CHAPTER 6

Summary

Insects are the most abundant animals on earth. Insects and other related arthropods account for a high proportion of species diversity in forest ecosystem. Since they are the major contributors to biodiversity, they play a variety of extremely important ecological roles in the many functions of an ecosystem. They serve as prey for other animals and play a vital role in pollination, defoliation and are also keys in nutrient cycling and in initiating the decay of vegetation. Insect orders vary in their micro-habitat requirements and tolerance to various biotic and abiotic environmental factors. The seasonality is an important aspect of the survival strategy of insects. Insects in tropical and subtropical regions exhibit seasonal variation in abundance due in part to cycles of wet and dry weather. The seasonality pattern has also been found highly variable in different insect groups.

The current investigation was carried out over a period of two years in three different sites of the sub-tropical forest at Phayeng, 15 Km from Imphal City, Manipur, lying between 24°50′25″ and 24°51′11″ North Latitude and 93°48′17″ and 93°48′39″ East Longitude. The altitude of the Phayeng sub-tropical forest ranges from 827 m to 925 m above mean sea level (MSL). The study area has a monsoonic type of forest climate. The annual rainfall was 1315.2 mm during the first year and 1303.8 mm in the second year.

Objectives:
- To study the seasonal changes of populations of insects.
- To study the population changes of insects in relation to abiotic factors.
- To study the biodiversity of insects in the study area.
- To study the biomass dynamics and secondary productivity of insects in the forest ecosystem.
The estimation of population density of insects was done by employing three removal trapping methods such as Pit-fall trap, Sweep Net and Cage method. In all the three methods, collected insects were sorted out, identified and counted. The insects were oven-dried at 60°C for 72 hours and used for the calculation of insect biomass. For the estimation of insect Biodiversity of the study area, in addition to the three sampling methods mentioned above, Light Trapping method was employed to collect nocturnal insects. A total number of 128 genera of insects belonging to 65 families and 10 orders (viz., Orthoptera, Hymenoptera, Coleoptera, Hemiptera, Lepidoptera, Odonata, Blattodea, Diptera, Mantodea and Dermaptera) were recorded during the study period. Altogether 93 species were recorded, though other insects were identified only up to the level of Genus. Among these orders, Lepidoptera claimed to have the highest number of families, and Coleoptera had the second highest number followed by Hemiptera.

During the study period, a total number of 7345 individual insects were recorded belonging to 8 orders (Coleoptera, Hymenoptera, Orthoptera, Lepidoptera, Diptera, Hemiptera, Odonata and Blattodea) with 51 families, 78 genera and 53 species, from the three study sites by using three different trapping methods—pitfall trap, sweep net and cage method. Among the eight insect Orders recorded during the investigation period, Hymenoptera and Orthoptera scored the highest percentages of population density, thus claiming to be the most dominant Orders, while the Order Coleoptera, Diptera and Lepidoptera were the next dominant insect groups. And, the other remaining insect Orders, Hemiptera, Odonata and Blattodea, contributed comparatively low percentages in all the study sites of the forest. The Order Coleoptera claimed the highest number of eleven families out of the fifty one families recorded in the present study.

Hymenoptera showed the highest population density in the first year and Orthoptera the second highest while Orthoptera claimed the highest figure in population density in the second year with Hymenoptera at the second place. Hymenoptera
contributed 25.6%, 23.1% and 25.4% to the total population density of insects in the forest site-I, site-II and site-III respectively during the first year of the investigation whereas, in the second year, the percentage contributions of Hymenoptera were 22.9%, 19.3% and 15.6% in the forest site-I, site-II and site-III respectively. The population density of Hymenoptera ranged from 0.7 insect m\(^{-2}\) (December) to 10.2 insects m\(^{-2}\) (August) in the study site-I, 0.4 insect m\(^{-2}\) (March) to 9.4 insects m\(^{-2}\) (July) in the study site-II and 0.8 insect m\(^{-2}\) (December) to 11.1 insects m\(^{-2}\) (August) in the study site-III during the first year of investigation. However, in the second year, the population density of Hymenoptera varied from 0.1 insect m\(^{-2}\) (February) to 6.2 insects m\(^{-2}\) (September) in site-I, 0.1 insect m\(^{-2}\) (February) to 6.9 insects m\(^{-2}\) (September) in site-II and 0.2 insect m\(^{-2}\) (February) to 3.8 insects m\(^{-2}\) (September) in site-III. The Order Hymenoptera was represented by the families- Formicidae, Vespidae, Apidae Ichneumonidae and Halictidae with Formicidae being the most dominant group and scoring the highest population density among the families observed during the study period. Formicidae was represented by *Pachycondyla astuta* Smith, *Solenopsis* sp., *Camponotus sp.*, *Oecophylla smaragdina* Fabricius, *Polyrhachis armata* Le Guillou, *Crematogaster dohrni* Mayr, *Leptogenys processionalis* Jerdon, *Creptogaster* sp., *Monomorium* sp. throughout the study period with the exceptions of *C.dohrni* and *Monomorium* sp. which were not observed in the second year.

