1. INTRODUCTION

Sikkim is situated in the Eastern Himalayas and is sandwiched between the Nepal in the West and Bhutan in the East, Tibet in the North and the Indian State of West Bengal in the South.

Sikkim has an area of 7046sq. km measuring 115km form North to South and 65km from East to West, the elevation ranging from 244 meters to over 8550 meters, above sea level approximately latitude of 27^0 North and longitude of 88^0 East. Climate ranges from sub-tropical in the South to Tundra in the Northern part.

It is divided into four district viz. North, East, West and South, which have headquarters at Mangan, Gangtok, Geyzing and Namchi respectively.

Various agricultural crops/cash crops are grown in Sikkim apart from them tea is also cultivated. Tea is cultivated at Temi Tea Garden, which is the Soul Tea Estate in Sikkim, located at South district “Namchi”. Namchi in English mean “sky high” as name suggest, Namchi is nestled cuddled among the hills at an altitude of 5500ft.

Temi Tea Garden only tea estate in the Indian State “Sikkim”. The Temi Tea Garden produces one of the top quality teas in the international market. The Temi Tea Garden is spread out on the gentle hill slope emerging from the Tendong Hill and presents a spectacular view of the surrounding villages and the river Teesta.

1.1 History of Tea

Drinking tea plays such a central part in our lives it is such a universal phenomenon with millions of people all over the world enjoying tea on a daily basis.

Tea is the agricultural product of the leaves, leaf buds and internodes of the plant, prepared and curved by various methods. After water, tea is the most widely consumed beverage in the world.

Tea is the common name of the shrub "*Camellia sinensis*" that has been cultivated from antiquity in China. This shrub is now widely cultivated in Japan, India, Sri Lanka, Sumatra, Java and other countries.

Historically tea's origin date back to around 2700 B.C. It is thought to have first been discovered in the mountainous areas of China's far Western Szechuan and Yunnan Provinces.

Emperor Shen Nung, a renowned herbalist in 2737 B.C. accidentally discovered tea, as one day while he was in his garden a few tea leaves fell by chance into his boiling water which then gave off rich, alluring aroma. The emperor, upon drinking this brew, discovered it to be refreshing and energizing. Then he immediately gave the command that tea bushes to be planted in the gardens of his palace.

A renowned author, Luyu, during the reign of the Tang Dynasty (618-907 A.D.) wrote a book in tea called **Ch'a Ching,** Which is the first ever book written on tea.

In addition to tea's attributed health benefits, the high level of "tea culture" was appealing to the people outside China as well. Since the 5th century A.D., tea has been exported by land and sea throughout Asia and reached Europe but the British who greatly developed it by transplanting it to India in early 1800's.

Camellia sinensis is an evergreen plant of wide adaptability that grows mainly in tropical and sub-tropical climates. Nevertheless, some varieties can also tolerate marine climates. Diseases of tea are numerous with specific attacking zone (i.e. different parts of the plant such as leaves, stems, buds and roots).

Varieties of tea pests inhabit the tea plant in different part in different seasons with different damage pattern and intensity depending on climate, altitude and cultural practices.

The causal factors of tea diseases prevailing in tea plant are as below:

- In animate agents like fog, humidity, light, temperature etc.
- Animate pathogens like bacteria, viruses, fungi, algae, nematodes.
- Arthropods like insects and mites.

1.2 Tea in India

Tea is indigenous to India and is an area where the country can take a lot of pride. The cultivation and brewing of tea in India has a long history of applications in traditional system of medicine and for consumption.

The consumption of tea in India was first clearly documented in the Ramayana (750-500 B.C.) for the next thousand years; documentation of tea in India was lost in history. Records re-emerge during the first century A.D., with the stories of Buddhist monks, Bodhidharma and Gann-Lee, and their involvement with tea. Research shows that tea is indigenous to Eastern and Northern India and was cultivated and consumed therefore thousands of years commercial production of tea in India didn’t begin until the arrival of British East India Company.

In 1788 on request of East India House, Sir Joseph banks wrote a memoir on the subject recommending the introduction of plants from China to Behar, Rungpur and Kooch Behar.

In Assam, the wild tea plant was believed to be discovered by Mr. David Scott an Indian civilian who took charge of the settlement of Assam, somewhere around 1819-1821 A.D., he sent a specimen of the Assam wild tea plant to Calcutta to his friend Mr. James Kyd, hence the specimen was identified by Dr. Wallach and Mr. Burell, it is the Wallichian herbarium now belonging to the Linnaean society.

Cultivating tea in the hill districts of Northern India was first originated by Dr. Royle in 1827. In early 1850, tea cultivation was initiated in Darjeeling Districts, several thousand acres of land were cleared and many nurseries were set up with China Jat.

The Tukvar Tea Estate the first tea garden in hilly areas of Darjeeling came into existence in 1857 then, tea cultivation increased rapidly in Terai and Doars.In 1969, the soul Tea Estate of Sikkim State "Temi Tea Garden" was founded.

In all aspects of tea production, consumption and export, India has emerged to be the world leader mainly because it accounts from 31% of global production. The range of tea offered by India from the original Orthodox to CTC and green tea from the aroma and flavor of Darjeeling tea is the strong Assam and Nilgiri Tea remains unparalleled in the world.

Tea trading in the domestic market is done in two ways, Auction and private selling. Market reports are received from the six major auction centers in India namely Calcutta (Kolkata), Guwahati, Siliguri, Cochin, Coonoor, Coimbatore and tea auction.com. Mauli, B.C. (1993)

2. OBJECTIVES

The study aims to investigate the arthropod pests infesting the tea plant on different seasons at “Temi Tea Garden (Estate)”. The specific objectives of the study are:

- Collect and identify the pest of tea plant and study their status.
- To explore the species diversity.
- To explore the seasonal variation of tea pests.

3. LITERATURE REVIEW

Review of literature is one of the integral parts of all research. A brief account of the literatures to the present investigation is presented in this chapter.

Tea Pests and Diseases

It is estimated that 1034 species of arthropods and 82 species of nematodes are associated with the tea plant. China, with the longest history of tea cultivation, has more than 430 species of insects and mites feeding on this crop. About 230 species of arthropods are known to attack tea in India.

In the first ever comprehensive report on tea diseases, only about 12 fungal diseases were mentioned by Watt and Mann in 1903 and this rose to 17 fungal in 1918.Today, its fairly known that about 385 species of pests occur on tea world over of which half occur on North East India. Banerjee (1966).

Aphids are of great economic importance since they suck up plant sap, hamper plant growth as well. Aphids are seen in clusters/colonies. They suck sap; secrete honey dew through anus, which attracts sooty mould, a fungus. They reproduce by parthenogenesis or by budding. Adult females are viviparous.

The main host of *Toxoptera aurantii*, Boyr is citrus. Tea, coffee, cocoa are the alternative hosts. Adults are shiny black, winged or apterous measuring 1.2 to 1.8 mm, have relatively short antennae. They produce living young, which are dark brown in color. At 25 degree Celsius, single generation completes in 6 days but above 30 degree Celsius, aphid population declines sharply. Hill (1993).

