CHAPTER -II
MATERIAL AND METHODS
2.1 PHYSIOGRAPHY

2.1.1 Location

The Kamrup district is located within the geographical limits of Longitudes 91°E to 91°55'E and latitudes 25°45'N to 26°30'N, is an important part of the civil state of Assam, India. The total forest coverage of this district is 1959.25 sq.km.

2.1.2 Configuration of the ground

The forests are located in the hilly and plain areas. The forests in hilly areas are the continuation of the Khasi hills range. There are also some hillocks surrounded by cultivations. The plains forests are located in alluvial terraces, locally known as 'taris' and these are cut up by numerous narrow, winding low-lying tracts known as 'Gullies'.

2.1.3 Geology, rock and soil

The area covered by the Kamrup district is composed mainly of alluvium of recent to sub-recent origin and rocks of the Pre-cambrian gneissic complex. The main block of forests with in this area is situated on an outlying portion of the Shillong Plateau. The Principal rocks are acid and basic gneisses, intruded by granite, pegmatite and quartz veins. The same type of Pre-cambrian gneissic complex are also seen to form the scattered hillocks, located in the Brahmaputra alluvial plain, which were originally part of the Shillong plateau and separated now by alluvial tracts. The alluvial tract of the Brahmaputra valley, which covers a major portion of the district, Composes mainly of silt, sand and clay with occasional pebble - beds.

2.1.4 Water Supply

The forests are drained by numerous natural lakes, streams, beels, tributaries and rivers opening in the mighty Brahmaputra.
2.1.5 Climate

The climate of Kamrup district is highly fluctuating with moderate temperature (Fig.-2.1), high humidity (Fig.-2.2) and trace, moderate and heavy showers of rains (Fig.-2.3) in addition to periodic wind, storm and thunders. On the basis of variation in temperature, humidity and precipitations the climate of Kamrup district as well as N.E. region are grouped in four seasons:

Fig. - 2.1 Monthly mean values of Maximum and Minimum temperature ($0_c$)
Fig. - 2.2 Monthly mean values of Maximum and Minimum Relative Humidity (%)

Fig. - 2.3 Monthly total Rainfall in mm
a) Pre-monsoon

It covers the months of March to May. Generally blown by dusty wind but occasional showers of medium to heavy rains may also take place which helps in spurting of leaves and blooming of the deciduous plants. The means value of minimum and maximum temperature is 19.75°C and 29.66°C respectively. The respective average relative humidity is, 63.2 and 75.66. The average total rainfall is 496.72 mm. The early part of the premonsoon is dry and maximum of the trees shed off. The late part of this season flourished with leafing and blooming of the plants.

b) Monsoon

Generally starts from early June and continues up to the month of the August, characterised by heavy showers of rain, clumsy warm, grim humidity, thick clouds luxurient growth of vegetation and spruting fauna. In this season the average minimum and maximum temperature is 25.43°C and 32.07°C respectively. The 2 average value of minimum and maximum relative humidity is 79.71 and 84.34 respectively. The average total rainfall is 888.42 mm.

c) Retreating monsoon

During the month of September to October, this is the transitional period between monsoon and winter where temperature and humidity remain comparatively high in mid day but fog appears in night and morning. The average minimum and maximum temperature in this season is 23.32°C and 30.91°C respectively. The average minimum and maximum relative humidity is 80.88 and 83.52 respectively and the average total rainfall is 279.54 mm.

d) Winter

From the month of November to February the season is characterized by cold, fog, dew and fall of temperature. The average minimum and maximum temperature are 13.19°C and 25.35°C. The average minimum and maximum relative humidity is 72.16 and 84.74. There is very scarce rainfall having average total of 48.63 mm. The leaves of almost all the plants become old and majority of the insect fauna undergoes diapause.

