher in shanties (39) in comparison to slum-rooms (22) and brick-built rooms (15).
5. Seasonal fluctuations in the population density of the *Anopheline species* were also noticed.

6. The study reveals that some *Anopheline species* of mosquitoes were highly sensitive to seasonal changes and their population density differs in different seasons and years. It was seen that maximum number of *Anopheles stephensi* were found in rainy season than that of summer and winter season from all the study sites.

7. *Anopheles subpictus* and *Anophels annularis* were also found more in the rainy season than that of summer and winter. Although, *Anopheles annularis* were found only in two areas namely Gajtala and Kasba Golpark. Per man hour collection of *Anopheles subpictus* was found to be higher amongst the six *Anopheline species* caught during the study period.

8. *Anopheles stephensi* lost its secretive habits being found in considerable number from different biotopes of Calcutta in most of the months.

9. Per man hour (PMH) collection of *Anopheles stephensi* was found to be higher in the shanties than that of slum rooms and brick-built rooms.

10. *Anopheles stephensi* preferred to take rest on folded umbrellas, gunny bags, inside tin drums, furniture, ceiling, iron pillars, etc. in different biotopes. *Anopheles stephensi* were also found to take rest on the household materials inside the temporary hutments, which becomes black due to smoke and dirt.

11. In the present investigation over two years, altogether 8 species of mosquitoes from Monoharpukuer and 9 species of mosquitoes from Gajtala on man-baits at night hours from 6 pm to 6 am were collected. Culicine mosquitoes were attracted to human beings in much greater number in comparison to Anopheline mosquitoes.

12. Eight species of mosquitoes, namely *Culex quinquefasciatus* (PMH 5.45), *Anopheles subpictus* (PMH 0.28), *Anopheles vagus* (PMH 0.06), *Anopheles stephensi* (PMH 0.07), *Anopheles barbirostris* (PMH 0.01), *Aedes aegypti* (PMH 0.13), *Amigeres subalbatus* (PMH 0.04), and *Mansonina annulifera* (PMH 0.001) landed on human bait both indoor and outdoor at Monoharpukur. Similarly, 9 species of mosquitoes namely, *Culex quinquefasciatus* (PMH 7.53), *Anopheles subpictus* (PMH 0.13), *Anopheles vagus* (PMH 0.09), *Anopheles stephensi* (PMH 0.03), *Anopheles barbirostris* (PMH 0.027), *Anopheles hyrcanus* (PMH 0.01), *Anopheles annularis* (PMH 0.024), *Armigeres subalbatus* (PMH 0.62) and *Mansonina annulifera* (PMH 0.005) landed on human bait both indoor and
outdoor at Gajtala. Per man per night (PMPN) contact of *Anopheles stephensi* was 0.95 at Monoharpukur and 0.42 at Gajtala.

13. Total 7483 Culex mosquitoes and 436 Anopheles mosquitoes were found to land on human bait both indoors and outdoors at the two study sites (Monoharpukur and Gajtala). Among the two study sites, *Anopheles stephensi* and *Anopheles subpictus* were found both in Monoharpukur (urban area) and in Gajtala (Peri-urban area). But *Anopheles annularis* were found to land on human bait only in peri-urban area i.e. Gajtala. *Anopheles subpictus* constitute (4.57%) of the total catch, followed by *Anopheles stephensi* (1.31%) in Monoharpukur. But *Anopheles subpictus* constitute (1.53%) of the total catch, followed by *Anopheles stephensi* (0.41%) and *Anopheles annularis* (0.29%) respectively in Gajtala.

14. *Anopheles stephensi* landed on man bait both indoor and outdoor but the proportion of landing outdoor was greater than indoor, which indicates that the species is exophagic nature in these areas. Moreover, most of the captures were made in the rainy season and the per man per night (PMPN) contact was also higher in the rainy season than that of summer and winter.

15. The density of *Anopheles stephensi* mosquitoes increased in the IV quadrant of night both at Monoharpukur (28, 60.86%) and Gajtala (15, 75.00%). The density of *Anopheles subpictus* increased in the IV quadrant of night (14, 46.25%) in Monoharpukur and in the III quadrant of night (46, 60.00%) at Gajtala. The density of *Anopheles annularis* increased in the IV quadrant of night (9, 64.28%) at Gajtala.

16. Several human bait experiments with mosquitoes conducted earlier in Calcutta indicate no *Anopheles stephensi/man contact was evident in certain months of the year. Although clinical manifestations of the infections were detected in every month. Manlanding catches conducted in Calcutta also revealed that the density of *Anopheles stephensi* was very low and most of the captures were made in the rainy season. The present study also depicts the similar picture and no *Anopheles stephensi* was evident in the month of March and April.

17. In the present study sporozoite infection was found both in *Anopheles stephensi* and in *Anopheles subpictus*. The natural infection rate was 0.26 (1 sporozoite infection out of 386 wild caught *Anopheles stephensi* dissected) in *Anopheles stephensi*. Similarly, the natural infection rate was 0.27 (1 sporozoite infection out of 368 wild caught *Anopheles*
18. Data of the present study shows that in Calcutta malaria transmission has been going on perennially. Considering the above findings and owing to the existence of some recognized malaria vectors, namely *Anopheles subpictus* and *Anopheles annularis* in Calcutta, it can be concluded, that these species, especially *Anopheles subpictus* might have some complementary role during the absence or at the time of low density of the vector *Anopheles stephensi*.