Toxoptera aurantii is also reported to be the vector of Citrus Tristeza Virus (CTV). Tristeza Virus is an aphid borne clostero virus. This virus infect the tender citrus buds

and therefore no foliage growth, hence no fruiting. Affected plants shows vein cleaning, stem pitting, cupping of new foliage, stunned growth and sometime wilting symptoms are also recorded. Ghimire (2002).

The cellulolytic enzymes, celluloses, pectinases and xylanase isolated from the tea fungus and lacase from *Trametes versicolor*, were tired for the improvement of black tea quality parameters, i.e. theaflovin (TF), therutrigen (TR), high polymerized substances (HPS), total lignor color (TLC), total soluble (TSS), caffeine(CAF) and dry matter content (DMC), were analyzed. Purified cellulose amended with Trametes versicolor lacase in enhancing tea quality.

The tea in K.T.E is damaged by a disease called blister blight caused by fungus *E. vexans*. Because of its topography, high altitude, abundant rainfall and low temperature, most of the common pests do not have the status in the economic injury level. Rai, M. (2004).

Tea mosquito bug *Helopeltis theivora* water house is one of the important pests of tea. They are more active during morning and evening (Hill, 1993). These are also sap feeders. The adult bug is 7-10 mm long with antennae nearly twice as long as the body. The antennae, head and wings are blackish. Most females have blood-red body and like the nymphs the adult have a pin like projection on the thorax. The nymphs are slender, delicate and yellow with pale red markings. The full-grown nymph has a body length of about 7mm, the antennae being much longer. There are five nymphal instars all except the 1st having pin like projection sticking up from the thorax, 3 weeks of nymphal period. The impact of environmental factors on infestation of tea leaves by *Helopeltis theivora*, and associated change in flavonoid flavor components

and enzymes activities. They found that the attack of tea plant leaves by the mosquito bug *Helopeltis theivora* (Miridae) was positively correlated to temperature and rainfall and partially to humidity, as determined in varieties during the period 2000-2002. The insect attack was maximum during May –September, and lead to an increase in the activities of the oxidative enzymes peroxidase, ascorbate, peroxidase and polyphenol oxidase.

The metallic green beetle, *Chrysolampra flavipes* Jacoby (Coleoptera: Chrysomelidae) has been recorded for the first time to cause extensive damage to tender stems of mature tea bushes in an estate in Jorhat circle in 1983. Das and Gope (1983).

Dev (1964), studied on the biology of Assam thrips *Scirtothrips dorsalis*. Hood. *S.dorsalis* population starts increasing from March and by August the population declines though it may persist in varying numbers on unpruned tea plants throughout the year. The life cycle is completed within 12-15 days depending upon the environmental conditions.

Andrews (1923) studied about the green fly (*Empoasca flavescens*). It is one of the major sap feeding pests of tea. Heavy infestation by these Jassids leads to a condition called rim-blight, the affected leaf margin turning brown. They leave no puncture on leaves but the affected leaves become stunted, dry up and fall. Though adults and nymphs cause the damage, the magnitude of damage by the nymphs is particularly high. Pruned tea is prone to Jassid attack particularly during drought.

Banerjee (1988). "Introduction to Agricultural Acarology" writes, the distribution and abundance of the tea mites are related to climatic factors like ambient temperature, rainfall, shade and cultural practices though it is not clear which one is

the most important. In fact, the relative contribution of each of these factors in regulating the mite population is not well understood. The population growth of mites synchronizes with the seasonal temperature cycle but the statistical correlations are not always formally significant. Rainfall, e.g. is one of the most important climatic factors that control the mite population outbreak but since it only dislodges the pests physically from the upper surfaces of tea leaves, undersurfaces of tea leaves are least affected.

Sivapalam, P. and V. Delucchi (1975) while studying the integrated approach to tea plants in Sri- Lanka wrote regarding termites. The precise reason for the termite outbreak is not clearly understood. In some cases, mulching and use of herbicides seems to have triggered the termite population but a casual relationship is difficult to establish. Some species show marked clonal susceptibility and shade may also influence the termite activities.

Banerjee (1970) studied the aggregating behavior of the caterpillars of the moth *Andraca bipunctata* wlk (Bombycidae Lepidoptera). These caterpillars are found in close physical aggregations at daytime, on leaf undersurfaces, but these aggregations breakup at night and they start feeding voraciously on the foliage.

Hampson reported that the habitat of *Andraca bipunctata*, a moth belonging to family Bombycidae is mainly found in Sikkim and Assam.

Das and Ganguly (1961) studied the Coccoids on tea in North East India. Over 30 species of scale insects and mealy bugs (coccoidea) infest tea plants in varying degrees: of them 12 are serious pests infesting stems and branches or leaves. The coccid and scale infested branches and shoots become highly unproductive leading to

serious leaf fall. If the attack prolongs, irregular swelling appears on the branches because of callus growth inside. Prolonged attack also debilitates the bushes, the branches die back and eventually the whole plant is killed. The long-term effect of the damage could be devastating as the seriously infested plants fail to produce young shoots of quality.

Watt and Mann (1903) listed seven species of nettle grubs including one jelly grub attacking tea in North-East India, almost all of them are more or less equally troublesome.

4. STUDY AREA

The study was performed at Temi Tea Garden which is the pride and the sole tea estate in the stunning Himalayan landscape of South Sikkim in the Northern Eastern Indian State of Sikkim. The Temi Tea Estate (27^0 14' 12' N 88^0 25' 20' E) with an elevation of 4800 ft – 6000 ft was established in 1969 with an area of 177 hectares (440 acres) divided into 17 plots. The land shows gentle slopes that originate from the Tendong Hill range. The ground conditions indicate loamy soils with slope of 30-50 %. The ground surface is subject to moderate erosion.

Before the estate was created, the land was degraded forest. During British rule, the site was a landmark for Scottish Missionary buildings in the early 1900's, which then functioned as Leprosy hospital.

Temi Project was initiated by Late Chogyal Palden Thondup Namgyal and work was carried by Anglo Indian "Sir Dickson". The garden has 406 workers supported by staff of 43 with 4 technicians and 6 administrative staffs.

For one to reach this garden, it is located around 44 km away from the State Capital "Gangtok" by road and 101 km form Siliguri (Indian State of West Bengal) by road.

Tea production in the estate has been switched over as per the guidelines issued by the Institute of Market logy (IMO) of Switzerland to produce organic tea; a project initiated in April 2005 and is fully organic from April 2008.

The changeover has involved use of organic bio-fertilizer such as cattle manure, Neem cakes and vermin-compost manure replacing the chemical fertilizers used in the past. The Bangalore unit of IMO inspects the product every year and issues IMO certificate.

Tea Estate possesses various cloned varieties such as T-78, P-312, T-383, B- 777, Pani Tola, Manipuray Dan gray, Sale bong, China Seed.