2.1.6 Forests types

The forests of Kamrup district can be classified briefly under the following categories:
a) Eastern hill Sal forests - Khasi hills Sal

The ridges and the spurs of the hilly areas are formed by this forest type with Shorea robusta (Sal) as the dominant fauna. The valleys and the middle slopes being occupied by miscellaneous species and bamboos. The others associated trees in the spurs and ridges are Schima wallichii, Adina cordifolia. On the top of the hills Gmelina arborea, Talauma phellocarpa, Lannea coromandelica, Lagerstromia parviflora, Dillenia pentagyna, Emblica officinalis etc. are the principal associates of Sal. The middle slopes are also rich with various species of trees, shrubs and climbers. In some hilly areas where the Sal forests totally perished due to the deforestation activities are planted by teak either in the slopes or foot hill areas. The ground is covered by numerous species of herbs, shrubs and climbers.

b) Moist plains Sal-forests-Kamrup Sal

The lower slopes of the foot hills and the 'taris' in the alluvial plains are occupied by this type of forests. Sal forms the pure stands with intermediate trees of about 30 species. The ground is variably covered by numerous species of herbs, shrubs and climbers. The ground level flora and fauna undergoes heavy annual burning a traditional practice used by the forest department. Patches wise Gramari plantations is another major plant species of this forest type.

c) Moist mixed deciduous forests

The middle slopes of the hills excluding spurs and ridges are occupied by this type of forest. Sal trees occurs scatteringly. The middle sotrey is occupied by bamboos and tall shrubs and climbers incorporated with about 50- different species of deciduous and evergreen tall tress.

d) Evergreen patches

This type of forests are very limited, occur mainly in the hills along the bank of perennial streams and in shady, moist pockets along nullas. The Mesua ferea, Stereospermum personatum, Garcinia sp, Garrallia brachiata, Dysoxylum sp, Echinocarpus sp Ficus sp, Amoora wallichii, Litsea sp, Alstonia scholaris etc. are the common but scanty species in the evergreen forests. In the hill slopes the bamboos are the dominant species with intermediate herbs, shrubs and climbers.
e) The monotypic teak forests
This type of forests are the planted forests that once were totally deforested. Occupied the hills, hillocks and foothill plain forests in the vicinity of the human dwellings and surrounded by agricultural lands that are over exploited by the people. In this monotypic forests teak is the dominant plants but few species of deciduous and evergreen plants may also occur.

f) Secondary moist bamboo brakes
In the hilly areas bamboo brakes with moist mixed deciduous forests covers a large tracts. There are about five species of bamboos of which *Dendrocalamus hamiltonii* and *Neohouzeana dulloa* are the dominant species. The bamboo forests are of high economic importance giving a good earning source to the business men. There are numerous bamboo industries for fancing and paper mills.

g) Secondary Euphorbiaceous Scrub
Shifting cultivation locally known as "Jum kheti " is a traditional practice of the tribes. The abandoned areas after Jumming generally have this type of forests. The major species comprising the only stories are *Macaranga denticulata*, *M. indica*, *Trema orientalis*, *Anthocephalous cadamba*, *Albizzia* sp, *Callicarpa* sp. etc. The ground covered with few shrubs and climbers.

i) Moist Sal Savannah
This type of forests occur as patches or pockets of grass lands in the 'taris' in the plains Sal areas adjacent to villages and cultivation lands. The trees common are *Shorea robusta*, *Careya arborea*, *Emblica officinalis*, *Semecarpus anacardium*, *Ziziphus jujuba*, *Wrightia tomentosa* and *Gmelina arborea*.

j) Moist Sissoo forests
This type of forests are found in the foothills and unused lands of plain and by the side of highways. Few deciduous and evergreen plants are also associated with this type of forest. Among the associated plants *Gmelina arborea*, *Acacia* sp., *Terminalia arjuna*, *Eucalyptus* sp. etc. are prominent.
2.2 SURVEY

The survey of the insects belonging to the order Lepidoptera and Coleoptera damaging commercially important forest timber plants were undertaken within Kamrup district covering an area of 1959.25 square kilometers for the years 1989-1993.

