STUDY OF ARTHROPOD PEST OF TEA AND IT'S DIVERSITY IN TEESTA VALLEY TEA GARDEN, DARJEELING

By:

JASU CHHETRI

A DISSERTATION SUBMITTED FOR THE PARTIAL FULFILLMENT OF THE REQUIREMENT FOR MASTER'S DEGREE OF SCIENCE IN ZOOLOGY

(CENTRAL DEPARTMENT OF ZOOLOGY ENTOMOLOGY)

INSTITUTE OF SCIENCE AND TECHNOLOGY

TRIBHUVAN UNIVERSITY

KIRTIPUR, KATHMANDU

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RECOMMENDATION

It is recommended that **Jasu Chhetri** has completed her dissertation work entitled **"Study of Arthropod Pest of Tea and It's Diversity in Teesta Valley Tea Garden, Darjeeling"** as a partial fulfillment of M.Sc. in Zoology under my supervision.

Recommended by:

…….....

Prof. Dr. Ananda S. Tamrakar, Ph.D.
Central Department of Zoology,
Tribhuvan University
Kirtipur, Kathmandu

Date: .....

LETTER OF APPROVAL

On the recommendation of supervisor, **Prof. Dr. Ananda Shova Tamrakar**, Tribhuvan University. This dissertation of **Jasu Chhetri** titled **"Study of Arthropod Pest of Tea and It's Diversity in Teesta Valley Tea Garden, Darjeeling"** is approved for examination and submitted to Tribhuvan University for partial fulfillment of the requirement for M.Sc. Degree in Zoology.

Recommended by:

.....

Prof. Dr. Vasanta Kumar Thapa, Ph.D.
Head of the Department
Central Department of Zoology,
Tribhuvan University,
Kirtipur, Kathmandu

CERTIFICATE

This is to certify that dissertation titled **"Study of Arthropod Pest of Tea and It's Diversity in Teesta Valley Tea Garden, Darjeeling"** by **Jasu Chhetri** has been accepted for the partial fulfillment of the requirement for M.Sc. in Zoology (Entomology).

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Examined by

.....	.....
Dr. Ananda S. Tamrakar, Ph.D.	**Prof. Dr. Vasanta Kumar Thapa, Ph.D.**
Professor	Head
Central Department of Zoology	Central Department of Zoology
Tribhuvan University	Tribhuvan University
Kirtipur, Kathmandu	Kirtipur, Kathmandu
Date:	Date: .....

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Last not the least, I would like to thank all the staffs of CDZ, my friends and other person who are directly or indirectly related to my dissertation work.

Jasu Chhetri
M.Sc. Zoology (Entomology)
Batch 2061/062
Roll No. 1165
Regd. No. 5-3-28-127-2004

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ABBREVIATIONS AND ACRONYMS

%	=	Percentage
A.D.	=	After Death
Alt	=	Altitude
CAF	=	Caffeine
CDZ	=	Central Department of Zoology
CTV	=	Citrus Tristeza Virus
DTT	=	Developmental Threshold Temperature
DMC	=	Dry Matter Content
Dept.	=	Department
Ft.	=	feet
Govt.	=	Government
HPS	=	High Polymerized Substances
i.e.	=	That is
IPM	=	Integrated Pest Management
KTE	=	Kanyam Tea Estates
Mn	=	Minimum
MRL	=	Maximum Residue Level
Mx	=	Maximum
NHM	=	Natural History Museum
NTDC	=	Nepal Tea Development Corporation
Sp.	=	Species.
Sq.Km.	=	Square Kilometer
TF	=	Theaflovin
TR	=	Therutrigen
TSS	=	Total Soluble Solid
TLC	=	Total Lignor Color
Temp.	=	Temperature
TVTG	=	Teesta Valley Tea Garden

ABSTRACT

Arthropod Pest of Tea of Teesta Valley Tea Garden (TVTG) was observed during the period of two seasons (Autumn, OCT-NOV 2006 and Monsoon, JUNE-JULY 2007). Altogether 359 arthropod pests were collected including 16 families 7 orders and 13 species.

The species diversity of autumn season was found to be 1.62 and of monsoon is 1.73 while evenness of autumn is 0.904 and of monsoon is 0.889. The community dominance of both seasons was found to be 0.997.

For the collection, sweeping insect net, forceps, camel hair brush was used and after collecting, killed by putting in 70% alcohol in vials. Then they were brought to the lab and identified.

Altogether 359 specimens were collected, 140 specimens were found during the monsoon and 219 during autumn season. Maximum populations of pests were collected from Family Formicidae and Aphididae and minimum population were collected from Chrysomellidae and Scarabaeidae. Similarly 0rder Lepidoptera was found to be dominant while Order coleopteran was found to be least dominant.

The relation exhibited between the insect population and different environmental factors like temperature and rainfall showed that with the increase of maximum temperature the population of pest also rises significantly and with increase of rainfall the population of pest falls down. India's famous Darjeeling tea may be laced with pesticide residues, threatening tea exports. And has received negative feedback from the consumers on pesticide residue. As a result of continuous use of pesticide, the plants resistance to pests and disease has declined. At the same time, increased pesticide use has made pest immune to the chemical. It is suggested to monitor the pests throughout the year and use of IPM techniques as far as possible.

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1. INTRODUCTION

1.1 Background

Tea, *Camellia sinensis* next to water is the most widely consumed beverage in the world that is made from young leaves and buds of tea plant. But there is still considerable speculation that who are the founder of this plant. It is believed that tea drinking habit was originated in China by a Emperor Shen Nung, a renowned herbalist in 2737 B.C. Containers for tea have been found in tombs dating from Han dynasty in 206 B.S – 220 A.D. but it was under the Tang dynasty (618 – 906 A.D.) and was established as the national drink of China, however it has been so popular in China when Lu Yu wrote the book entitled Ch'a Ching for the first time about tea. It was shortly after this that tea was first introduced to Japan by Japanese Buddhist monks who had traveled to China to study. Tea drinking has become a vital part of Japanese culture, as seen in the development of the tea ceremony, which may be rooted in the rituals described in the Ch'a Ching (www.coffee-tea-etc.com).

From its center of prime distribution in south East Asia, Tea dispersed either naturally or by human agencies into other parts of the world. Now it is grown world widely.

1.2 Tea in India and Nepal

As early 1788 it appears that Sir Joseph Banks the request of the East India House wrote a memoir on the subject recommending the introduction of plants from China to Behar, Rungpur and Kuch Behar. Some years afterwards considerable interest was aroused by the reported discoveries of indigenous tea plant in Burma, Assam, Nepal, Kumaun and Basahar. Mr. Burell is inclined to believed that the discoverer of the wild tea plant in

Assam was Mr. David Scott an Indian civilian who took charge of the settlement of Assam. It appears that some time between 1819 and 1821 he sent a specimen of the Assam wild tea plant to Calcutta to his friend Mr. James Kyd whose father, Colonel Kyd. Corresponded with Sir Joseph Banks about tea cultivation in India among other matters. This specimen was handed over to Dr. Wallich and Mr. Burell has succeeded in identifying it is the Wallichian herbarium now belonging to the Linnean society (Atkinson, 1980).

The idea of 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 thousands acres of lands were cleared and many nurseries set up with china Jat. The first garden in hilly area of Darjeeling came into existence in 1857, the Tukvar Tea Estate. After that the tea cultivation increased rapidly and in Terai and Doars also the cultivation was started.

Nepal is an agricultural country; about 90% people are based on agriculture. Tea cultivation is one of the favorite cash crops of Nepalese people. Nepal has a long history dating back to almost 140 years when its cultivation was initiated in Illam districts. Shree Gajraj Singh Thapa was the initiator of tea plantation in Illam districts. It came as an industry only after the establishment of Nepal Tea development Corporation, in 2023 B.S. (1966 A.D.).

1.3 Historical Data of the Teesta Valley Tea Garden

Teesta Valley Tea Garden is situated in the Darjeeling hills. Garden were planted by 13 European planters from 1841-1855 and were managed by them till 1856 when Davenport and Co Ltd. A leading agency house, took over the management of this garden.

This garden is located around 43 km away from Darjeeling town by road, 52 km from Siliguri and 67 km from Bagdogra Air port, easily accessible from all directions. Average altitude of the garden is 3,000 ft (above sea level). TVTG lies between $28^0$31' and $27^0$13' north latitude and $87^0$59' and $88^0$53' east longitude. Teesta valley tea garden is one of the pioneers in releasing its own clone name TEESTA – 1, which is one of the best quality clones. This company owns other gardens also in Assam and Doars along with export business of tea. Total area of this tea estate is 298.34 hactares. One of the highest yielding gardens in Darjeeling. The factory is well equipped with all modern machines. This garden is expanded over an elevation of 3000 ft to 5100 ft which contains 80 percent China bushes. This garden was awarded a Gold Medal for producing top quality tea way back in 1883-84. The garden has every panoramic view with gentle slope along with 100 percent north facing towards snow capped Kanchunganga Mountain. The older bush of the garden is mostly of the China variety, although there are areas of the Assam and Combad varieties.