The tea produced by the Temi Tea Estate is packaged 0.250 kg (0.55lb) under many brand names; the brand name "Temi Tea" is of the best quality consisting a pure tea "golden flowery orange pekoe #1 (TGOFP1). The next in quality is popular brand of "Sikkim Solja" followed by Mystique and Kanchenjunga Tea. About 75% of the tea produced in the estate is auctioned at Kolkata and the balance 25% is marketed as packaged tea in the domestic market.

The Tea Board of India awarded the "All India Quality Award" to the Temi Tea Garden for two consecutive years in 1994 and 1995.

Table1: Production of tea by TTE in last three years

Year	Green leaves (kg)	Processed tea (kg)
2007	360,525	80,210
2008	365,916	82,433
2009	266,394	59,365
Total	992,835	222,008

Source: TTE office record, 2009.

4.1 Climate

TTE is located at stunning landscape of South Sikkim, with overlooking high mountains and deep river valleys.

The climate is moderate/temperate, according to the TTE recorded data. In August 2008, maximum temperature reached 26 ºC whereas the minimum temperature fall to 1 ºC in the month of January and February 2008 while in July 2009 maximum

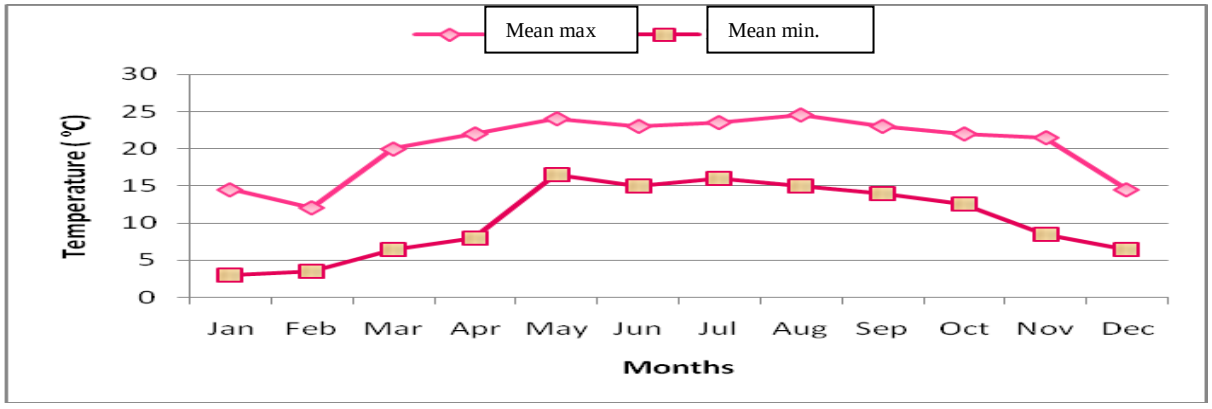
temperature was recorded as 25 ºC and the minimum of 4 ºC in the month of December.

The annual rainfall of TTE in 2008 was recorded as 3113.5mm and June recorded the highest rainfall of 786mm and lowest 3.50mm in January 2008 while the annual rainfall of TTE in the year 2009 was 2645.75mm July 2009 recorded the highest rainfall of 592mm whereas January and December recorded the lowest.

Fig 1: Variations in average monthly rainfall (mm) recorded for the year 2008-09 at TTE.

Source: TTE office record, 2009.

Fig 2: Monthly variations in mean maximum and mean minimum temperature recorded for the year 2008-09 at TTE.



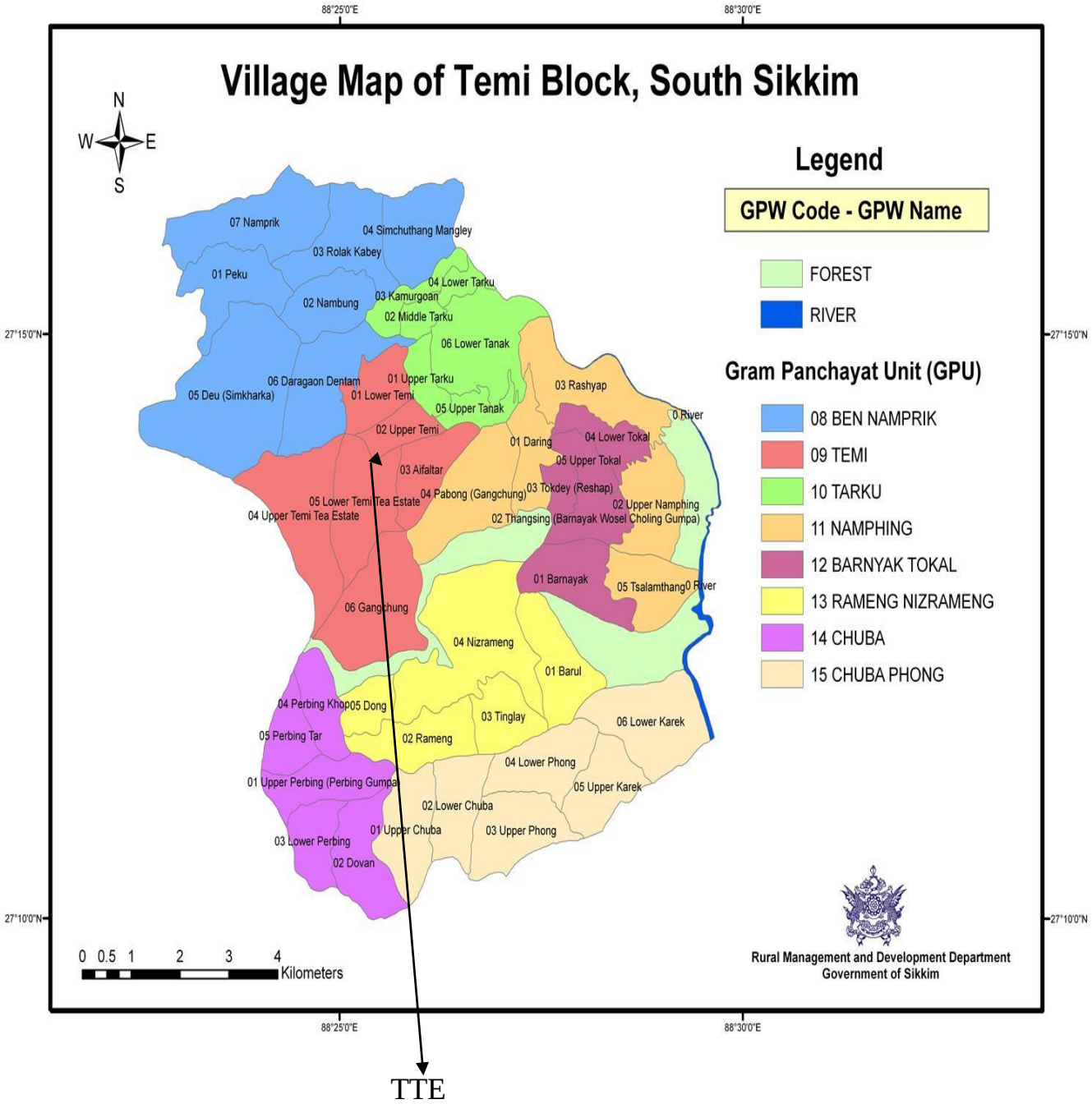
Source: TTE office record, 2009

Fig.3: Map of Sikkim, showing TTE.