The first phase of the survey was to identify the most important and widely used wood yielding forest plants within the boundary of the study area. The plants which are extensively used as wood and exploited commercially were located first in the field and identified as per Kanjilal et al. (1934, 1938, 1939), Bor (1939), Das and De (1940), Prain (1963), Department of Botany Gauhati University, Office of the Chief-Conservator of Forests Guwahati, Office of the DFO Guwahati. The plants thus identified, selected for the survey of the insects infestation. The preliminary survey showed that 56 plants are most important in the study area in terms of economic value. For the convenience of the study the 3 forest area are selected and plant to plant survey was carried out. The following are the plants surveyed:

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Botanical name</th>
<th>Vernacular Name</th>
<th>Family</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Acacia catechu Willd.</td>
<td>Khair</td>
<td>Leguminoseae</td>
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<tr>
<td>2</td>
<td>Aegle marmelos Corr.</td>
<td>Bel</td>
<td>Rutaceae</td>
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<tr>
<td>3</td>
<td>Albizzia lebbeck Benth.</td>
<td>Sirish</td>
<td>Leguminoseae</td>
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<tr>
<td>4</td>
<td>Albizzia procera Benth.</td>
<td>Korol</td>
<td>Leguminoseae</td>
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<td>5</td>
<td>Alstonia scholaris R.Br.</td>
<td>Satiana</td>
<td>Apocynaceae</td>
</tr>
<tr>
<td>6</td>
<td>Aphanamaxis polystachya Blatter. (Syn. Amoora rohituka W &amp; A.)</td>
<td>Boga-Ameri</td>
<td>Meliaceae</td>
</tr>
<tr>
<td>7</td>
<td>Artocarpus heterophylla Lamk. (Syn. A. integrifolia Linn. A. Integra Thumb.)</td>
<td>Kathal</td>
<td>Moraceae</td>
</tr>
<tr>
<td>8</td>
<td>Artocarpus lakoocha Roxb.</td>
<td>Bohot,Chama</td>
<td>Moraceae</td>
</tr>
<tr>
<td>9</td>
<td>Azadirachta indica (Syn. Melia azadirachta Linn.)</td>
<td>Neem</td>
<td>Meliaceae</td>
</tr>
<tr>
<td>10</td>
<td>Bauhinia acuminata Linn.</td>
<td>Kanchan</td>
<td>Leguminoseae</td>
</tr>
<tr>
<td>11</td>
<td>Bauhinia variegata Linn.</td>
<td>Boga-Kotra, Kurol</td>
<td>Leguminoseae</td>
</tr>
<tr>
<td>No.</td>
<td>Scientific Name</td>
<td>Common Name</td>
<td>Family</td>
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<td>12.</td>
<td><em>Bombax ceiba</em> D.C.</td>
<td>Simulu</td>
<td>Bombacaceae</td>
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<tr>
<td>13.</td>
<td><em>Butea frondosa</em> Roxb.</td>
<td>Palas</td>
<td>Leguminoseae</td>
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<tr>
<td></td>
<td><em>(Syn. <em>B. monosperma</em> Taub.)</em></td>
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<td>14.</td>
<td><em>Cassia fistula</em> Linn.</td>
<td>Sonaru</td>
<td>Leguminoseae</td>
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<tr>
<td>15.</td>
<td><em>Cedrela toona</em></td>
<td>Poma</td>
<td>Meliaceae</td>
</tr>
<tr>
<td></td>
<td>*(Syn. <em>C. velutina</em>)</td>
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<tr>
<td>17.</td>
<td><em>Crataeva religiosa</em> Forst.</td>
<td>Barun</td>
<td>Capparidaceae</td>