Table 1 : Production of Tea (Last Five Years)

Year	Area Under Production	Production Per Hactare (Yielding)
2002	298.34 hactare	673 kg
2003	do	813 kg
2004	do	817 kg
2005	do	818 kg
2006	do	815 kg

Source: TVTG, 2007.

1.4 Pest of Tea

Investigations of tea pests were started about the turn of the century and notable treaties by pioneers in the field are those of Watt and Mann found 103 pests in India and Green found 77 in Ceylon. Other more general

works which make considerable mention of tea pests are those of Dammerman found 306, Beeson found 14, Kalshoven found 84 and Hainsworth found 78. Work has been, pursued by the Tocklai experimental station, Assam (India Tea Association), The Scientific Department of the United Planters' Association of south India, The Tea Research Institute of Ceylon and the Tea Research station at Buitenzorg, Java in 1965.

Moreover, tea planted as monoculture and perennial in habit, tea plants provides a stable microclimate for the existence of disease causing agents and pests. Varieties of tea pests inhabit the tea plant in different seasons with different damage pattern and intensity depending on climate, altitude and cultural practices. In addition to this, shed trees planted in tea gardens also shelter a number of pests. In the first ever comprehensive report on tea diseases, only about 12 fungal diseases were mentioned (Watt and Mann, 1903) and this rose to 17 fungal in 1918. Today, it is fairly known that about 385 species of pests occur on tea all over the world, of which just about half occur on North-East India (Banerjee, 1996).

In North-East India , outbreaks of flushworm occurred in Darjeeling in 1956 and spread to other districts causing considerable damage to tea. The attack then gradually subsided though there has been occasional report of severe outbreaks. The primary reason for sudden and severe outbreak of flushworm may be due to destruction of natural enemies by the use of modern pesticides like aldrin and dieldrin. According to my field survey, the population of this pest was recorded more in autumn than in monsoon. Though adult couldn’t be collected, the pest couldn’t be identified. The larva normally attacks the young shoots. The just hatched larvae tie up the margins of two or three tender leaves and form a case.

It is estimated that 1034 species of arthropod and 82 species of nematodes are associated with tea plants. 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 arthropod are known to attack tea in India (Muraleedharan 1993)

Table 2: Control schedule practised against Tea Pest at TVTG

Pest	Control
Red Spider mite	Spray of Ethion, Dicofol, wettable sulphur formulations, Neem formulations etc.
Aphids	Control by natural enemies, The Pesticides Sprayed against mites, thrips, etc. are effective against them.
Thrips	Spray of Monocrotophos, Spray of Neemazol etc.
Common looper	Neem formulations, Diflubenzuron (Dimilin), flufenozuron. Toxcin of *Bacillus thuringensis*. Sulphate, ammonia or urea is also recommended
Neetle Grubs	Endrin, parathion

Source: TVTG, 2007.

2. OBJECTIVES

The main objectives of the study are to update the information of Arthropod Pest of Tea in Darjeeling Districts especially in 'Teesta Valley Tea Garden". The specific objectives of the study are:

1. To explore the species diversity with the analysis of habitat.
2. Collect and identify the arthropod pests of tea plant and study their status.
3. To explore the major and minor Arthropod Pest of tea.
4. To explore the seasonal variation of Arthropod pests of tea.

3. LITERATURE REVIEW

Review of literature is one of the integral parts of all research. It enables researcher to define intellectual tradition that has been drawn in the study of researcher's topic. The literature pertinent to the present investigation entitled "Study of Arthropod Pest of Tea and its Diversity in Teesta valley Tea Garden, Darjeeling Districts, India" has been reviewed under the following sub-headings.

3.1 History of Tea

Chinese Emperor Shen Nung accidently discovered tea *Camellia sinensis* in 2737 B.C., when a leaf of tea dropped into his bowl of hot water while he was in the garden near the tea plant.

Tea in Nepal was introduced in the same decade as that in Darjeeling Hills. Around 1920 B.S., the then ward officer Shree Gajraj Thapa initiated tea plantation in Illam district, East zone of Nepal (NTCDB, 2002).

In India tea is believed to have known as early as 1824 A.D. The most authentic source of information on existence of tea came from Major Robert Bruce, who discovered tea plant in upper Assam. Tea cultivation in Darjeeling started around 1839. By 1856, major production centers began in Darjeeling and Cachar in the Terai in 1862 and in Dooars in 1874. This was followed by rapid growth in south India (Banerjee, 1996).

3.2 Tea Pests and Diseases

Lu Jian et. al. (2006) worked on the cues in host acceptance of *Tetrastichus sp. Tetrastichus sp.* is a gregarious pupae endoparasitoid. It parasitizes mainly in the tea leaf roller (*Homona magnanime*) pupae. The role of wash vision and olfaction and host pupae movement in host

acceptance of the wasp was investigated. They found that host pupae movement had no significant effect on its host acceptance, olfaction of the female wasp played the major role in its host acceptance and vision also played a minor role in host acceptance.

Kun-Shan and Quiang (2006) worked on the developmental threshold temperature (DTT) and effective accumulated temperature of *Euproctis pseudoconspersa* larvae. *Euprocits pseudoconspersa* strand were determined under five instar larvae from the first instar to the seventh instar were 4.57, 8.38, 7.00, 8.86, 7.10, 4.84 and 3.8°C respectively, and their EAT was 114.45, 80.94, 91.28, 8.23, 94.54, 117.83 and 129.46 degree day respectively. They found that the above data is useful in predicting the optimal control time and the optimal virus infecting time of the past for proliferation of *E. pseudoconspersa* virus.

Chakraborty et. al. (2005) worked on 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 tea mosquito bug *Helopletis 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.

Rai, M. (2003), the tea in KTE 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.

Swaminathan et. al. (2002) worked on the effects of tea fungal enzymes on the quality of black tea. The cellulolytic enzymes, cellulases,

pectinases and xylanase isolated from the tea fungus and lacase from *Trametes versicolor,* were tried for the improvement of black tea quality parameters, i.e. theaflovin (TF), therutrigen (TR), high polymerized substances (HPS), total lignor color (TLC), total soluble solid (TSS), Caffeine (CAF) and dry matter content (DMC), were analyzed. Purified cellulose amended with trametes vesicolor lacase in the ratio of 3:2 (V/V) was found to be most effective in enhancing tea quality.

Toxoptera aurantii is also reported to be a 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, stunted growth and sometime wilting symptoms are also recorded (Ghimire, 2002).

Tamrakar et. al. (2000) Aphids are of great economic importance since they suck up plant sap. Hamper plant growth as well. Aphids are of great economic importance since they suck up plant sap, hamper plant growth as well as spread several plant virus diseases, floricultural, silivicultrual and wild plants Aphids are seen in colonies. They suck sap, secret honeydew through anus, which attracts sooty mould, a fungus. They reproduce by parthenogenesis or by budding. Adult females are viviparous.

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, it is fairly known that about 385 species of pests occur on tea world over of which about half occur on North East India (Banerjee, 1996).

It is estimated that 1034 species of arthropods and 82 species of nematodes are associated with tea plants. 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 (Muraleedharan, 1993).

Tea mosquito bug *Helopeltis theivora* waterhouse, 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 to 10mm long with antennae nearly twice as long as the body. The antennae, head and wing are blackish. Most females have blood-red body and like the nymphs the adults 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.

In his book "Introduction to Agricultural Acarology" Banerjee (1988) 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, for example, 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, its undersurfaces of the tea leaves are least affected.

Sharma and Bezbarua (1988) observed that the Tea seed bug (*Poecilocoris latus*) could even puncture the tougher seed coat at the later stage of seed maturity. They have also observed that 76 percent of the bugs carry fungal spores on their proboscis. The fungi isolated are *Fusarium sp., Aspergillus niger* etc.

The metallic green beetle, *Chrysolampra flavipes* jacoby (coleoptera: Chrysomellidae) 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).

Banerjee (1970) studied the aggregating behaviour 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.

Beson (1941) mentioned that small Green weevils feed on tea leaves in Burma and North India. It also defoliates *Aleurites fordii* and *A. montana* plantations. He also reported it as a pest of tea.