TTE

Fig. 4: Map of South Sikkim.

Fig. 5: Map of Temi Block.



5. MATERAILS AND METHODOLOGY

5.1 Methodology

The investigation “Study of tea pests of Temi Tea Estate in Namchi, South Sikkim” was carried out on October–November 2008(dry season) and June–July 2009(monsoon).The study was based on primary as well as secondary data. Detailed secondary information and personal communication were made with the personnel involved with the tea garden before starting the investigation.

5.2 Materials for Pests Collection

- Insect collecting jars.
- Insect collecting sweep net.
- Petri dish.
- Forceps.
- Brush.
- Entomological pins.
- Cardboard Sheet (white).
- 70% alcohol as preservative.

5.3 Data Collection

For collection and information various techniques and sources were applied for the observation done at Temi Tea Garden, South District, Sikkim, India. Hence the study was based upon primary as well as secondary data for analysis.

The primary data has been collected by visiting the study site. Data was collected by visiting the field on two seasons viz. Dry season (Oct-Nov2008) and in monsoon

(June–July2009).First visit was made in the dry season i.e. 30thOct 2008 - 6th Nov2008 and 15th Nov 2008 and the second visit was done during monsoon i.e. June 25th-30th2009 and July 12th-17th 2009. Pests were collected employing various collecting methods and their infestation in tea plants. The observation was helped by assistant manager of TTE. The informal questionnaire survey was also done to enhance the knowledge about pests and their damage, seasonal abundance, crop loss due to pests and natural calamities.

With the help of Temi Tea Garden office records, publications of related field, websites, various libraries, Governmental and Non-Governmental institutions/organizations, Biological Abstract, Master thesis/dissertation the secondary data has been collected.

Interaction with the concerned officials, labors, manager proved useful for the study.

5.4 Pests Collection

To study the population density and collect pests, five bushes were chosen from every corner of the respective garden, as Temi Tea Garden is divided into 17 plots where plot no 14 was chosen as the observation site. Hand picking method was employed for the pests which were readily visible with the naked eye, and were collected with the help of a forceps and were put in a bottle/vile containing 70% alcohol as preservatives.

Specimens like aphids, thrips, mites etc were collected with the help of a soft brush and kept in a vials containing 70% alcohol as preservatives. Those insects remaining hidden inside the bushes were collected by placing the card board sheet beneath the bushes and then jerking the bush and the fallen insects in the card board were

collected with forceps/brush and then preserved in 70%alcohol. For flying insects' pests such as bugs, grasshoppers, crickets etc. process of sweeping with sweep net was employed.

Collected specimens were then labeled with primary information, which proved useful later.

5.5 Slide Preparation/Photography

The smaller insect pests preserved during collection were now mounted on slides to prepare permanent slides by undergoing usual process of dehydration in alcohol series and staining. Permanent slides were photographed with Carl Zeiss Micro photographic Binocular Microscope.

5.6 Identification

The collected specimens were identified by referring to literature from the library, consulting Insect Taxonomic Keys: Baker and Wharton. (1964), Banerjee (1983), Borer, De Long and Triple horn (1981), Chhetri (Batch 2061/62 B.S.), Fletcher (1914), Joshi (2051 B.S.), Maxwell, Hewlett (1971) and Neupane (2058 B.S.), and also taking guidance from expertise of Entomology, TTE officials and research supervisor.

5.7 Data Analysis

(i) Species Diversity

Species diversity was calculated by using Shannon's Diversity Index and Community Dominance by Simpson's Index (Odum, 1996), where

$$\overline{H} = -\sum\left(\frac{ni}{N}\right)Ln\left(\frac{ni}{N}\right)$$

Where,

$\overline{H}$ =Shannon's Diversity Index.

ni= Importance value for each species

N= Total no. of Importance Value.

[$\therefore$ Importance Value = Number of Individual]

(ii) Evenness (e) = $\frac{\overline{H}}{\log s}$

Where, s =Total no. of species.

(iii) Community Dominance (C) = $\sum\left(\frac{ni}{N}\right)^2$

Where, C=Simpson's Dominance Index.

6. **EXPERIMENTAL RESULTS**

To study the population of pests, season of major abundance, nature of infestation, crop loss by the pest and the required control measures the study site was visited two times, viz.(Monsoon and Autumn season) to learn and assemble more information about the variability of the season.

In order to assemble more ideas and information random questionnaire was conducted with the administrative staffs and also with the laborers' working at the tea garden.

List of pests collected during the study period have been presented in the table. ***Table2:***

Table: 2 Pests collected, time of collection and nature of damage on tea plant at TTE.

Pest	Time of Collection	Nature of Damage
Red Spider Mite	Oct-Nov/Jun-July	Sap sucker found on upper surface of mature leaf.
Aphids	Oct-Nov/Jun-July	Sap sucker found on young leaves, .buds, tender stems
Thrips	Oct-Nov/Jun-July	Sap sucker found on young shoot and buds.
Jassid (green leaf hopper)	June-July	Sap feeder found on young leaves.
Scale Insects	Oct-Nov	Sap sucker/leaf damager found on leaves and stem.
Termites	Oct-Nov/Jun-July	Damage roots found on stem, root

Table3: Seasonal Distribution of Tea Pests at TTE.

Order	Family	Species	Autumn (Oct/Nov) Number of individual species.	Monsoon (June/July) Number of individual species.
Hemiptera	Aphididae	*Toxoptera aurantii.*	24	15
	Coreidae	*Leptocorisa chinensis.*	2	4
	Pentatomidae	*Not Identified*	6	4
Thysanoptera	Thripidae	*Scirtothrips* Sp.	28	11
Lepidoptera	Bombycidae	*Andraca bipunctata.*	6	3
	Geometridae	*Not Identified*	4	2
	Lymantridae	*Not Identified*	-	2
	Limacodidae	*Thosea* Sp.	2	2
Hymenoptera	Formicidae	*Dorylus orientalis.*	22	13
Acarina	Tetranychidae	*Oligonychus coffeae.*	16	5
Orthoptera	Acrididae	*Gastrimargus africannus orientalis.*	3	4
	Tettigonidae	*Not Identified*	2	2
Coleoptera	Chrysomelidae	*Not Identified*	-	3
	Scarabaeidae	*Not Identified*	-	4
Predators	Ladybird beetle (Coccinellidae)	*Coccinela.* Sp.	3	4
	Spider	*Not Identified*	5	3
	Preying mantis (Mantidae)	*Mantis* Sp	2	1

6.1 Characteristic Features of Recorded Pests:

Tea Aphid (*Toxoptera aurantii*)

Systematic Position:

Order: Homoptera.

Family: Aphididae.

Genus: *Toxoptera*

Species: *aurantii*.

Tea Aphids were found in clusters, these black tea aphids were abundant on tea bushes during both the seasons, aphid infested leaves curl up and growth is stunted resulting unproductive plant. They were not only common to the old bushes but they were also found on the plants recovering from pruning and even in nurseries. Thus it can be concluded that aphids are the potential pests of the tea in TTE that cause significant crop loss.