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<td></td>
<td><em>(Syn. <em>C. nurvala</em> Buch-Ham.)</em></td>
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<td>18.</td>
<td><em>Dalbergia sissoo</em> Roxb.</td>
<td>Sisu</td>
<td>Leguminoseae</td>
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<tr>
<td>19.</td>
<td><em>Dillenia indica</em> Linn.</td>
<td>Otwenga</td>
<td>Dilleniaceae</td>
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<tr>
<td>20.</td>
<td><em>Dillenia pentagyma</em> Roxb.</td>
<td>Oxi</td>
<td>Dilleniaceae</td>
</tr>
<tr>
<td>21.</td>
<td><em>Duabhanga grandiflora</em></td>
<td>Khokon</td>
<td>Lithraceae</td>
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<td></td>
<td><em>(Syn. <em>D. sonneratoides</em> Ham.)</em></td>
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<td>23.</td>
<td><em>Dysoxylum procerum</em> Hierm.</td>
<td>Lali</td>
<td>Meliaceae</td>
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<tr>
<td></td>
<td><em>(Syn. <em>Phyllanthus emblica</em> Linn.)</em></td>
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<td></td>
<td><em>(Syn. <em>Syzygium cuminii</em> Skeels.)</em></td>
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<tr>
<td>26.</td>
<td><em>Ficus benghalensis</em> Linn.</td>
<td>Bar</td>
<td>Moraceae</td>
</tr>
<tr>
<td>27.</td>
<td><em>Ficus elastica</em> Roxb.</td>
<td>Athabor</td>
<td>Moraceae</td>
</tr>
<tr>
<td>28.</td>
<td><em>Ficus glomerata</em> Roxb.</td>
<td>Dimoru</td>
<td>Moraceae</td>
</tr>
<tr>
<td>29.</td>
<td><em>Ficus religiosa</em> Linn.</td>
<td>Ahot</td>
<td>Moraceae</td>
</tr>
<tr>
<td>30.</td>
<td><em>Gmelina arborea</em> Linn.</td>
<td>Gamari</td>
<td>Verbenaceae</td>
</tr>
<tr>
<td>32.</td>
<td><em>Lagerstroemia speciosa</em> Pers.</td>
<td>Ajar, Jarool</td>
<td>Lythraceae</td>
</tr>
<tr>
<td></td>
<td><em>(Syn. <em>L. flos-reginae</em> Retz.)</em></td>
<td></td>
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<tr>
<td>33.</td>
<td><em>Lagerstroemia parviflora</em> Roxb.</td>
<td>Sida</td>
<td>Lythraceae</td>
</tr>
<tr>
<td>34.</td>
<td><em>Mangifera indica</em> Linn.</td>
<td>Aam</td>
<td>Anacardiaceae</td>
</tr>
<tr>
<td>35.</td>
<td><em>Mesua ferrea</em> Linn.</td>
<td>Nahar</td>
<td>Guttiferae</td>
</tr>
<tr>
<td>37.</td>
<td><em>Phoebe attenuata</em> Nees.</td>
<td>Bomsum</td>
<td>Lauraceae</td>
</tr>
<tr>
<td>38.</td>
<td><em>Shorea robusta</em> Garten.</td>
<td>Sal</td>
<td>Dipterocarpaceae</td>
</tr>
</tbody>
</table>
40. **Spondias pinnata** Kurz.  
(Syn. **S. mangifera** Willd.) Amra, Amra  
Anacardiaceae

41. **Streblus asper** Lour. Hewra  
Moraceae

42. **Sterculia villosa** Roxb. Odal  
Sterculiaceae

43. **Stereospermum personatum** (Syn. **S. chelonoides** D.C.) Boga-Ameri  
Meliaceae

44. **Talauma phellocarpa** King. Titasopa  
Bignoniaceae

45. **Tamarindus indica** Linn. Teteli  
Leguminosae

46. **Tectona grandis** Linn. Segun  
Verbenaceae

47. **Terminelila arjuna** W&A Arjun  
Combretaceae

48. **Terminelila bekerica** Roxb. Baha,  
Combretaceae

49. **Terminalia chebula** Retz. Hilkha  
Combretaceae

50. **Vitex glabrata** Br. Prodr. Bandi-Kari  
Verbenaceae

51. **Vitex peduncularis** Wall. Ahoi  
Verbenaceae

52. **Vitex pinnata** Bhadia  
Verbenaceae  
(V. pubescens Vahl.)