Andrews (1923) carried out studies in the Dooars to find out the relationship between *Helopeltis* and the soil type. He reported in 1923 that high potash content of soil decreased the population of mosquito bug, while tea plants growing in soil having a low ration of available potash to available phosphoric acid are more prone to mosquito blight.

Andrews (1923) studied about the tea green fly (*Empoasca flavescens*). It is one 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 marks on leaves but the affected leaves become uneven and usually curl downwards, shoot growth is prevented and the 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.

Andrews (1921), the beetle can be seen almost throughout the year, the peak occurrence being in March and April and again in September and October.

The bunch caterpillar is the earliest known tea pest having been found in Taiwan in 1820. It was reported as a very widely distributed pest occurring over almost all the districts in north-east India (Watt and Mann, 1903).

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

The tea leaf miner (*Agromyza thea)* is the only dipterous fly that attacks tea. The Larvae mines into the upper epidermal layer of the tea leaf and can be found in most gardens, but only one or two mature leaves on scattered bushes are normally attacked (Watt and Mann, 1903).

3.3 Pest Control/Pesticides Residue

Jana et. al. (2006) worked on the bioefficacy of fenopropathrin against tea and spider mite, *Oligonychus coffeae* Nietnar at Terai, Darjeeling (West Bengal). Relative efficacy of a synthetic pyrithroid, Fenpropathrin 30 EC (IUPAC) name (RS) –a- Cyano – 3 phenoxy benzyl/2, 2, 3, 3 – tetramethyl - cycloporpane = (Carboxy late) along with two acaricides, i.e., dicofol (18.5 EC), ethion (50 EC) and broad spectrum acaronisecticide profenophs (50 EC) was evaluated at 0.5, 0.75, 1.0, 2.5, 2.0 and 1.0 ml/lit of water dosages respectively on a tea clone "TV_2" at Motidhar tea estate, terai, Darjeeling, W.B. They found that fenopropathrin 30 EC exhibited excellent control of tea red spider mite (a) 0.75 and 1.0 ml/lit of water than conventional acaricides at recommended dosages.

Wang et. al. (2006) worked on the evaluation of mass trapping for control of tea tussock moth, *Euproctis pseudoconspera* (Lepidoptera: Lymantridae) with synthetic sex pheromone in south China. The optimal dosage of synthetic sex pheromone was 1.5 mg/septum in a trap. The control effect by mass-trapping technique on tea tussock moth was investigated in the same tea plantation in 2000 and 2003. Twenty-five traps/hac were used in the 2-year, large-scale mass trapping experiments and a total of 146, 767 males were captured. In the pheromone treated field mating rates were significantly reduced on nine of 12 samples dates. Larval and egg densities were reduced by 27.87 – 50.85 and 38.89 – 51.11 percent respectively compared with the untreated field. Their results suggest that mass – trapping is promising as a control agents for use against the tea tussock moth.

Rahman et. al. (2005) carried out the toxicological study of plants extracts on termite and laboratory animals. Toxic activity of leaf extracts ploygonum hydropiper and pogostemon parviflorusbenth were tested in the laboratory against termite, *Odontotermes assamensis* Holm. They found that both the tested extracts caused mortality of the termite.

Sarmah et. al. (2003) worked on the prospects in use of neem formulation and biocides in tea pest, management in North-East India. Four different field equipments have been conducted to explore (i) the phytopesticidal impact of different neem formulations (ii) effect of combination of neem products with acaricides (iii) entomopathogenic potential of *Bacillus thuringensis* var. Kurstaki against major pests of tea as red spider mite (*Oligonychus coffeae*), greenfly (*Empoasca flavescens*), thrips (*Scirtothrips dorsalis*), tea mosquito bug (*Helpopeltis theivora*) and looper caterpillar (*Buzura suppresaria*) at Borbhetta Tocklai, Gabropurbat tea estates of north-east India. They found that neem formulations containing 0.03 and 1.5 percent azadirachtin showed percent reduction to the tune of 37.6 – 68.3 percent, 31.8 – 34.7 percent an 29.4 percent in red

spider mite, thrips and greenfly, respectively up to 4 weeks but 20.32 – 57.86 percent week. Their trails revealed that among sucking pests, greenfly was more sensible to neem formulations followed by red spider mite and thrips.

Han et. al. (2003) worked on the behavioral and electrophysiological responses of natural enemies to synomones from tea shoots and kairomones from tea aphids, *Toxoptera aurantii*. Olfactometer bioassays and electrophysiological studies showed that the aphid parasitoid, *Aphidius sp.*, responded to volatile from tea aphids, *Toxoptera aurantii*, to hexane or ether rinses of tea aphid cuticle, and to synomones released by aphid damaged tea shoots, as well as to the tea shoot aphid complex. They found that the interaction between synomones from aphid damaged shoots and kairomones from tea aphid enhanced the responses to the plant-host complex.

Yanagi et al. (2003) studied about the development of a novel lepidopteran insect control agent, chromafenozide. Chromofenozide is a novel dibenzoylhydrazine insecticide that was developed in the collaborative research project and is categorized to be an insect hormone – ecdysone against various lepidopterous insects, but at the same time almost non-toxic to non-lepidoterous species including pollinators, predators and parasitoids. As chromofenozide has a low toxicity profile in mammals and non-target organisms, and has minimum impact on the environment, it would be an ideal agent for integrated pest management.

Wang et. al. (2003) carried out the field experiments for controlling the tea tussock moth, *Euproctis pseudoconspersa* strand by mating disruption with sex pheromone in Gnizhon, a southern provinces of China in 2003. The control efficacy was optimized when dispensers containing 0.5 mg sex pheromone lure were placed at 5 m intervals. Male moth catch rate, mating rate, larvae and egg density reduced by 83.90 percent and 70.25

percent, 78.18 percent and 73.21 percent, 50.02 percent and 45.71 percent respectively compared with that of untreated field in over wintering and first generations experiment. The result of the experiment indicated that mating disruption method with sex pheromone lure could all as an agents in controlling tea tussock moth.

The seasonal appearance of pests during tea cultivation necessitates timely management of the crop through pesticides. However, care has to be taken not to overdose on pesticides because this can lead to a high residue level of toxic substances in tea leaves in excess of the MRL set by the importing countries. Consequently, emphasis is laid on striking a balance between pest toxicity and mammalian toxicity. Pests that commonly attack tea crop include mites, thrips, jassids, tea mosquito bug, leaf eating beetles and defoliating caterpillars. Tetradifon is the most effective pesticide to counter a potent pest- the red spider mite (*Oligonychus coffeae*). For other mites, dicofol and ethion are used. Endosulfan helps to tackle pests like thrips, aphids, tea mosquito bugs and other sap feeder. Unlike mites, other sap feeders disperse rapidly and can be dealt with by applying pesticides over a large area. Organophosphate insecticides such as Quinalphos and phosphamidon are also used to control sap feeders and leaf eaters. When conventional chlorinated hydrocarbons like endosulphan fail to control leaf eaters and defoliators, synthetic pyrethroids like deltamehrin are applied. On account of the complex pest situation in tea cultivation a total avoidance of pesticides does not appear feasible. It is in this context that MRL assumes importance (Tvedten, 2002).

The problem of pesticide residue on processed tea is receiving attention. The monitoring is strict for the tea, which is exported. This problem has not been recognized in tea for local consumption however, teas which contain more than tolerance limits of pesticides run the risk of being discarded or destroyed. Pesticides applied on tea are degraded and further,

diluted by rain and dew, evaporation, photolysis through sunlight and biodegradation. Synthetic pyrethroids and also the organochlorines are lipophilic and they get bound to the cuticle. This is possibly why pesticide like dicofol is appearing in the exported tea. Considerable amount of pesticide on the leaves is lost during the process of manufacture. The loss may be 30-60% (by evaporation or thermal decomposition). Compounds with higher vapour pressure are likely to leave less residues than those with lower vapour pressure. Processed tea when infused with boiling water will extract smaller quantities of minimum residue leaves in tea in relation to standarized method of extraction in the liquor rather than on black/green tea as it is the liquor which is consumed (Agnihothrudu, 1993).

India's famous Darjeeling tea may be laced with pesticide residues. The high priced tea is produced using large amounts of pesticides, creating the health hazards for workers and consumers, while threatening tea exports. Gastrointestinal disease, pulmonary disorders and suicides are common among tea workers. Many physical deformities have been observed among children in the tea estates.

One of the most commonly used pesticides is monocrotophos, listed by the World Health Organization as class Ib, highly hazardous. Monocrotophos, an organophosphate used to kill insects and mites, is a nerve toxin that can cause weakness, blurred vision, profuse perspiration, confusion, vomiting and pain.