Characteristics features:

Adults are shiny black in color, winged or apterous. Body length ranges from 1.2 -1.8 mm in length. The 1st and 2nd antennal segments are black while 3rd, 4th and 5th segments are light colored/ transparent.

Thrips (*Scirtothrips* Sp.*)*

Systematic Position:

Order: Thysanoptera.

Sub- Order: Terebrantia.

Family: Thripidae.

Genus: *Scirtothrips.*

Thrips are the major pest in most tea growing countries, apart from aphids, thrips are also abundantly found of all pests in TTE. They are minute and found in clusters and prefer warm and humid condition. Thrips are weak fliers and are easily dispersed by wind. Females possess saw like ovipositor by which she lay eggs inside leaf tissues. Life cycle completes in 14-20 days, and attack young leaves, buds and produces lacerations' which appears as a streak, resulting in curled, uneven, yellowing along leaf margin and matty leaves (leaf loses shine).

Characteristics feature:

Adult thrips are yellowish-brown in color measuring 0.5 - 0.8 mm in length. Adults have brown abdomen. Antenna 5 segmented with one segmented terminal style, wings present narrow and pointed apically. Nymphs are creamy white and possess prominent eyes. Female possess well developed curved downward ovipositor.

Red Spider Mite (*Oligonychus coffeae).*

Systematic Position:

Class: Arachnida.

Order: Acarina.

Family: Tetranychidae

Genus: *Oligonychus*

Species: *coffeae.*

Red Spider Mite is the largest of all the mites, which is large enough to be easily seen with naked eyes, they occur mainly on the upper surface of the leaves.

Female are larger than males and lays reddish and apple shaped eggs. Banerjee, B. and S.C Das. (1969). The adults, nymphs actively feed on the mature leaves causing reddish- brown spots at the point of sucking; these spots finally coalesce into a large single patch leading ultimately to leaf fall. Life cycle is completed in 10 – 14 days (Hill, 1993).

These mites were abundant during monsoon, found in un-shaded mature bushes. They feed on leaf sap and hence damage the leaves. Banerjee, B. (1974).

Characteristics features:

They are oval, red in shape and color. Four pair of legs in adults while only three pair of legs in case of the nymphs. Body size ranges from 0.3 – 0.5 mm in length, makes thin silky web, found on the upper surface of the mature leaves, feeds on the leaf sap and hence damage the leaves. Cotes and E.C. (1985).

Common Lopper

The larvae are dark green to black in color measuring about 1-7mm to 2cm in length. They eat away the young and mature leaf. Though adult couldn't be collected, the pest couldn't be identified. Andrews, E.A. (1931).

Green leafhopper (Jassids)

These green leaf hoppers of tea was studied and described by Andrews (1923). Jassid *Empoasca flavescens* Fabr. is a major sap feeding pest of tea and heavy infestation causes a condition known as "Rim Blight". Both adults and nymphs cause damage but the magnitude of damage by nymphs is high.

They are found during monsoon as well as in dry season, they contribute to be important pests of TTE. Due to lack of adult form the collection was barred.

Scale Insect.

The Scale Insect has specialized piercing/sucking mouthparts, besides the effects resulting from removal of plant sap, they injure plants as a result of toxic effects from their saliva causing distortion and stunting of growth. They produce honey dew on which sooty moulds often develop causing another problem. Rai, M. (2004)

In TTE the populations of these insects were few and considered as negligible.

Table4: Site of attack of the pest on tea plant and their status at TTE.

Pest	Site of Attack	Status
Red Spider Mite	Upper surface of mature leaves.	Transitional
Aphids	Young leaves, buds and tender stems	Major
Thrips	Young shoots and buds	Major
Jassid	Young leaves	Minor
Scale insects	Leaves and stem	Negligible
Termites	Stem and roots	Minor

PLATE – I

A Glance of Splendor: Temi Tea Estate.

A Side View of Temi Tea Estate Factory.

PLATE- II

Collection of insects by jerking the tea bushes.

Scale insects attached to the bark of the plant.

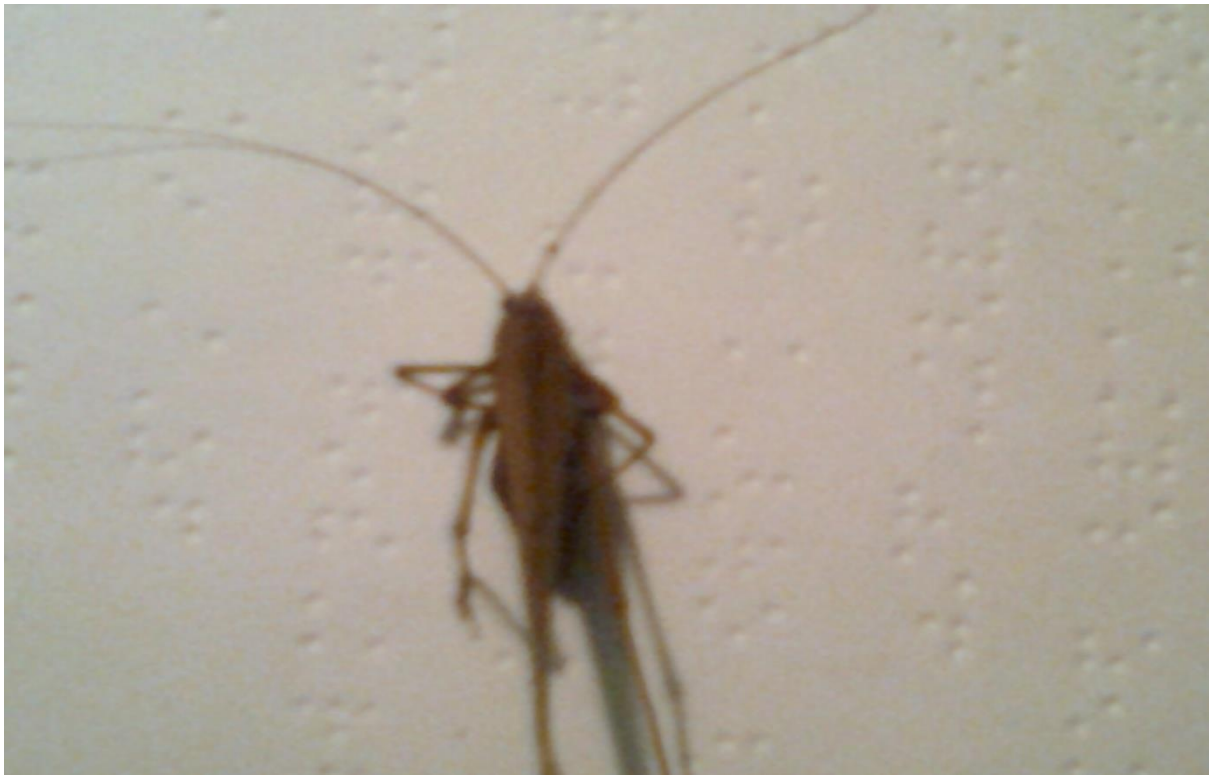
TABLE- III

Aphid *T.aurantii*. (apterous).