53. **Wrightia tomentosa** Roem & Schult Dudhi  
Apocynaceae

54. **Zanthoxylum trifoliatum** Linn. Bajranali  
Rutaceae  
(Syn. **Acanthopanax trifoliatum** Merr.)

55. **Zizyphus mauritiana** Lamk. Bagari  
Rhamnaceae  
(Syn. **Z. jujuba** Lamk.)

56. **Zizyphus oenoplia** Mill. Banbagari  
Rhamnaceae

2.2.1 **Time of Survey**

The survey was conducted in three different seasons of the year.

1. **Pre-monsoon** : March - May.
2. **Monsoon** : June - August.
3. **Retreating monsoon** : September - November.

The Winter period was avoided because most of the insects undergoes hibernation during this period.
The field study was carried out from 5AM - 11AM, 2PM - 6PM and 7PM - 10 PM.

2.2.2 Procedure of Survey

The procedures adopted to conduct the survey are mentioned below.

(I) Road side forests were preferably selected for study.

(II) High power telescope, ladder and hill slopes were used to survey the insects.

(III) Help of local people and forest authority were also taken to enter the core areas of the dense forests.

(IV) Normally Govt. and Public transport facilities were used to reach in the study areas.

After being confirmed of the infestation the adults were collected and preserved for identification. The collection and preservation of insects were done as per the methods of Morris and Upton (1974), the instruction mannuai of Commonwealth Institute of Entomology London and Instruction of Zoological survey of India.

Since it is a very difficult task to identify the larval stages of the Lepidopterans, the larvae or pupae were collected from the host plants and carried to the Laboratory and reared for adult emergence. After emergence of the adult it was preserved properly for identification. Identification of the insects were done by consulting available literature and with the help of Commonwealth Institute of Entomology, London, U.K. The insects were photographed with damaged leaves or damaged plant parts either in the fields or in the Saroda Photo Studio Maligaon, by using closeup lenses X1, X2, X3, X4 or 80-205 mm Zoom(with macro). Fuji-Japan, Konika and Kodak coloured photo film were used during the entire study.

2.3 ECOLOGICAL STUDY

2.3.1 Population Study

2.3.1.1 Selection of Insects

From the survey it was observed that as many as 74 number of insects were directly damaging the economically important plants of the study area. It is not practically possible to study the ecology of all the insects, so 3 species of insects were selected for ecological study on the basis of following criteria:
(a) Extent of damage caused to the host plant by both larvae and adults.

(b) Monophagous, Oligophagous or Polyphagous insects of high degree damage potential to host plants and destructive stages covered maximum duration in a year.

(c) Insects whose larval stages are of short durational but having more generations in a year.

(d) Whose larval periods are of longest durational and consumption potential is very high.

(e) Insects whose infestation were found equally or with slight variations of damage potential or period of infestation in all the survey Zones.

(f) Whose population was comparatively higher within the Survey Zones (Harris, 1974; Southwood, 1978).