In 1992-93, Germany refused to import a shipment of Darjeeling tea contaminated with tetradifon, used against spider mite larvae. A one kilogram sample from the shipment contained 240 micrograms of tetradifon. Twenty-four times above the maximum residue limit. As a result of continuous use of pesticide, the plants resistance to pests and disease has declined. At the same time, increased pesticide use has made pest immune to the chemical.

4. MATERIALS AND METHOD

4.1 Methodology

The present investigation "Study of Arthropod Pest of Tea and its Diversity in Teesta Valley Tea Garden, Darjeeling" was carried out on Oct. – Nov. 2006 and June – July 2007. This study was based on primary as well as secondary data. Before starting the observation, detail secondary information and personal communication was made with personnel involved in Tea Garden. The details of the materials used and techniques employed for studies during the course of investigation are described below.

4.2 Materials

Insect collecting sweep net, insects collecting jars, Petri dish, vials, forceps, camel hair brush, entomological pin, cardboard sheet, 70 percent alcohol as preservatives.

4.3 Study Site

This study is performed at Teesta Valley Tea Garden (TVTG), Darjeeling district, India. TVTG are situated in the Darjeeling hills. This garden is located around 43 km away from Darjeeling town by road, 52 km from Siliguri and 67 km from Bagdogra Airport, easily accessible from all directions. Average altitude of garden is 3,000 ft (above sea level). Darjeeling district lies between $26^0$31' and $27^0$13' north latitude and $87^0$59' and $88^0$53' east longitude with annual rainfall of 320cm.

Total area of this tea estate is 298.34 hactares, one of the highest yielding gardens in Darjeeling. The factory is well equipped with all modern machines. This garden is expanded over and elevation from 3000 ft to 5100ft which contains 80 percent China Bushes.

Fig. 1: Map of Teests Valley Tea Garden

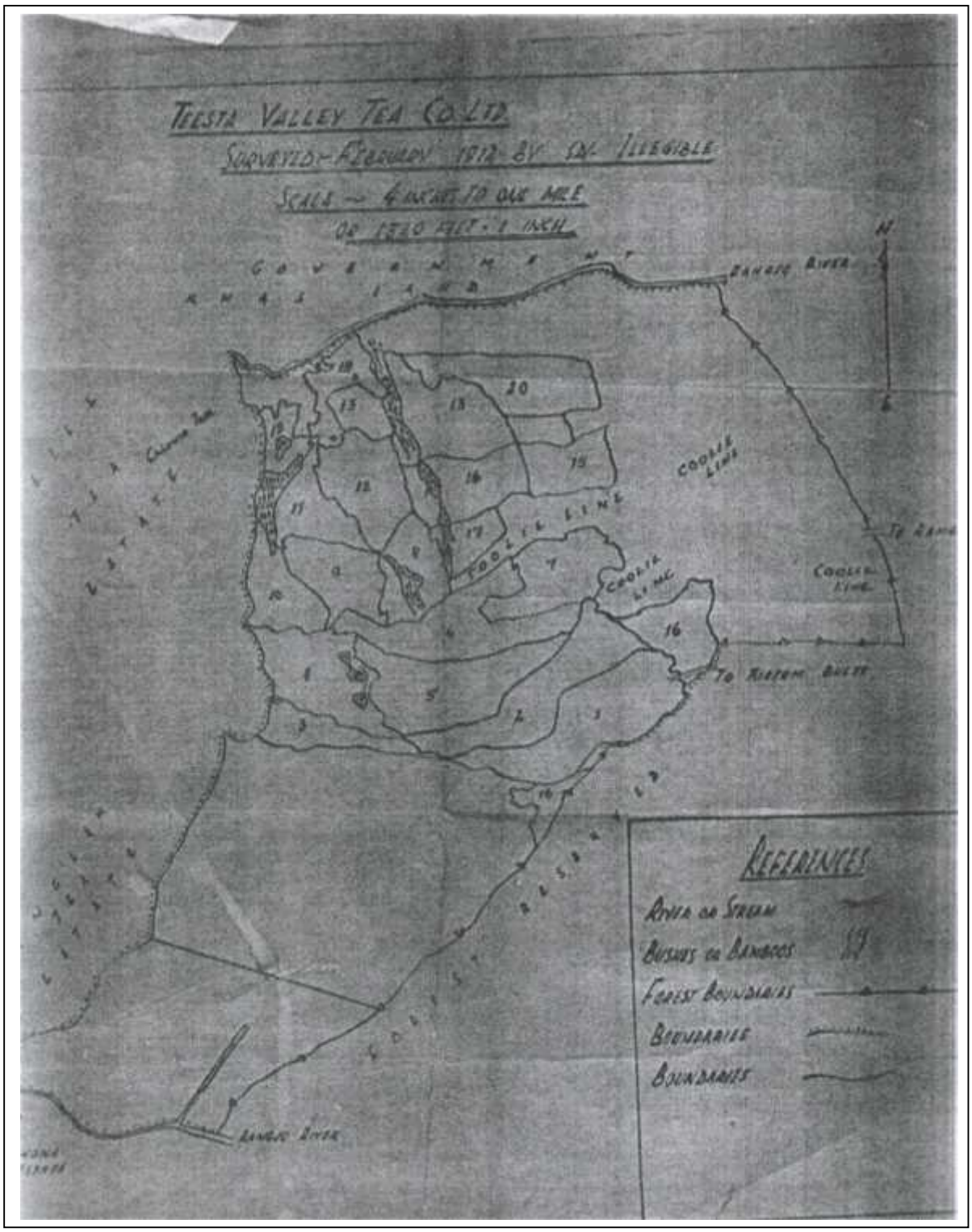


Fig. 2: Map of Darjeeling District showing Teesta Valley

Fig. 3: Map of West Bengal showing Darjeeling District

4.4 Data Collection

Various sources and techniques were used together with collection and overview of the relevant information. This study is based on primary as well as secondary data for the analysis.

4.5 Source of Primary Data

The observation was taken inside the Teesta Valley Tea Garden, Darjeeling District, India. The primary data has been collected by visiting the study site. The data was collected from October 28 - Nov. 5th, 2006 in autumn (dry Season) and the second visit during monsoon i.e., June 20th - 26th, 2007, and the third visit during, July 8th – 15th, 2007. Data were collected directly observing the pests and their infestation in tea plants. The questionnaire survey was done to learn about the pests, their nature of damage, seasonal abundance, awareness of people regarding pesticide hazards, and major and minor pests. Study area was visited with assistant manager and other official employees.

4.6 Source of Secondary Data

The secondary data has been collected from different libraries, Teesta Valley Tea Garden office record, publications of related field related websites, government and non-government institution/organizations, Biological Abstract, Masters Thesis.

4.7 Insect Pest Collection

One of the best ways to learn about insects is to go out and start collecting them. For collecting the pests and studying their population density, six bushes were chosen from every corner of the respective garden, as the Teesta Valley Tea Garden is divided into twenty plots. Plots no.7 was chosen as the study area. The specimens thus collected were preserved as,

wet preservation in 70 percent alcohol. The insects, which were large enough to be seen by naked eyes, were collected by hand picking method with the help of forceps and were put in bottles containing 70 percent alcohol as preservatives.

The smaller insects were also collected by placing the cardboard sheet covered with white paper below the tea bushes and then jerking the plant and finally fallen insect were picked up and put in vials. Sweeping net was also applied for collecting the flying insect pests like bugs, grasshopper, crickets etc. The minute insects like aphids, thrips, mites etc. were collected with the help of a soft brush and kept directly in small vials containing 70 percent alcohol as preservatives.

4.8 Identification

The collected specimens were identified at laboratory of Central Department of Zoology, Tribhuvan University. The identification was made by comparing with existing specimens at laboratory of Entomology Division and consulting insect taxonomic keys and taxonomic expertise of entomology were also consulted.

4.9 Specimen Preparation/Photography

The minute insect pests which were preserved directly in the alcohol were first taken out of the alcohol and were mounted on permanent slides by undergoing usual process of dehydration in alcohol series and staining. The bigger insects were dried and pinned by entomological pin and placed as dry preservation in the insect collection box at laboratory. Photographs of permanent slides were taken by using Carl Zeis microphotography binocular microscope with the help of expert.