Red Spider Mite (*Oligonychus coffeae.)*

PLATE- IV

Thrips (*Scirtothrips* Sp.*)*



Long Horned Grasshopper.

PLATE- V

Pluck able shoot of tea infested by Aphid.

Predator of tea pests, *Mantis.*Sp.

6.2 Diversity of Tea Pest

Among the collected specimens, maximum numbers were collected from Order: - Hemiptera (Family: Aphididae), Order: Thysanoptera (Family: Thripidae), Hymenoptera (Family: Formicidae) and minimum from Order: Coleoptera. Altogether 205 specimens were collected from TTE, 125 specimens were collected during autumn season and 80 specimens during the monsoon season.

A total of 8 species of arthropod pests and 2 species of predators were recorded at TTE, South Sikkim during the study period. These species belonged to Family of 7 Orders: Thysanoptera, Hemiptera, Orthoptera, Hymenoptera, Acarina, Lepidoptera, and Coleoptera. The predator species were of order Coleoptera, Dictyoptera etc. Seasonal distribution of pests is shown in the table 3.

6.3 Species Diversity of Tea Pest

To determine the diversity of species between the autumn season and monsoon season, Shannon's Diversity Index was applied. It was based upon the relationship between total number of species and individual species within a family.

Table5: Shannon's Index for Species Diversity of Autumn Season

Order	**-(pi)Ln (Pi)**	**Evenness** $\left(e = \frac{\overline{H_1}}{\log s} \right)$
Hemiptera	-0.356	0.807
Thysanoptera	-0.344	
Lepidoptera	-0.236	
Hymenoptera	-0.316	
Acarina	-0.274	
Orthoptera	-0.136	
	$\overline{H_1} = -\sum pi \log e\ pi$ = **1.662**	

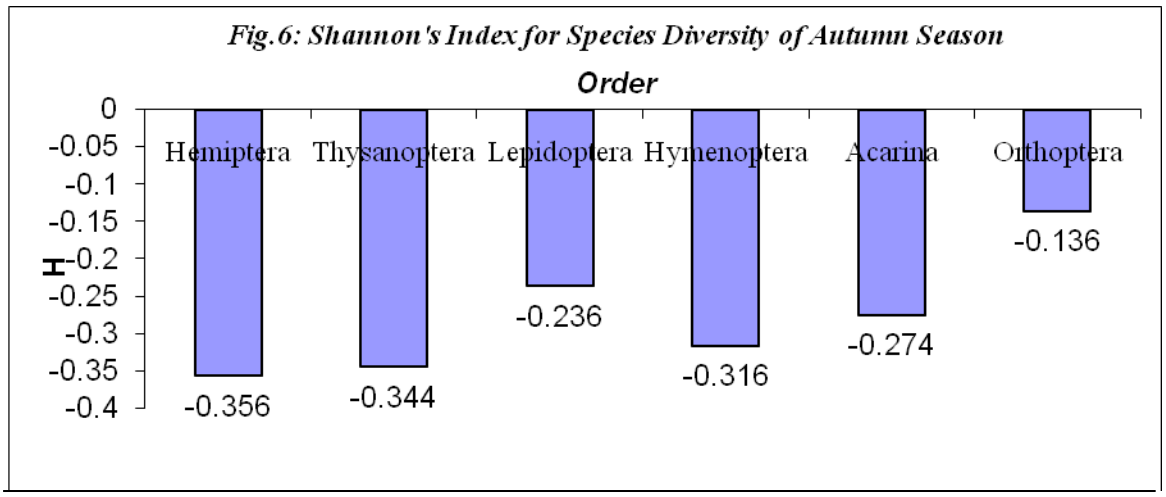
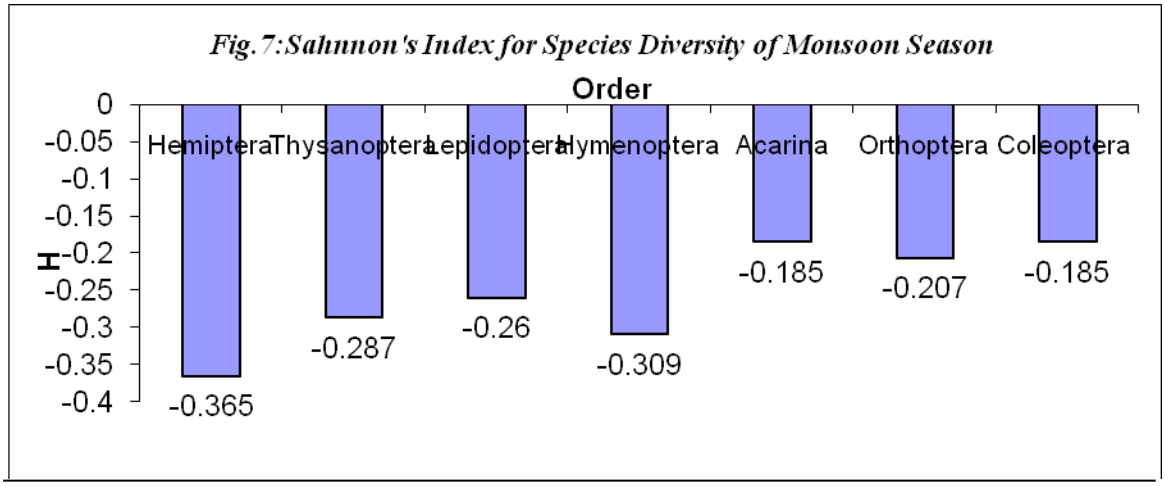


Fig.6: Shannon's Index for Species Diversity of Autumn Season

Table6: Shannon's Index for Species Diversity of Monsoon Season

Order	**-(pi) Ln (Pi)**	**Evenness** $\left(e = \frac{\overline{H_2}}{\log s} \right)$
Hemiptera	-0.365	0.968
Thysanoptera	-0.287	
Lepidoptera	-0.260	
Hymenoptera	-0.309	
Acarina	-0.185	
Orthoptera	-0.207	
Coleoptera	-0.185	
	$\overline{H}_2 = -\sum pi \log e\ pi$ = **1.798**	



The Species Diversity at TTE in autumn season was recorded as 1.662 while

Evenness was recorded as 0.807.