The percentage contributions of Orthoptera were 19.9%, 20.6% and 24.0% to the total population density of insects in site-I, site-II and site-III respectively in the first year of the study period while it contributed 24.5% in site-I, 26.8% in site-II and 31.3% in site-III during the second year. The population density of Orthoptera ranged from 1.4 insects m\(^{-2}\) to 7.5 insects m\(^{-2}\) in the site-I, 0.1 insect m\(^{-2}\) to 7.9 insects m\(^{-2}\) in site-II and 0.5 insect m\(^{-2}\) to 9.3 insects m\(^{-2}\) in site-III during the first year of investigation. In all the study sites, the minimum population density of Orthoptera was exhibited during the cold and dry
winter months. In the second year, the population density of Orthoptera varied from 0.5 insect m$^{-2}$ to 7.8 insects m$^{-2}$ (July) in site-I, 1.0 insect m$^{-2}$ to 6.4 insects m$^{-2}$ (May) in site-II and 0.6 insect m$^{-2}$ to 7.9 insects m$^{-2}$ (June) in site-III. The Order Orthoptera was represented by the families- Gryllidae, Tettigoniidae, Acrididae and Tettigoniidae. Among these, Acrididae, represented by the species *Cantantops humilis humilis* (Serv.), exhibited the most dominant group throughout the study period in all the study sites of the forest. The seasonal patterns of populations of the other remaining insect orders were also studied.

The total insect population density exhibited variation in different months as well as in different seasons in the study site-I, site-II and site-III during the two years of the study period. The density varied from 6.4 insects m$^{-2}$ to 37.6 insects m$^{-2}$ in the site-I, 8.3 insects m$^{-2}$ to 32.4 insects m$^{-2}$ in site-II and 7.0 insects m$^{-2}$ to 29.9 insects m$^{-2}$ in site-III during the first year of the study period. The maximum density was recorded during the rainy season in all the study sites. In the second year also, the total insect population density exhibited the same trend as it was in the first year. In the study site-I, site-II and site-III, the minimum total insect population densities were recorded to be 5.5 insects m$^{-2}$, 6.7 insects m$^{-2}$ and 6.8 insects m$^{-2}$ while the maximum densities were 20.7 insects m$^{-2}$, 19.2 insects m$^{-2}$ and 21.3 insects m$^{-2}$ respectively. In all the three study sites of the forest, the maximum density was recorded in the month of September.

During the two consecutive rainy seasons of the study period, about 59.5%, 59.6% and 52.7% to the total population density of insect were recorded in site-I, site-II and site-III respectively in the first year while 48.6%, 54.2% and 53.9% to the total population density of insect were recorded in the site-I, site-II and site-III respectively during the second year. It was revealed from the result that the maximum total insect density was recorded during the rainy season and the insect catch had a tendency to decline gradually towards the dry and cold winter season. The result thus shows that the rainy season is the
most favorable season for the population growth of insects. Pearson Correlation coefficients and Linear regression analysis were used to explain the interrelations between the insect density in different sites and abiotic factors. Analysis of variance (ANOVA) of the population densities of total insects of the three study sites showed significant variations (F=12.21, P<0.01 for first year and F=10.71, P<0.01 for second year).