4.10 Data Analysis

4.10.1 Species Diversity

Species diversity was calculated by using Shannon's diversity index and community dominance by Simpsons index (Odum, 1996), where:

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

Where,

$\bar{H}$ = Shannon's diversity index

ni = Importance value for each species

N = Total no. of importance value

[$\therefore$ Importance value = number of individual)

4.10.2 Evenness (e) = $\frac{\bar{H}}{\log s}$

Where, S = Total no. of species

4.10.3Community Dominance (C) = $\acute{g}\left(\frac{\mathbf{ni}}{\mathbf{N}}\right)^2$

C = Simposon's Dominance Index

5. EXPERIMENTAL RESULT

The study site was visited two times and the population of pests, season of major abundance, nature of infestation, crop loss by the pest and control measures being taken them were studied. The two visits (Monsoon and Autumn season) were targeted so as to gather information about the seasonal variability. Random questionnaire was conducted mainly with the people working in the tea garden and also with the office and administrative staff. The pests collected during the study period have been presented in the following table.

Table 3: Pests collected, Time of collection, Nature of damage, Site of attack and Their Status on Tea Plant at TVTG

Pest	Time of Collection	Nature of Damage	Site of Attack	Status
Oligonychus coffeae	Oct-Nov/Jun-July	Sap Sucker	Upper surface of the mature leaf	Major
Toxoptera aurantii	Oct-Nov/Jun-July	Sap Sucker	Young leaves, buds, tender stems	Major
Scirtothrips sp.	Oct-Nov/Jun-July	Sap Sucker	Young shoot and buds	Major
Andraca bipunctata	Oct-Nov/Jun-July	Defoliator	Under surface of leaf and whole leaf	Major
Eterusia magnifica	Oct-Nov/Jun-July	Defoliator	Edges and whole leaf	Major
Common looper	Oct-Nov/Jun-July	Defoliator	Young and mature leaf	Minor
Flush worm	Oct-Nov/Jun-July	Defoliator	Young leaf and shoots	Major
Poecilocoris latus	Oct-Nov/Jun-July	Sap Sucker	Seed cotyledons	Minor
Thosea sp.	Oct-Nov/Jun-July	Defoliator	Older leaves	Minor
Dorylus orientalis	Oct-Nov/Jun-July	-	Stem and root	Minor
Gastrimargus africannus orientalis	Oct-Nov/Jun-July	Chewing	Mature leaves	Minor
Acridium melanocorne	Oct-Nov/Jun-July	Chewing	Mature leaves	Minor
Oxycetonia jucunda	Jun-July	Chewing	Stems of young shoots	Minor
Leptocorisa chinensis	Jun-July	Sap sucker	leaf	Occasional

Table 4: Seasonal Distribution of Tea Pest at TVTG, Darjeeling

Order	Family	Species	Autumn (Oct-Nov) Number of individual species	Monsoon (Jun-July) Number of individual species
Lepidoptera	Bombycidae	*Andraca bipunctata*	20	10
	Zygaenidae	*Eterusia magnifica*	21	8
	Limacodidae	*Thosea* sp.	10	4
	Geometridae		12	4
	Lymantridae		-	3
	Eucosmidae		21	14
Hemiptera				
	Pentatomidae	*Poecilocoris latus*	10	6
	Aphididae	*Toxoptera aurantii*	25	22
	Coreidae	*Leptocorisa chinensis*	-	4
Thysanoptera	Thripidae	*Scirtothrips sp.*	28	11
Hymenoptera	Formicidae	*Dorylus orientalis*	30	25
Acarina	Tetranychidae	*Oligonychus coffeae*	30	10
Orthoptera	Acrididae	*Gastrimargus africannus orientalis*	3	4
		Acridium melanocorne	3	4
		Atractomorpha crenulata	3	3
	Tettigonidae		3	4
Coleoptera	Chrysomelidae		-	2
	Scarabaeidae	*Oxycetonia*	-	2
		juncunda		
Predators				
1.	Ladybird beetle	*Coccinell sp.*	2	2
2.	Spider		5	4
3.	Preying mantis	*Mantis sp.*	1	1

5.1 Characteristic Features of Recorded Pest

Characteristic Feature of Bunch Caterpillar - *Andraca bipunctata*

They Congregates on the branches in cluster at the daytime. The full grown caterpillar is about 65mm long. The head and prothoracic segments are brownish black and the body is densely covered with fine hairs. In addition to three thoracic pairs of legs, there are four pairs of prolegs and a pair of claspers at the hind end of the body. Though the adults couldn't be collected on the basis of the characters, occurrence and feeding behaviour of the larva as described by Banerjee (1996), the collected specimen is most likely to be *Andraca bipunctata*. (Plate 10)

Characteristics Feature of Red Slug Caterpillar - *Eterusia magnifica*

The caterpillar prefers mature leaf. The caterpillars are usually active during the early and later parts of the day. The full grown larvae are slug-like, about 25mm long, brownish red to brick red with a brown head. In addition to three pairs of thoracic legs, it has five pairs of prolegs. Though adult couldn't be collected on the basis of the characters, occurrence and feeding behaviour of the larva as described by Watt, Sir G. and Mann H.H.(1903), the collected specimen is most likely to be *Eterusia magnifica*.

Characteristic Features of Neetle Grub- *Thosea sp.*

They resemble a slug in the form of the body, usually green, with multi coloured markings. Short, thick, fleshy body, minute thoracic legs, Body is provided with tufts of hairs. Though adult couldn't be collected, on the basis of the characters, occurrence and feeding behaviour of the larva as described by Watt & Mann (1903), the collected specimen is most likely to be *Thosea* sp.

Characteristic Feature of Common Looper

The larva is dark green to black in colour measuring about 1-7 to 2cm in length. They eat away the young and mature leaf. Though adult couldn't be collected, the pest couldn't be identified.

Characteristic Feature of Flushworm

The caterpillars are slender and green in colour. The larva normally attacks the young shoots. The young larva feeds by scraping off the tissues of the upper surface. (Plate 11)

Characteristic Feature of Tea Seed Bug - *Poecilocoris latus*

The adult bug is ovate, convex, about 22mm long and is reddish in colour. The scutellum is very large extending to the posterior end of the abdomen and entirely covering the wings. There is a spot on each anterior angle of pronotum. The head and antenna are violaceous black, short with green. They suck the juice of seed cotyledons. (Plate 12)

Characteristic Feature of Tea Aphid - *Toxoptera aurantii*

Adults are shiny black in colour, winged or apterous. Body length ranges from 1.2 to 1.8 mm in length. The pterostigma sector of the forewings is distinctly dark to black in colour. (Plate 5)

Characteristic Feature of Thrips - *Scirtothrips sp*.

Adults are yellowish-brown in colour measuring 0.5 to 0.8 mm in length. Antenna 5 segmented with one segmented terminal style. Wings present, narrow and pointed apically. Ovipositor well developed and curved downwards. (Plate 4)

Characteristic Feature of Red Spider Mite - *Oligonychus coffeae*

It is oval in shape and red in colour. Adults have four pair of legs while the nymphs have only three pair of legs. Body size ranges from 0.3 to 0.5 mm in length. Make thin silky web. Found on the upper surfaces of mature leaves. They are largest of mite pest of tea and can be seen with naked eyes. (Plate 6)

Characteristic Feature of Short Horned Grasshopper

The antenna is usually much shorter than the body. Tarsi are 3-segmented. Most are grey or brownish in colour. The ovipositor is not conspicuous and its valve is short and curved. (Plate 7)

Characteristic Feature of Long Horned Grasshopper

Pronotum extends backward over the abdomen and is narrowed posteriorly. Ovipositor frequently attains a great length. (Plate 9)

5.2 Diversity of Tea Pest

Among the collected specimens, maximum numbers were collected from the Family Formicidae and Aphididae and minimum from chrysomellidae and scarabaeidae. Likewise, order Lepidoptera includes the maximum number of specimen and order coleoptera includes the minimum number of specimen. A total of 219 specimens were collected during the autumn season and 140 specimens during the Monsoon season, altogether 359 specimens were collected from TVTG.

A total of 13 species of arthropod pests and 2 species of predators were recorded on TVTG, Darjeeling during the study period, which is presented in Table 4. These insect species belonged to family of seven orders i.e. Lepidoptera, Coleoptera, Hemiptera, Orthoptera, Acarina, Thysanoptera, Hymenoptera. The predator species were of order Coleoptera, Dictyoptera etc.

5.3 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.