On the basis of the above criteria the following insects were selected for detailed ecological investigations under the ecological conditions of Kamrup District.

i) *Calopepla leayana*, Roxb.
   Order- Coleoptera, Family- Chrysomelidae. Both larvae and adults damaged extensively the host plant *Gmelina arborea*, monophagous, multitoline.

ii) *Pionea damastesalis*, Walker.
   Order - Lepidoptera, Family - Pyriliidae. The larvae of which severely damaged to the leaves of all maturity stages of the commercial wood yielding teak plant - *Tectona grandis*, monophagous, multitoline.

iii) *Eupterote undata*, Blanch.
   Order - Lepidoptera, Family - Eupterotidae. The larvae severely damaged to the leaves of the wood yielding commercially exploited host plant *Gmelina arborea*, polyphagous, univoltine or partially bivoltine.
Fig. 2.4 MAP OF THE KAMRUP NORTH DIVISION
SCALE : 1" = 4 MILES.
2.3.1.2 Sampling methods

As there is no universal sampling methods for insect population study (Southwood, Opp.Cit.), the random sampling was followed with practical conveniences, where the leaf of the plants was taken as the sampling unit (Harris, 1960; Richard and Waloff, 1961; Aman, 1969) as it is desirable that the sampling unit should be as small as possible (Southwood, Opp.Cit.). The random sampling methods were used for the insects whose stages are distributed all over the plants and remain individually or groups or few individuals but not in the form of clumping. The random sampling is seems to be not applicable for the insects that remains in the form of clumping and may not be found to infested all the plants, where single plant was taken as an unit and total counting of larvae per clumping were followed.

For the Lepidopteran larvae that clumped on different leaves in early stages and clumped on the trunk during later stages, it is tried to count out the total number by direct counting. For the detailed investigation on the various ecological aspects of the three selected insects, the study area was divided into 3-investigational zones (Fig - 2.4, Fig-2.5 and Fig-2.6). Zone-1 (Fig-2.4) comprises of the over exploited forests with maximum of barren spaces and also with nursery plants. Zone-2 (Fig-2.5) comprises of the monoculture forests and Zone-3 (Fig-2.6) with mixed forest. In Zone-2 dominant plant is Teak whereas in Zone-3 the dominant plant is Sal. As per the statistical requirement for the population study 5% of the infested plants of each zones were selected randomly and marked (Morin and Martin(1983). Of the selected plants hundred leaves of each plant were observed randomly.

2.3.1.3 Methods of data collection

In field condition data were recorded through direct counting (Moore, 1964). The larvae of clumped Lepidoptera were counted directly through unaided eyes or by using magnifying lens. The characteristics of the maturity stages, like length, breadth, size, colour, mature of damage and behaviour of damaging stages were minutely observed in the laboratory by raising laboratory culture of the particular insects to authenticate the field observation. For the convenience of the data collections Telescope 0X100 Rusia, was used wherever necessary. The number of larvae of different maturity stages on the lower canopy were counted with unaided eyes. Above this range telescope was used to findout the larvae on the ventral surface of the leaves. The larvae on the dorsal surface were counted through unaided eyes by riding on the ladder.
The larval stages were determined by morphological characteristics and by the resting, hiding and feeding cages, whatever were possible. The insect population of the tall trees situated on the foothills and hill slopes were easily counted by maintaining the elevation or ridges of the hills from where all the canopies can be easily observed.

During the data collection the following precautions were taken.

(I) Data recording of Coleoptera and caterpillar of Lepidoptera upto a height of 15-feet were done through unaided eyes; above which telescope and Ladder were used for data collection.

(II) The first instar larvae and eggs were counted with the help of magnifying lense.

(III) The Lepidoptera larvae were counted after determination of larval characteristics through proper Laboratory investigations.

(IV) Among the larval characteristics size and colour of the larvae; size of the resting, hiding and feeding cages or nature of feeding were taken into consideration.

(V) The egg laying behaviour and fecundity were determined through point to point careful repeated searching.

(VI) The eggs of the nocturnal insects were collected in day times after repeated daily searching.

(VII) The facundity of the Lepidopterans were confirmed through dissections of the gastrophismic females. The fecundity of Coleopterans were determined either by counting of the egg mass or egg masses or by dissecting out the ovary of gastrophismic females.