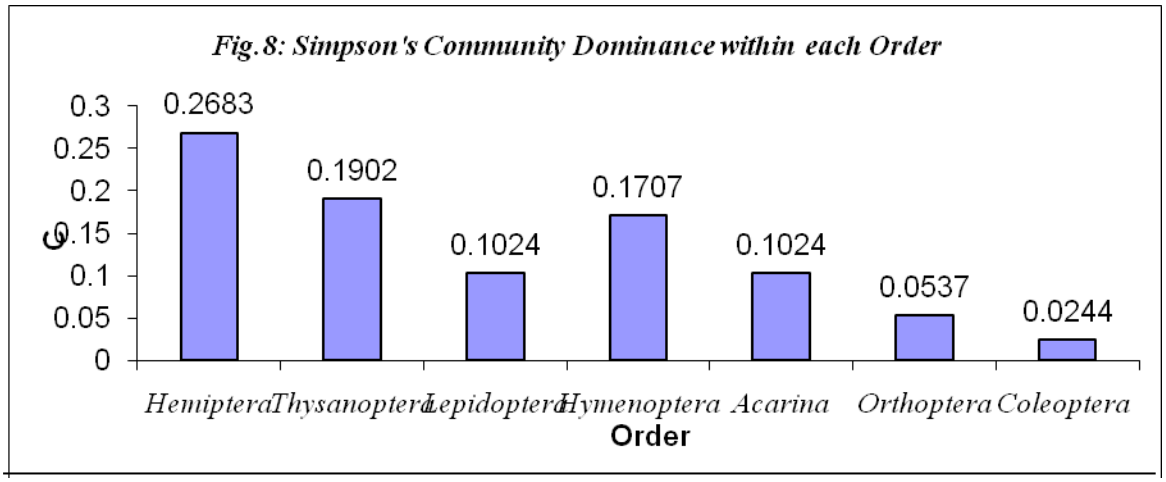
Similarly, Species Diversity at TTE in monsoon season was recorded as 1.798 while Evenness was recorded as 0.968.

6.4 Community Dominance

Community Dominance calculated within each order and within each season is shown in the table:

Table7: Simpson's Community Dominance within each order.

Order	**(ni/N)**
Hemiptera	0.2683
Thysanoptera	0.1902
Lepidoptera	0.1024
Hymenoptera	0.1707
Acarina	0.1024
Orthoptera	0.0537
Coleoptera	0.0244
	C = $\Sigma\left(\frac{ni}{N}\right)$ **= 0.9121**



Community Dominance within each order was found as 0.9121. Hemiptera was found to be dominant with the value of 0.2683 and Coleoptera was found to be recessive with the value of 0.0244 among the Orders.

6.5 Control Measures

As mentioned earlier, the use of pesticides/ insecticides are banned since April 2005 at TTE, so to control the pests population the spray schedule prepared by the TTE officials, like they are making efforts by using botanicals mainly Neem- based products like A chook, Econeem, Neemazol etc (Rahman, A., M. Sarmah and K. Singh (2003)., traditional products/homemade herbal botanicals like Dhokray flower liquid, Neem leaves, 2kg garlic cloves, marigold flower 2 kg when grinded into a fine paste and mixed into 20 liters of water and soaked overnight and sieved serves as a regulator against many tea pests like aphids, thrips etc, augmentation of natural biological predators like ladybird beetle etc are also emphasized to control tea pests and it seems they are mainly focusing on the control of potential pests i.e. thrips, mites, jassids and aphids.

Table8: Control schedule practiced against tea pests at TTE.

Pest	Control measures
Thrips (*Scirtothrips sp.)*	Spray of Neemazol/A chook/ also traditional product (Dhokray flower liquid).
Red Spider Mite (*Oligonychus coffeae)*	Spray of Neem products Neemazol/Econeem/A chook/ Bio Acaricide
Aphids (*Toxoptera aurantii*)	Spray of Neemazol/Nembecidine and other Neem products.
Jassids (*Empoasca flavescens*)	Same as that against mites and thrips.
Scale insects	Neem products sprayed.

7. DISCUSSION

From the study, entitled "Study of Tea Pests of Temi Tea Estate (Garden), South Sikkim, India". It was observed that a pest belonging to different taxonomic groups affects the tea plant. A total of 8 species of arthropod pests and 2 species of predators were identified from the specimens collected belonging to 8 orders and 16 families. Identified order were Hemiptera, Thysanoptera, Lepidoptera, Hymenoptera, Acarina, Orthoptera, Coleoptera, Dictyoptera. Correspondingly the families allied to these Orders were Hemiptera: (Pentatomidae, Aphididae, and Coreidae), Thysanoptera: (Thripidae), Lepidoptera: (Bombycidae, Geometridae, Lymantridae, Limacodidae), Hymenoptera: (Formicidae), Acarina: (Tetranychidae), Orthoptera: (Acrididae, Tettigonidae), Coleoptera: (Chrysomelidae, Scarabaeidae, Coccinellidae), Dictyoptera: (Mantidae). Predator species belonged to Order Coleoptera: (Coccinellidae) and Dictyoptera: (Mantidae), while remaining Orders were pests of tea plant.

The tea pests collected and identified were: Thrips (***Scirtothrips* Sp.*)*** Aphids: (***Toxoptera aurantii***), Red spider mite: (***Oligonychus coffeae***), Red Ant: ***Dorylus orientalis***, Short horned Grasshopper: (***Gastrimargus africannus orientalis***), Long horned Grasshopper, Bunch Caterpillar: (***Andraca bipunctata***), Bug :(***Leptocorisa chinensis***) pests belonging to family Scarabaeidae, Chrysomelidae, Pentatomidae, and Geometridae were also collected; some forms couldn't be identified due to lack its adult forms.

At TTE, major pests found in the tea plant were Thrips (***Scirtothrips sp***.), Aphids (***Toxoptera aurantii***). Thrips and Aphids are the pests that cause substantial crop loss as they are sapsuckers, though management is using effective control measures to prevent crop loss. The tea plant is also partly affected by a fungal disease called Blister Blight caused by ***Exobasidium vexans***, as some plots of TTE is sited at high altitude and seize abundant rainfall.

Thrips (***Scirtothrips sp.),*** was considered as the major pest of tea at TTE because their population was found high during the study period and interaction with the TTE management. During my two visits it was found that thrips population was more in autumn season than in monsoon season. As they prefer warm humid weather and they attack young leaves, buds and produce lacerations. Leaf surface gets curled and yellowing along leaf margin.

Aphids (***Toxoptera aurantii***), were found in clusters, abundant in both the seasons. It is also a major pest of tea at TTE, as they suck up plant sap, hamper plant growth as well as spread several plant viral diseases thereby causing loss of output in agriculture etc. Tamrakar and Singh (2000).

T. aurantii, are reported to be the vector of Citrus Tristeza Virus (CTV). Tristeza Virus is an aphid borne clostero virus. This virus infect the tender citrus buds and therefore the foliage fail to grow and hence no fruiting. Ghimire (2002).

Mites have been considered one of the notorious pests of tea worldwide, from the analysis of study period and recorded data the mites at TTE can be designated as transitional pests they were neither major nor minor pests as they were found on both

seasons. Among the pests of North-East India, the Red Spider Mite (***Oligonychus coffeae***), breeds throughout the year and can be found at any time on tea bushes. During March- April when the temperature rises, the multiplication rate increases, from June onwards the pests virtually disappears except for few mites as rain flushes away the mites. Das, G.M.(1959), Das, G.M. and S.C. Das. (1967).

Tea is not threatened by the arthropod pests in KTE. Rather the tea in KTE is damaged by a fungus ***Exobasidium vexans***. Rai, M. (2004). During the survey at TTE and interaction with the field supervisor of TTE some plots and bushes are susceptible to this fungus ***E.vexans***, as some plots of TTE is sited at high altitude and seize abundant rainfall.