Table 5: Shannon's Index for Species Diversity of Autumn Season

Order	-(pi)Ln (Pi)	Evenness ($e = \frac{\overline{H_1}}{\log s}$)
Lepidoptera	-0.367	
Hemiptera	-0.292	
Thysanoptera	-0.262	
Hymenoptera	-0.271	0.904
Acarina	-0.271	
Orthoptera	-0.157	
	$\overline{H_1} = -\sum pi \log e\, pi = 1.62$	

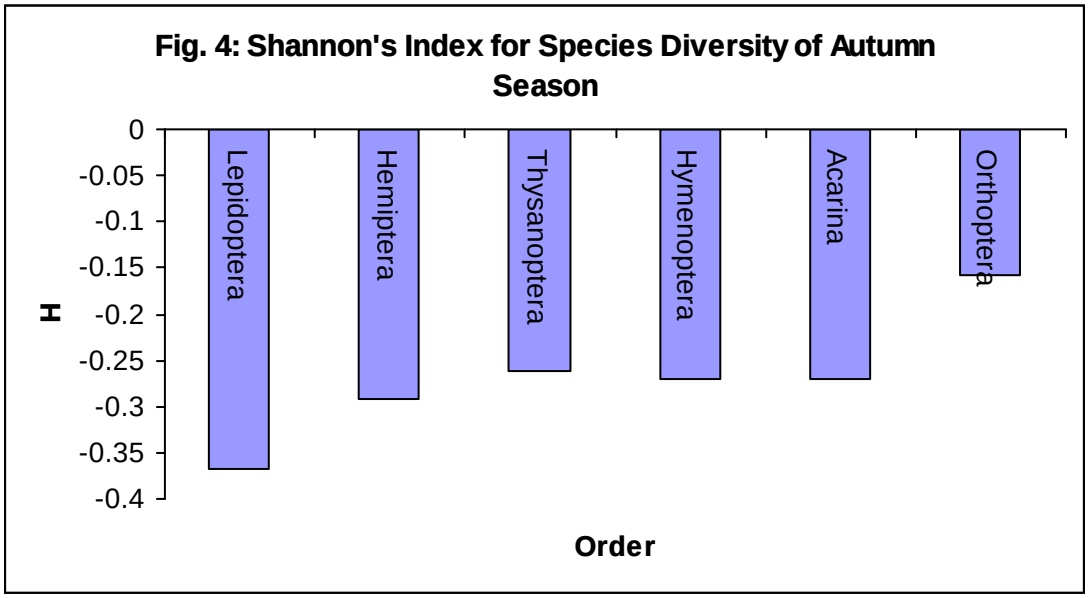
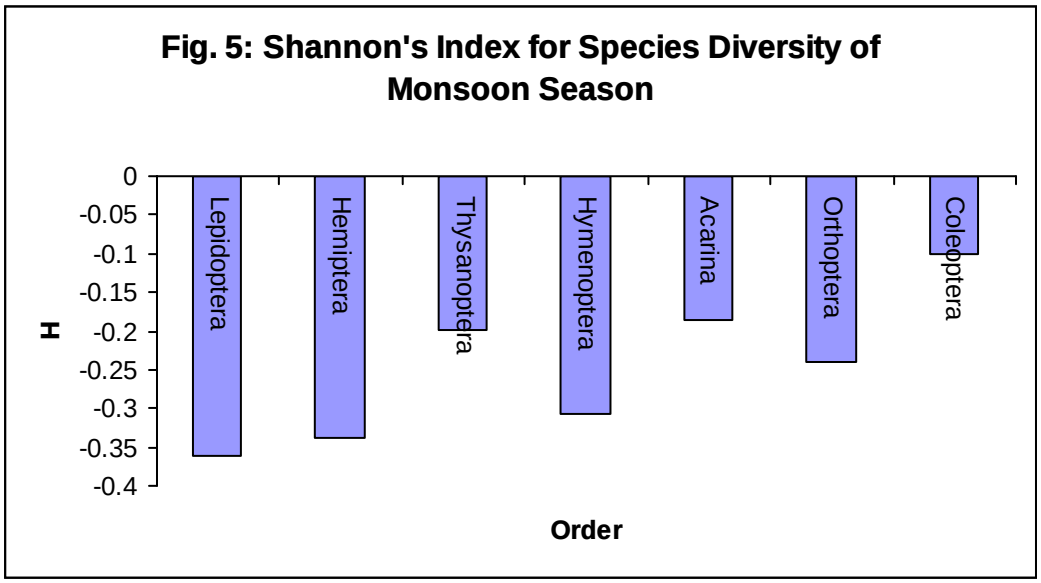


Table 6: Shannon's Index for Species Diversity of Monsoon Season

Order	-(pi) Ln (Pi)	Evenness ($e = \frac{\overline{H_2}}{\log s}$)
Lepidoptera	-0.362	
Hemiptera	-0.337	
Thysanoptera	-0.198	
Hymenoptera	-0.307	0.889
Acarina	-0.187	
Orthoptera	-0.239	
Coleoptera	-0.100	
	$\overline{H_2} = -\sum \text{pi} \log e \text{pi} = 1.73$	



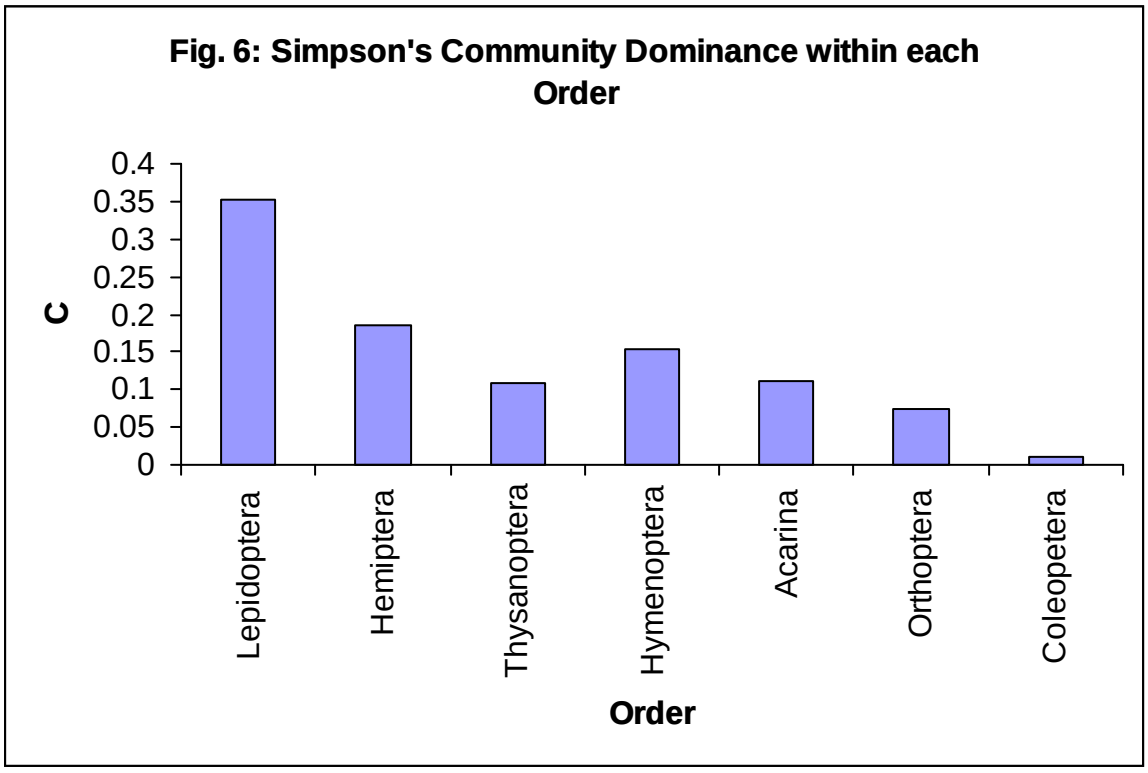
The species diversity in TVTG in autumn season was recorded 1.62. Evenness recorded is 0.904. Similarly, the species diversity in TVTG in monsoon season was recorded 1.73 .Evenness recorded is 0.889.

5.4 Community Dominance

Community dominance calculated within each Order and within each season found as below:

Table 7: Simpson's Community Dominance within each Order

Order	(ni/N)
Lepidoptera	0.353
Hemiptera	0.186
Thysanoptera	0.108
Hymenoptera	0.153
Acarina	0.111
Orthoptera	0.075
Coleopetera	0.011
	$C = \sum\left(\frac{ni}{N}\right) = 0.997$



Community dominance within the Order was found average as 0.997. Among the OrderLepidoptera was found to be dominant as its value was 0.353 while Coleoptera was found to be least dominant as 0.011.S

Majority of the respondents (15 out of 22) commented that the arthropod pests are the main problem that leads to considerable loss of

crops. According to the people working in the tea garden and also with the office and administrative staff, among the pests that leads to loss of crop; red spider mite, thrips, aphids, bunch caterpillar, flush worm, red slugs, mosquito bug etc. were the major and they concentrate more on young leaves, buds, young shoots, mature leaf. TVTG lies at 914.4m above the sea level with annual rainfall of 320cms. The maximum temperature is 22^0C - 28^0C while the minimum 4^0C - 10^0C. They are spraying the tea bushes with ethion, dicofol, neem formulations, monocrotophos etc. to get rid of the arthropod pests.