(VIII) The facundity of the Coleopterans and Lepidopterans were also determined by the egg laying of the insects in laboratory conditions.

IX) Throughout the study periods the days having heavy rains, strong winds and thick fogs were generally avoided for data collection.
The population of Coleopteran borer species were determined through close observations and direct counting of the adult emergence holes on the stem or branches of the infested host plants because of the fact that different wood borer larvae of Coleopteran species were found to make varied channels and subsequently the adults emerged by following the different paths. Further, the size of holes of emergence of the adults of different insects were found varied in different seasons.

The presence of adults inside the infested stems were detected by striking hard on the stem which produces croaching sounds of the adults in the holes. Where possible the adults were collected by cutting the stems of the host plants.

The population of the bark borers Coleopterans were determined by removing the infested barks of the host plants.

Borer Coleopteran species were also collected by using freshly cut log traps after being loosen the bark at both the ends by hammering.

2.3.1.4 Climatological data

The temperature and relative humidity % were measured by using field thermometer (Zenith - West German), dry and wet bulb thermometer (Zeal-England) and hygrometer (Barigo-West German) respectively. Raingauge (Sico-India) was used to measure the Rainfall.

2.3.1.5 Laboratory Investigation

In laboratory conditions the foliage consumption potential of the larval and adult stages of the selected insect species were investigated as per the methods of Boldt et al (1975) and Baruah (Opp.Cit.) on different leaf maturity stages and were estimated by using Polar planimeter. In field condition it is troublesome to measure accurately the consumption potential of an insect species. The damage was assessed through comparison and expressed in terms of damage percentage. The advantage of Laboratory investigations were:

(I) To get the exact amount of foliage consumption.
(II) To find out the time, duration, behaviour & nature of feeding of a particular insect species.

(III) To find out the damage percentage in the field conditions of the selected insect species.

2.3.1.6 Culture

The culture of the insects were maintained in culture cage (24"X24"X28) well covered by finely meshed (0.02 mm) steel nets. After washing the cage with rectified spirit and 40% formaline solution the cages were kept in well ventilated laboratory room having the system of artificial fanning and lighting. The relative humidity was maintained at 70-80% while temperature at 27-29°C by using wet black markin cotton clothes. The eggs of the insects were collected from different ovipositional sites and kept on clean petridish with distilled water soaked filter paper, and allowed to hatch inside the BOD-chamber.

The weak and diseased insects were removed immediately after detection. The excreata were allowed to deposite on a white fullscape paper and were removed periodically. The damaged and the dried leaves were also removed periodically.

2.3.1.7 Grouping of leaves

The leaf of the host plant used for laboratory investigations of consumption potential were classified into three categories by studying the colour and physical texture of the leaves:

(I) Tender leaves
Characterised by the softness, transparency and lightness in colour. These are newly sprouted leaves available in the top shoot regions of the twigs.

(II) Young leaves
Comparatively more dark greenish in colour due to greater accumulation of chlorophyll. Leaves are of medium hardness in comparision to tender leaves.

(III) Matured leaves
Darker in colour due to heavy accumulation of Chlorophyll and sometimes having yellowish tinge due to accumulation of Xanthophyll. The matured leaves are hard and thick.
2.4 EXPERIMENTAL SETUP

The experiments on damage potential were performed coinciding with the peak period of infestation in the field conditions (Baruah, Opp.Cit.) when the host plants were flourishing with different maturity stages of leaves. To find out the damage potential 18 glass jars (1000 ml) filled with tap water and covered with finely meshed nylon cloths were placed in insect cage (24"X24"X28"). Fresh leaves were placed in the jars through the holes made on cloths.

