CHAPTER VI

SUMMARY

The study of population dynamics of mosquitoes in the field will probably always be difficult, because of sampling problems and the intricate complex of varying influences to which such populations are subject. Another difficulty has been the obscurity and uncertainty of how best to go about such studies. Without claiming that the conceptual difficulties have been entirely overcome, some useful steps and few solid advances have been achieved from the present study.

The thesis is divided into two parts. The population dynamics of vectors and the susceptibility status of the vectors to insecticides. Major part of the work pertains to the population dynamics of *Culex quinquefasciatus* say, the vector of bancroftian filariasis, *Culex tritaeniorhynchus* Giles, an important vector of Japanese encephalitis, in India, *Anopheles culicifacies* Giles, the vector of rural malaria and *Anopheles stephensi* Liston, the vector of urban malaria in India. The chapter on insecticide susceptibility status of mosquitoes pertains to only the malaria vectors; *A. culicifacies* and *A. stephensi* and the objectives of the study was mainly to get baseline data on the susceptibility status of these important malaria vectors to the available or commonly used insecticides in Public Health.
POPCULATION DYNAMICS

Development of methodology for measuring density of immatures

Standard methods to measure the density of immatures of mosquitoes are needed because 1) such a method would permit expression of the degree of breeding taking place in a given habitat 2) such methods would allow direct comparison between the breeding potential of different habitats and 3) such a tool would be particularly useful for accurately assessing any control attempts.

An unbiased sampling technique to measure the density of immatures of C. quinquefasciatus in a drain situation where the distribution of immatures was heterogeneous, has been developed. Significant correlation has been found between the measured relative density and absolute density estimated by mark-release-recapture method. Parameters were obtained to measure absolute population of immatures of C. quinquefasciatus in different habitats like drains, Cesspits, wells and stagnant waterpools, from the relative density measurements. The regression methods could be used, for all the habitats studied except in pools, for estimating the absolute population.

A method for marking mosquito larvae for use of mark-release-recapture studies is described. When the larvae were marked with 0.1 per cent Methylene Blue, for 8 hours, the mortality was insignificant and emergent adults also carried bluish black colour. There was no apparent adverse effect of the staining on the survival of either stages.
Distribution pattern and sample size required for accurate measurements of density

The negative binomial distribution was found to be satisfactory model for *C. tritaeniorhynchus* in wells and stagnant water pools, *C. quinquefasciatus* in drains and *A. culicifacies* in rivers and stagnant water pits. The sample size required to give a desirable level of accuracy of the average was calculated using a method described by Rojas (1964) for the breeding situations studied for different species.

**Duration of Immature Stages in Different Seasons**

The study on the duration of immature stage of *C. quinquefasciatus*, *C. tritaeniorhynchus* and *A. culicifacies* was made to provide the basic data for life table analysis. A floating container was devised to measure the duration and density effect on duration of *C. quinquefasciatus* in a well habitat. The immature duration of *A. culicifacies* was studied by seeding newly hatched first instar larvae in small pits on the riverbed. Studies on immature duration of *C. tritaeniorhynchus* was made in an ambient condition.

There was marked differences in the duration of development of immature stages of mosquitoes in different seasons. It took 10.5 days in summer to 49 days in winter for *C. quinquefasciatus* to emerge as an adult. In the case of *C. tritaeniorhynchus* the duration of developmental period varied from 12.5 days in hot
season to 49 days in cold season. *A. culicifacies* took only an average of 6 days in summer and 23 days in winter to emerge out as adults. The duration of immature development was prolonged at higher densities. However, there was little difference between developmental period in containers of 25 egg rafts and more, although the actual larval numbers differed greatly, probably because of high mortality sustained at these levels.

**SURVIVAL RATE OF IMMATURES IN DIFFERENT SEASONS**

The survival rate of immature stage of *C. quinquefasciatus* in a drain, *C. tritaeniorhynchus* in a well, pool and drain habitats, and *A. culicifacies* in a river and pool habitats were estimated using service's method: The numbers of different larval instars and pupae collected were recorded and age distribution was calculated by dividing the numbers of different instars, by the respective instar duration and plotting the values against the values against the midpoint of the stadia to give an age distribution curve. Density effect on survival rate of immatures was studied for *C. quinquefasciatus* by seeding different densities of egg rafts in a floating container.

The highest survival rate obtained for *C. quinquefasciatus* immatures in a drain breeding situation was 24.7 per cent in April, when the natural population was on the increase. The survival rate decreased in June to 10.4 per cent and to 10.00 per
cent in July, to 6.5 per cent in November and reached a low rate of 2.6 per cent in January.

The survival rate of *C. tritaenioryynchus* was highest in April (20.0%) and lowest in the month of December (0.8%) in wells. The average daily mortality was highest in the second instar in all the months studied. Highest pupal mortality occurred in April to June and in December.