6. DISCUSSION

During the study period on present investigation entitled "Study of Arthropod Pest Of Tea and It's Diversity in Teesta Valley Tea Garden, Darjeeling" it was observed that different pest belonging to different taxonomic groups affects the tea plants. A total of 13 species of arthropod pests and 2 species of predators were identified from the collected specimen which belong to eight orders and 18 different families. The order identified were Lepidoptera, Coleoptera, Hemiptera, Orthoptera, Hymenoptera, Thysanoptera, Acarina, Dictyoptera. Similarly, the families belonging to these orders are Bombycidae, Zygaenidae, Limacodidae, Lymantridae, Geometridae, Eucosmidae, Chrysomelidae, Coccinellidae, Pentatomidae, Coreidae, Aphididae, Acrididae, Tettigonidae, Formicidae, Thripidae, Tetranychidae, Scarabaeidae, Mantidae. Among these Coleoptera (Family coccinellidae) and Dictyoptera (Family Mantidae) are predators while remaining are arthropod pests of tea plant.

The arthropod pests collected and identified are Red Spider Mite (*Oligonychus coffeae*), Aphids (*Toxoptera aurantii),* Thrips (*Scirtothrips sp*.), Red Slug Caterpillar (*Eterusia magnifica*), Bunch Catterpillar(*Andraca bipunctata),*Tea Seed Bug (*Poecilocoris latus*), Red Ant (*Dorylus orientalis*), Short Horned Grasshopper (*Gastrimargus africannus orientalis, Acridium melanocorne, Atractomorpha crenulata*). Common Looper, Flushworm, Flea Beetle, Long Horned Grasshopper of family Geometrida, Eucosmidae, Chrysomelidae, Lymantridae and Tettigonidae were also collected but due to lack of its adult forms, the pest couldn't be identified.

The major pests found in the tea plant are Red Spider Mite (*Oligonychus coffeae*), Aphids (*Toxoptera aurantii*), Thrips *(Scirtothrips sp.),* Red Slug Caterpillar (*Eterusia magnifica*), Bunch Caterpillar (*Andraca bipunctata*) and Flushworm. Similarly, Tea Seed Bug (*Poecilocoris latus*), Red Ant (*Dorylus orientalis*), Acrididae (*Gastrimargus africannus*

orientalis, Acridium melanocorne, Atractomorpha crennulata), Long Horned Grasshopper, *Oxycetonia jucunda* and Flea Beetle was observed as minor pest in TVTG.

Though TVTG is totally conventional Tea Garden, some pesticides adversely affect the balance between pests and their natural enemies like predators and parasitoids on many crops, some pesticides do reduce the field population of natural enemies of the pests and the main reason for sub-optimal control of pests and recurrence of pest problems is that pesticide application technology is not sufficiently developed to hit the target site in different plant parts. The thick foliage of the unpruned tea often prevents spray droplets from penetrating deep into the canopy where pests are often located (Banerjee, 1986).

Rai, M. (2003) advocated that tea is not threatened by the arthropod pests in KTE. Rather the tea in KTE is damaged by a disease called blister blight caused by fungus *Exobasidium vexans*. But during the field survey, it was observed that different arthropod pests belonging to different taxonomic groups is above the threshold level, probably due to TVTG lies at 914.4m above the sea level which is favourable for the development of different arthropod pests as well as garden is cultivated with china and Asssam varieties which is suitable host of some arthropod pests.

Rai, M. (2003) has collected red spider mite (*Oligonychus coffeae*), Aphid (*Toxoptera aurantii*), bunch caterpillar, Jassid (greenfly), cockchafer grub, looper caterpillar, termites and scale insects. Among them only thrips and aphids was considered as major while the remaining are considered as minor pest. But according to field survey data, the major pests found in the tea plants were the red spider mite, thrips, aphids, bunch caterpillar, flushworm, red slug. Similarly ant, termites, grasshopper, beetles, tea seed bug were observed as minor pests. The differences in the collected data may be due to the variations of climatic condition of the two garden namely TVTG & KTE, as the TVTG lies at the attitude of 914.4m whereas KTE lies

at 1678m, above the mean sea level and though TVTG is totally conventional area the result of continuous use of pesticide, the plant resistance to pests has declined. At the same time, increased pesticide use has made pest immune to the chemical.

The Red Spider Mite (*Oligonychus coffeae*) was regarded as the major pest in TVTG because their population was found comparatively high during the study period which is comparable with the research work that had been carried out by Banerjee, 1988. Among the major pests of tea in North-East India, the red spider mite (*Oligonychus coffeae*), breeds throughout the year and can be found of any time on tea bushes. During March-April, when the temperature rises, the multiplication rate greatly increases, from June onwards, the pest virtually, disappears except for few mites as rain flushes away the mites. According to the field survey, the population of spider mite is higher in the month of Oct. - Nov. than in the month of June-July, as the data was collected only in the two seasons i.e. autumn & monsoon. Out of the 12 species recorded (Banerjee, 1988), red spider mite, the pink mite and the purple mite are common in North East India. Only the red spider mite could be collected at TVTG. The status of these as a major pest in TVTG is due to the suitability of climatic factors like temperature, rainfall. The maximum temperature is of about 22-28^{0}C which is favourable for the growth and development of the red spider mite. A negative correlation was observed between rainfall and red spider mite. Rainfall is one of the most important climatic factors that control the mite population outbreak. But, the inhabiting the undersurface of the leaves are least affected.

Thrips (*Scirtothrips sp*.) was regarded as the major pest because their population was found high during the study period which is comparable with the work done by Rai, M. (2003), in KTE, which is further confirmed by personal interaction with TVTG, as they prefer warm humid weather. Adults thrips have brown abdomen, nymph creamy white have prominent eyes. Wings present, narrow and pointed apically. They attack young leaves

and buds and produce lacerations. Leaf surface curled, yellowing along the leaf margin. They can cause heavy loss and reduce the quality of tea. In the light of my two visits, it was found that the population of thrips was found to be more in autumn than in the monsoons, as the humidity is up to 70-80 percent during the rainy season which is very high and unsuitable for the development of thrips.

Aphids (*Toxoptera aurantii*) were found in clusters. These black tea aphids were quite abundant on tea plants both in monsoon and dry weather. They were found to be significantly injurious in some of the bushes. Aphid infested leaves curl up and growth is stunted. According to my collected data, aphids were observed as a major pest of the tea in TVTG that cause significant crop loss. *Toxoptera aurantii*, are reported to be the vector of Citrus Triesteza Virus (CTV). Triesteza 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, 2000). It is also possible that they may transmit disease in tea plants too. Adults are shiny black in colour, winged or apterous. The pterostigma sector of the forewings is distinctly dark to black in colour, their population seem to be controlled by the pesticide spray applied against other pests like, thrips, mites, etc. In addition to this natural enemies like ladybird beetles also play a significant role in their control.

Watt & Mann (1903) advocated bunch caterpillar as the major and widely distributed pest of tea plants in North-East India in accordance with their abundance and feeding behaviour, which is comparable with the collected data as their population was high in number. Caterpillar are very distinctive due to its conspicuous colour and peculiar habit of congregating on the branches in clusters and completely stripped of their leaves. The caterpillar is light yellow with the head and prothoracic segments are brownish black and body is densely covered with fine hairs. In addition to three thoracic pairs of legs, there are four pairs of prolegs are present. 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 (1996), the collected specimen is most likely to be *Andraca bipunctata*.

Similarly, Red slug caterpillar is one of the notorious pests of tea in TVTG. During nineteen fifties and sixties this pest was recorded to be a sporadic pest i.e. they appear and disappear suddenly after causing severe damage (Watt & Mann, 1903). The pest now occurs almost regularly every year probably due to the deforestation and disturbance of the natural equilibrium. The caterpillars are usually active during the early and later parts of the day. The full grown larva prefers mature leaf. The full grown larvae are slug-like, brownish red to brick red with a brown head. In addition to three pairs of thoracic legs, it has five pairs of prolegs. Though the adult couldn't be collected, on the basis of characters, feeding behavior of the larvae as described by Banerjee (1996), the collected specimen is most likely to be *Eterusia magnifica*.