The biomass of insects was studied by taking dry weight of insect tissue and was expressed as mg dry weight m$^{-2}$. The total biomass of insects varied in different months throughout the study period. The variation in the total biomass of insects did not always correspond to the fluctuation in the population density of insect. In the first year of the investigation, the total biomass of 7055.5 mg dry weight m$^{-2}$ in site-I, 6119.4 mg dry weight m$^{-2}$ in site-II and 5557.2 mg dry weight m$^{-2}$ in site-III were recorded whereas, in the second year, the total biomass were recorded to be 5315.4 mg dry weight m$^{-2}$ in site-I, 4648.2 mg dry weight m$^{-2}$ in site-II and 6066.4 mg dry weight m$^{-2}$ in site-III. The value of the total biomass was comparatively higher during the first year of the study period than that of the second year except in site-III. In all the study sites of the forest, the maximum biomass was recorded during the rainy season while minimum biomass was observed during the dry and cold winter season. Among the collected insects, Orthoptera exhibited the maximum biomass in all the sites followed by Coleoptera throughout the study period. The lowest value of biomass was shown by Blattodea.

Among the families of Orthoptera, Tettigoniidae (represented by *Mecapoda* sp.) was accounted for the maximum value of biomass throughout the study period except in site-III of the second year where the highest value was shown by Gryllidae (*O. saltator*).

The tissue production has been taken as secondary production and was calculated by using the formula given by Wiegert (1965). The total annual secondary productivity of insects was comparatively higher in the first year of the investigation in all the study sites.
than that of the second year. The total secondary productions during the first year of the investigation were recorded to be 4504.3 mg m\(^{-2}\), 3541.2 mg m\(^{-2}\) and 3442.6 mg m\(^{-2}\) in site-I site-II and site-III respectively. However, during the second year, the total secondary production was 3666.4 mg m\(^{-2}\) in site-I, 2875.6 mg m\(^{-2}\) in site-II and 3181.2 mg m\(^{-2}\) in site-III. Order Orthoptera exhibited the maximum secondary production throughout the study period with the exception of site-III in the second year where the maximum secondary production was exhibited by the Order Coleoptera. Among the families of Orthoptera, Tettigoniidae (\textit{Mecapoda} sp.) exhibited the maximum secondary productivity in all the study sites in the first year of study period while, during the second year, Acrididae (\textit{C. humilis}) showed the maximum secondary production in site-I but Tettigoniidae continued to exhibit maximum value of secondary production in the site-II and site-III. Throughout the study period, the lowest secondary production was exhibited by Blattodea though Odonata exhibited the lowest secondary production in site-I during the first year.

From the present findings, it can be concluded that the rainy season is the most favourable season for the population growth of insects and, thus, the highest population densities. This might be due to the fact that the rainy season supports the luxuriant growth of vegetation which indirectly supports the food resource availability to insects and the prevailing climatic condition was also congenial for the insect activities.

The total insect biomass exhibited a wide range of variation in different months and seasons as well. The variation in the total insect biomass somewhat showed a similar trend with the variation in the total insect population. However, increase in total biomass of insects does not always correspond to the increase of population density and vice versa.

Insects have a significant role in the forest community, affecting both primary productions by their grazing activities, and nutrient turnover by their roles as decomposers, frass deposition, their cadavers, etc. Although insect herbivory is common in terrestrial
ecosystems, it has only recently been considered an important and persistent control on ecosystem processes and has not been included as a factor in most ecosystem models. In addition to their direct effects on productivity via consumption of plant tissues, herbivores can influence ecosystem function by changing the nature of organic matter inputs to the soil. Herbivore by-products (i.e., frass, carcasses, honeydew) often have distinctive chemical properties that alter rates of organic matter decomposition and nutrient release within an ecosystem. Over the longer term, selective herbivory can alter plant community composition, thus altering the dominant litter types available for decomposition.

The estimation of secondary productivity has a significant role in the ecosystem as it is considered as an index in terms of food resources made available to other predatory population in the food chain. Due to responsive nature to the changes of environmental conditions, secondary production is variable from one season or year to the next. In the present investigation also, there were fluctuations in the secondary production of insects in different study sites of the forest owing to the differences in the vegetation composition and environmental factors.

Studies on food consumption by the various stages of larval instars of two species of Lepidoptera, *Euproctis albolyclene* (Holloway) and *Cerace stipatana* (Walker) were also performed to quantify the amount of foliage of the host plant consumed which also reveals that food consumption and weight gain by the larvae have direct relationship with the age of the larvae. Thus, as the larvae grow older and enter into subsequent instars, they gain comparatively more weight and consume more food. These studies emphasize on the estimation of quantitative loss of foliage caused by different insect pest in the forest ecosystem.

On the other hand, herbivore population densities in forests are often kept low either by the activity of natural enemies or the low nutritional quality of the foliage or both.