The survival rate of immatures of *A. culicifacies* was highest in June (8.3%) and lowest in October (2.0%) in a river breeding habitat. The average daily mortality was highest in the second instar in June and October (61.0% and 61.3% respectively). The third instar showed the highest mortality rate in July (59.2%) and the fourth instar in December (21.4%).

In a pool breeding habitat, the immatures of *A. culicifacies* had shown a highest survival rate of 6.2 per cent in October. The average daily mortality was highest in the second instar.

Survival rates of immatures of *C. quinquefasciatus* at different density levels were studied both in floating containers and in natural breeding sites (wells) in rural areas. A clear tendency of survival rate depending on density was seen in some wells. The strength of the density dependent factors varied from well to well and was related to its carrying capacity. In some wells density dependent factors controlled the population so that the density does not increase to the critical level. The
regulatory function of the density dependent factors on a population as a whole in a village depends on the number of wells with high density. The number of wells with high density increased along with the total population increase indicating the regulatory function of the density dependent factors.

Estimates of the relationship between survival of *C. quinquefasciatus* larvae and their density in an urban drain was studied for all seasons. There were marked differences between seasons in survival rate and it was due to density dependent factors. Varley and Gradewell's proof of density dependent test was carried out by calculating two regressions, one for log egg density on log pupal density and another for log pupal density on log egg density. The observed slopes (b) lay on the same side of 1.0 and differed significantly from a slope of 1.0. Thus, a genuine casual relationship of survival on density was proved in all seasons.

The effect of introduction of egg sterility into a hitherto uncontrolled population was estimated based on the above results. In the early and late summer and in the monsoon season moderate levels of sterility would be expected to be effective in population suppression, e.g., 70 per cent sterility would suppress the pupal yield in one generation to less than 50 per cent of the undisturbed level. Conversely in the post monsoon
and in winter months, it appears that no appreciable progress would be made unless at least 90 per cent of egg sterility could be achieved.

The minimum sterility necessary in an artificially suppressed population, to continue a downward trend, relative to the natural fluctuations in the population was estimated for different seasons. The data indicate that only moderate sterility would be necessary to enhance control of a suppressed population in the early and late summer. In the monsoon season very little sterility would be required to prevent recovery of the population. However, in the post monsoon and winter season a much higher percentage of sterility would be necessary to continue control of the population.

The minimum sterility required to reverse the trend during seasons of natural increase was also studied. In summer and post monsoon months, when the natural population increases rapidly, to achieve absolute reduction in the adult density would require not only enough sterility to overcome density dependent regulation but also an amount sufficient to overcome the natural increase per generation.

**Life Table Attributes of Larvae and Pupae**

The life table attributes of immature stages of *C. quinquefasciatus*, *C. tritaeniorhynchus* and *A. Culicifacies* were constructed from the field data for different seasons in different habitats.
The larval life table of four populations of A. stephensi in a laboratory condition was studied to find out strain variation in their life table attributes. The four population studied were: Arthala type, Bhuj type, Okhla type and Pondicherry type. The Pondicherry strain showed significant difference from other strains probably due to the geographic isolation of this strain from others studied. A Stephensi var. mysorensis did not show significant differences in their life table attributes from the type forms.

Life Table attributes of adults

The life table attributes of adult mosquitoes were studied from field and laboratory observations. The life and fecundity table for C. quinquefasciatus in the month of April indicated a reproductive potential (R₀) of 12.41 and a generation time (T₀) of 19.2 days. The generation time was short during the hot dry months when the population builds up rapidly after winter (17.8 days in March and 19.2 days in April). During April the generation time was slightly higher (22.5 days). In the coldest month of the year, January, it was the longest (74 days).

The predicted values of finite rate of increase have been compared to the values obtained from the observed periods of seasonal increase or decrease by relative density measurements. The data indicates that immediately after winter, when the population starts increasing, it increases 1.00027 per head per day. In April, when usually the density reaches a peak, the increase was 1.1401 per head per day. When the population
declines in June, the rate was 0.9849 per head per day. The population actually decreases in November, January and February.

Life table attributes of adults A. stephensi strains (Arthala type, Okhla type, Pondicherry type and Bhuj type) were studied to find out the differences, if any, in the life table characteristics of this species from different geographic regions. Age specific survivorship, $L_x$, expectancy of life $e_x$, reproductive potential $R_x$, innate rate of increase $r_m$, mean generation time $G$, the birth rate $b$, the death rate $d$ and the finite rate of increase $\lambda$ were compared for the different populations. The life table attributes of A. stephensi var. mysorensis were very similar to Arthala and Okhla type and the study did not give any evidence of two races of A. stephensi.

**Susceptibility Status to Insecticides**

A. Culicifacies and A. stephensi larval instars (IV instar) and adult female mosquitoes were collected from four localities in the study area for testing them to determine the susceptibility status to DDT, BHC, Dieldrin and Malathion. The results indicated that the immature stages as well as adults of A. stephensi and A. culicifacies are still susceptible to the widely used insecticide DDT, eventhough resistance has developed in them at varying levels. All the mosquitoes tested showed high susceptibility to malathion.