Among the minor pest in TVTG, Tea Seed Bug (*Poecilocoris latus*) is a medium sized brilliantly coloured bug; adult bug is ovate, convex, and reddish in colour. The scutellum is very large extending to the posterior end of the abdomen and entirely covering the wings. The bug suck the juice of the seed cotyledons, it occasionally attacks the flower, buds and tender stem and leaves. Sharma & Bezbarua (1988), however, observed that 76% of the bugs carry fungal spores on their proboscis. In the light of my two visits, least number was collected in both the autumn and monsoon.

Ants, termites, beetles and grasshopper are very minor pest in TVTG. Though considerable numbers of ant were collected, this pest couldn’t cause considerable loss. Beetles were rarely found in TVTG, similarly three species of grasshopper were collected from the field but it was not considered as serious pest because of its behavior of feeding on multiple hosts.

Among the natural enemies of the pest, ladybird beetles (*Coccinella sp.*) are common predators of aphids. *Mantis sp.* and Spiders were also recorded from TVTG.

Watt & Mann (1903) mention that the tea mosquito bug (*Helopeltis theivora*) recorded in the Southern and Northern Banks of the Brahmaputra, the Dooars and Darjeeling cause damage to tea plant. On the basis of the sscollected information from official personnel and related books and journals, tea mosquito bug (*Helopeltis theivora*) is taken as a major pest in TVTG which cause considerable damage to the crops; during field survey 2007. These pests couldn't be collected and observed because they are rarely seen during mid-day and are active only at dawn and dusk.

Altogether 359 specimens were collected, 140 specimens were found during monsoon and 219 during autumn season. The calculated species diversity of autumn season is 1.62 and of monsoon season is 1.73 and community dominance is 0.997.

Out of 359 specimens, maximum were collected from family Formicidae and Aphididae. Similarly minimum numbers were collected from chrysomellidae and scarabaeidae. The Lepidoptera was found to be dominant as its value was 0.353 while coleopteran was found to be least dominant as 0.011.

During the study period it was observed that the environmental factors also play a major role in pest population. The increase or decrease of maximum and minimum temperature, humidity and precipitation influenced the insect visitors in tea plants. From the observation it was found that the increase of maximum temperature resulted in the increase of tea pest population, especially like red spider mite, bunch caterpillar, thrips, aphids, tea mosquito bug etc. Similarly from the observation it was found that the population of arthropod pests also decreased in tea plants with the fall of temperature. A negative correlation was observed between rainfall and pest

population in tea plant, which means with the rise of rainfall the occurrence of pest population decreased in tea plants.

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, the 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 TVTG are nearly about 150 years. It is also because of this fact that TVTG was found to harbor more number of pests.

6.1 Pesticide Residue and Hazards

A very significant step in the control measure taken by TVTG is the use of chemical pesticide. Botanical pesticides are rarely applied.

In 1992-93, Germany refused to import a shipment of Darjeeling tea contaminated with tetradifon used against spider mite larvae. A one kilogram sample from the shipment contained 240 micrograms of tetradifon. According to the respondents of the questionnaire survey and interview with the manager of the tea garden it was revealed that its products to the foreign countries, it knows little about the pesticide residue in its product, bio-fertilizers and IPM.

7. CONCLUSION

The experimental results of the present investigation entitled "Study of Arthropod Pest of Tea and its Diversity in Teesta Valley Tea Garden, Darjeeling, India" Conducted at during OCT-NOV 2006 and JUNE-JULY, 2007.

A total of 13 species of arthropod pests and 2 species of predators were identified from the collected specimens during the study period which belong to families of eight order and 18 different families. The orders identified were Lepidoptera, Coleoptera, Hemiptera, Hymenoptera, Thysanoptera, Acarina, Orthoptera and Dictyoptera. Similarly, the families are Bombycidae, Zygaenidae, Limacodidae, Chrysomellidae, Lymantridae, Aphididae, Thripidae, Tetranychidae, Mantidae, Coccinellidae, Eucosmidae, Acrididae, Tettigonidae, Pentatomidae, Coreidae.

The study showed red spider mite, thrips, aphids, bunch caterpillar, red slugs and flushworm as a major pest of tea plant at TVTG, Darjeeling. There are some minor pests like Tea Seed Bug, Ant, Termites, Beetles, Grasshopper were also recorded. Besides the arthropod pests, crop loss is also due to a fungal disease called Blister Blight, Black Rot, Brown Rot etc. in TVTG, among these, Blister Blight was consider as major.

Altogether 359 specimens collected, 140 specimens were during monsoon and 219 during autumn season. The calculated species diversity of autumn season was observed as 1.62 and evenness as 0.904. Similarly species diversity of Monsoon season was observed as 1.73 and evenness as 0.889. Community dominance was found to be 0.997. Out of 359 specimens, maximum were collected from family formicidae and aphididae and minimum were collected from chrysomelidae and scarabaeidae. Lepidoptera was found to be dominant as its value was 0.353 while coleopteran was least dominant as a 0.011.

The study shows that the environmental factors play major role in visiting patterns of pest population. From the observation it was found that the increase of maximum temperature resulted in the increase pest population at tea plant. Similarly with the fall of temperature, the population of arthropod pests also decreased. Rainfall also plays a significant role in the increase or decrease of pest population. As the rainfall is high the population of pest decreased. Moreover, the pest infestation in tea bushes is also controlled by the "age effect" of the plant. The older the plant more will be the pest attack. Apart from this, the natural enemies of the pests also contribute to check their population below the economic threshold. As a result of continuous use of pesticide, the plant resistance to pests has declined. At the same time, increased use of pesticide has made pest immune to the chemical.

8. RECOMMENDATION

The recommendation of the present investigation entitled "Study of Arthropod Pest of Tea and its Diversity in Teesta Valley Tea Garden, Darjeeling, India" is summarized as below.

- Proper monitoring of the pests throughout the year should be performed in Tea Garden in order to impart proper knowledge about the pests and their status. The data base on the diversity and abundance of major and minor pests should be maintained throughout the country. This data base could be useful tool for pest forecasting.
- From the study it was observed that many pest populations were reduced due to the presence of natural enemy such as ladybird beetle, praying mantis. So it is strongly recommended to protect and encourage the natural enemy present at the garden.
- From the observation it was found that larvae are more destructive to tea plant. So it is recommended to use cultural control like collection and destruction of caterpillars by hand picking of or through hand nets. It is also useful in producing quality tea.
- Chemical pesticides should not be encouraged in Tea Garden as the pesticides have entered the natural food chain, contaminating every layer in the ecosystem. Human beings are most vulnerable to the health risks, because tea plant parts are directly fed by man. So, it is advisable to use different bio-pesticides such as microbial pesticides, safe pesticide as plant based pesticides, etc.
- Proper education and public awareness is most essential about the hazards of pesticide residue.
- Use of Integrated Pest Management Techniques should be applied for effective pest control measures. Among them it is recommended that the larvae of pests should be managed by hand picking. Similarly, other cultural practices like sanitation, timely pruning, cultivation of

resistance variety of tea plant, and bio-control agent are suggested. Clean cultivation of tea plant is very important in reducing the pest population as it facilitates hibernating, aestivating and other biological activities.

- Production of organic tea should be encouraged as there is great demand of organic tea in the international market as well as organic tea is hygienic.

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APPENDIX - I

QUESTIONNAIRE

Date: .....

Name:

Age:

Sex:

Education:

1. How many members in your family?

   .....

2. How many of you are employed in the Tea Garden in your family?

   .....

3. In which section you are employed?

   a) Field ..... b) Office .....

   c) Factory ..... d) Spray division .....

4. When did you become employees of this Tea Garden?

   In AD .....

5. How long had you worked as employees of this Garden?

   .....

6. Do you have any idea about tea pests?

   .....

7. What are the pests that affect the tea plant?

   .....

8. Do you know about major and minor pests?

   If yes

   a) Major ..... b) Minor .....

9. Did you find Tea Pest in all seasons?

   .....

10. Which parts of the tea plants are more affected by pests?

    .....

11. Do you have any idea about pesticide hazards?

    .....

12. In your view which fertilizers is more effective in tea plant?

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

13. Have you ever heard about Integrated Pest Management?

    .....

14. What are the major factors that influenced the occurrence of pests?

    a) Rainfall ..... b) Tempt .....

    c) Humidity ..... d) Altitude .....

APPENDIX - II

LIST OF PESTICIDE BANNED IN INDIA

Aldrin

Benzene Hexa Chloride

Calcium Cyanide

Chlorodane

Endrin

Ethyl Mercury Chloride

Nitrofen

Hepta Chlor

Dieldrin

Toxafen

Ethylene dibromide

Aldicarp

Tetradifon