19. Sporozoite infection in *Anopheles subpictus* in Hooghly by Chatterjee et. al., (2003) and the detection of the same in *Anopheles subpictus* in the present study have added a new dimension in malaria epidemiology in West Bengal, especially in Calcutta and also reinforces the apprehension of multivectorial involvement.

20. The principal vector (*Anopheles stephensi*) and the complementary vector (*Anopheles subpictus*) possibly keep the parasite circulating perennially in its maintenance cycle in Calcutta. Moreover, in a complex mosquitogenic and malariogenic situation, the stability of malaria transmissions increases with the increasing diversity of the vectorial system.

21. Seasonal variation of malaria incidence was noticed in Calcutta. It had been seen that maximum number of malaria cases were reported in the rainy season (58,921) than that of summer (26,542) and winter season (27,420), during the present investigation.

22. Percentage of mixed cases (where both *Plasmodium falciparum* and *Plasmodium vivax* infections were present in the patient) were more in the second year (12.35%) than that of first year (0.18%) and third year (0.15%) respectively. Percentage of *Plasmodium vivax* infection was more or less same in all the studied years, while the percentage of *Plasmodium falciparum* was less in the third year (8.25%) than that of the first year (17.56%) and second year (18.2%). Interestingly, it was found that *Plasmodium vivax* cases were more in the monsoon and post monsoon months and less during late winter months. *Plasmodium falciparum* cases were maximum in early winter months. Death cases were reported only in the third year of the study period and all of them were due to *Plasmodium falciparum*. *Plasmodium vivax* mainly dominates the rainy season, whereas *Plasmodium falciparum* dominates the winter season.
23. The scenario was similar to Calcutta in Ward No. 84 (under Calcutta Municipal Corporation). Maximum number of malaria cases were reported in the rainy season (2049) than that of summer (683) and winter (991) season.

24. Both *Plasmodium vivax* and *Plasmodium falciparum* cases were found to be maximum amongst the people who are above 15 years of age. It was seen that males are more affected by malaria than the females.

25. Temperature, rainfall and relative humidity are the three important climatic factors that affect malaria transmission. During the study period in Calcutta, malaria cases were found throughout the years, encompassing all the months, with a pronounced peak in the monsoon (58.90%) 60.46% cases were reported when the monthly rainfall was between 0.22 to 5.37 mm. When temperature varies from 26.01°C - 33.81°C coupled with an average rainfall ranges between 0 mm - 8.56 mm, 91.03% malaria cases have been encountered.

26. Altogether 3723 malaria cases were found in Ward No. 84 (under Calcutta Municipal Corporation). 74.66% cases were found between the mean maximum temperature (m.m.t.) 29°C - 32°C. 61.75% cases were found when the monthly average rainfall varies between 0 - 7.54 mm. 94.91% cases were found when the mean maximum relative humidity was between 92 - 97%.

27. *Anopheles stephensi* was mostly container breeders. They were also found in the perennial water bodies, like Ponds, Ditches and Lakes, although in very low density. It was found that *Anopheles stephensi* breeds mostly in cement tanks and least in plastic buckets. They were also found in tin drums and earthen tubs. The collection of *Anopheles stephensi* larvae was maximum (176) in the rainy season from the perennial water bodies, such as Ponds, Ditches and Lakes. *Anopheles subpictus* was found to breed in earthen tubs and cement tanks.

28. Both Guppy and Panchax were found to be potential larvivorous fishes but Guppy was more predacious than Panchax.

Suggestions which may be adopted to control malaria in Calcutta are as follows:

- Blood test for the detection of malaria parasite, if any, of all the fever cases.
- Pathological laboratories and private nursing homes in Calcutta should send their monthly report of the blood test for malaria to Calcutta Municipal Corporation for proper monitoring and assessment of the malaria situation.
• To know the vector bionomics (both larval and adult) in order to formulate the strategy for antimosquito measure.

• To develop a cadre of personnel who are skilled in carrying out the basic entomological techniques and antimosquito measures.

• Early diagnosis and prompt treatment should be the main aims of the control measures. For this active case detection is important.

• To study the epidemiological data regularly in order to monitor the seasonal transmission patterns of malaria.

• Feasibility studies and cost-effectiveness analysis should be made of different environmental management measures, for vector control in order to select the best alternatives to suit the given situations.

• Application of control measures and their continued maintenance (an integrated approach of control is necessary) even when the incidence and prevalence have been reduced to the target level.

• Environmental management should emphasize Community involvement and participation at all stages of projects and programmes.

• Enforcement of Stringent Municipal Law against the residents in order to prevent the mosquito breeding in residential places.

• During treatment of *Plasmodium falciparum* cases, the possibility of drug resistance should be kept in mind.

• Source reduction (of the larvae) is the most important of all the procedures to control the vector mosquitoes.

Malaria control requires new approaches and targets, selective and sustainable vector control strengthening of health delivery at the periphery and rapid absorption of new technologies into the National Malaria Eradication Programme.