Watt and Mann (1903) advocated bunch caterpillar as the major and widely distributed pest of tea plants in North-East India.

These caterpillars have distinctive characteristics due to its conspicuous color and peculiar habit of congregating on the branches in clusters. The caterpillar is light yellow with brownish black head and prothoracic segments and body covered with fine dense hairs. During daytime they are found on the branches under the bush, feeding at night. Though adult couldn't be collected, on the basis of the characters, occurrence and feeding behavior of the larvae as described by Banerjee (1979).

Watt and Mann (1903) mentioned that the Tea mosquito Bug (***Helopeltis theivora)*** was recorded in the Southern and Northern banks of River Brahmaputra, the Dooars and Darjeeling cause damage to the tea plant. These pests couldn't be collected and observed as they are rarely seen during mid day and are active only at dawn and dusk. Ants, termites, beetles, jassids, grasshopper are very minor pest in TTE, though substantial numbers of ants were collected during the visit but they couldn't cause

considerable loss, termites are active during cold weather, they can be checked by removing dead, dying, damaged branches of the plant and shade trees.

Among the natural enemies of the pests, lady bird beetles (***Coccinela.*** sp.), spiders and preying mantis (***Mantis*** sp.) were recorded. Ladybird beetles have received a wide attention for a long time. ***Chilomenes sexmaculata = Menochilus sexmaculata*** is widely reported as a common predator of aphids and scale insects. Agarwala and Yasuda (2000).

During the study period a total of 205 specimens were collected, 125 specimens during autumn season and 80 during monsoon season. Maximum species belonged from Aphididae, Formicidae and Thripidae families and minimum species belonged from Scarabaeidae, Chrysomelidae families. Hemiptera was found to be most dominant with the value of 0.2683, likewise Coleoptera was found to be recessive with the value of 0.0244.

The Species diversity for autumn season was 1.662 and for monsoon season was 1.798 and Community Dominance was 0.9121.

The pest infestation on tea plants is found to have regulated by “age effect” to some extent. A comparison of the arthropod species that inhabit tea in young and old habitats revealed that plants in older habitat harbored more species Banerjee (1983). In large tea growing regions, saturation level in the number of species occurred during a period of 100-150 years (Agnihothrudu, 1993).

In this context, the tea plants in the TTE are not older than 40-41 years old; subsequently of this fact TTE was found to harbor comparatively less no. of pests.

8. CONCLUSION

The "Study of Tea Pests of Temi Tea Estate, South Sikkim, India", was conducted during two seasons Autumn (Oct-Nov 2008) and Monsoon (Jun-Jul 2009).

During the study a total of 8 species of arthropod pests and 2 predator species were collected and identified belonging to 8 Order and 16 different families. Identified order were Hemiptera, Thysanoptera, Lepidoptera, Hymenoptera, Acarina, Orthoptera, Coleoptera, Dictyoptera. Correspondingly the families allied to these Orders were Hemiptera: (Pentatomidae, Aphididae, and Coreidae), Thysanoptera: (Thripidae), Lepidoptera: (Bombycidae, Geometridae, Limacodidae, Lymantridae), Hymenoptera: (Formicidae), Acarina: (Tetranychidae), Orthoptera: (Acrididae, Tettigonidae), Coleoptera: (Chrysomelidae, Scarabaeidae, Coccinellidae), Dictyoptera: (Mantidae).

The study showed Thrips as major and Tea aphid as potential pests of tea plant at TTE South Sikkim, India. Mites were considered as transitional pests and there are some minor pests like Ants, Termites, Beetles, Grasshoppers, Jassids, but they are unable to instigate their population as a major pest, as TTE is suited at high altitude, low temperature, maximum rainfall. Besides, these pests' tea plant is also damaged by fungal disease ***Exobasidium vexans*** at TTE. The crop loss per year due to pest's invasion has not been estimated so far. It was reported that in 2009, hailstones affected the tea production.

During the study period a total of 205 specimens were collected, 125 specimens during autumn season and 80 during monsoon season. Maximum species belonged

from Aphididae, Formicidae and Thripidae families and minimum species belonged from Scarabaeidae, Chrysomelidae families. Hemiptera was found to be most dominant Order with the value of 0.2683, likewise Coleoptera was found to be recessive Order with the value of 0.0244.

The Species diversity for autumn season was 1.662 and for monsoon season was 1.798 and Community Dominance was 0.9121.

It is also concluded that environmental factors play a major role in the pests' population. i.e. increase in the temperature results in increase of pests population and with the fall of temperature results in the declination of pest's population. Rainfall too plays a vital role in the control of pests' population, more rainfall less pests'. The pest infestation in tea bushes is also controlled by the "Age Effect" of the plant.

Recognisation given by IMO, Bangalore, as Organic Tea Estate played a very significant role at TTE as the Estate is using homemade herbal pesticides, botanicals Neem products (Neemazol, Econeem, A chook etc) for the control of pests, which controls the pesticide residue and hazards as well as enables the enhancement of natural enemies against the prey pests' and doesn't affect the non targeted organisms.

9. RECOMMENDATION

- Focus should be given for the implementation of IPM techniques, cultural practices like bush sanitation, maintenance of shade trees, use of resistant varieties. Clean cultivation of tea plant should be emphasized as it helps in reducing the pests' population.
- In a tea estate appropriate monitoring of the pests should be performed all year round in order to convey acquaintance about the pests' and their status.
- Efforts should be made by educating the workers of the Garden about the IPM, and benefits of botanicals.
- Workers should be made aware of beneficial insects and necessity of beneficial insects.
- As Garden has been graded as Organic Tea Estate, they should be aware of negativity of the chemicals pesticides and carelessness as they should encourage the production of Organic Tea as it is hygienic and has a great demand in the international market.

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APPENDIX - I

QUESTIONNARIE

DATE:

NAME:

AGE:

SEX:

EDUCATION:

1. Where do u live?

……

2. What brought you to work here at TTE?

……

3. How long have you been working here?

……

4. Does every members of your family work here in this garden?

……

5. How many of you are employed here from your family?

……

6. Which is the section that you are employed in?

(a) Factory…….. *(b) Office……..*

(c) Field…….. *(d) Spray division……*

7. Which of the section do you find the most difficult? Why?

……

8. Do you have any idea about tea pests?

……

9. Which parts of the tea plants are mostly attacked by pests?

…….

10. What are the pests that cause serious damage to the tea?

…….

11. Do you find tea pests in all seasons?

…….

12. As the garden has been graded as organic, do you find any difference?

…….

13. In your opinion, which fertilizers is more effective?

(a) Chemical Fertilizers…… (b) Bio-Fertilizers……..

14. Do you have any idea about chemical pesticides hazards?

…….

15. Have you ever noticed the effect of chemical pesticides sprayed in the garden affected non targeted organisms? Previously.

…….

16. What causes the maximum crop loss (a) Climatic factors……..
(b) Diseases…… (c) Pests……..