During night the Larvae were allowed to feed in dark. While during the day larvae were fed in diffused light. The leaves were cut from single branch of a host plant preferably from where the eggs were collected. The leaves were cut early in the morning and in the dusky evening. Fresh and undamaged leaves were collected. Three sets of experiments one for each maturity stages of leaves were carried parallely throughout all the different seasons. Five larvae were allowed to feed at a time in a jar to get the appropriate average value of consumption potential. The selected larvae were allowed to fed on different maturity stages of host plant leaves from 7AM and 7 PM. Then the area consumed were measured with the help of Planimeter at 6 PM and 6 AM respectively.

2.5 STATISTICAL PROCEDURE

For universal truth any experimental findings must supported by statistical rules and methods so that it cannot be treated as invalid. Every Biological findings has some practical importance in the fields of experimentations. The statistical analysis of the data of Biological experimentations has tremendous ecological importance and are accepted internationally in field of quantitative Bio-ecology. Following are the applied statistical methods for data analysis:

2.5.1 Density

Density is the number of individuals per unit area (Harnett, 1982). The mean density (m) is the mean number of individuals per quadrate. Overall density is the density of the insects in the study area. Mean crowding (m*) is the mean number per individual of other individuals in the same quadrate which varies greatly with mean density. The mean density (m) and mean crowding (m*) were calculated following the formula of Richards and Mann (1967) as:

\[ \text{Density} = \frac{\text{Number of Individuals}}{\text{Area}} \]

\[ \text{Mean Density} (m) = \frac{\text{Total Number of Individuals}}{\text{Total Number of Quadrates}} \]

\[ \text{Mean Crowding} (m^*) = \text{Mean Density} - 1 \]
i) Overall density \( (m) = \frac{\Sigma_{j=1}^{Q} x_i}{Q} \) 

ii) Mean crowding \( (m^*) = \frac{\Sigma_{j=1}^{Q} x_i^2}{\Sigma_{j=1}^{Q} x_i} - 1 \) 

Where, 
\( Q \) = Total number of quadrate studied. 
\( N \) = Total number of individuals and 
\( X_i \) = Variates. 

2.5.2 Standard deviation

The standard deviation \( \delta_t \) is the measure of the dispersion about an average, such as the mean was calculated by using the formula:

\[
\delta_t = \sqrt{\frac{\Sigma_{i=1}^{n} (X_i - \bar{X})^2}{n-1}}
\]

Where, 
\( X_i \) = Variates values 
\( \bar{X} \) = The sample mean. 
\( N \) = Number of observations

2.5.3 Co-efficient of correlation and Regression Line

To find out the impact of abiotic factors on the population characteristics of the insects, the co-efficient of correlation between the two factors were calculated with the help of following formula:

(I) Co-efficient of Correlations\("r"\):

\[
r = \frac{N \Sigma X_i Y_i - \Sigma X_i \Sigma Y_i}{\sqrt{(N \Sigma X_i^2 - (\Sigma X_i)^2) (N \Sigma Y_i^2 - (\Sigma Y_i)^2)}}
\]

Where, 
\( r \) = Co-efficient of correlation. 
\( N \) = Number of observations. 
\( X_i \) = Values of independent factors. 
\( Y_i \) = Values of dependent factors.
(II) Regression Line:

The regression line was given by the equation $Y=a+bx$ (Bishop, 1966) where, 'a' and 'b' are two constants of the two parameters $X$ and $Y$ respectively and were obtained through the principles of least square method. Thus -

$$a = \bar{Y} - b\bar{X}$$

$$b = \frac{\sum X_i Y_i - \sum X_i \sum Y_i}{N \sum X_i^2 - (\sum X_i)^2}$$

$$Y_c = a + bX_i$$

Where, $X_i$ and $Y_i$ = Obtained values of the two respective parameters.

$Y_c$ = Calculated values of the parameter $Y$.

2.5.4 Aggregation

The aggregation was studied by using the formula

$$A = \frac{m^*}{m}$$ (Taylor, 1961).

where, $m^*$ = Mean crowding.

$m$ = Mean density.

Computer and fx calculator were used for statistical analysis.