INSECT PESTS OF JAPANESE PEAR, (*Pyrus pyrifolia* Nakai,1926) IN THE CENTRAL HORTICULTURE CENTRE, KIRTIPUR, NEPAL

Meena Shrestha

T.U Registration No: 5-2-37-817-2012

T.U Examination Roll No: 621/074

Batch: 2074

A thesis submitted in partial fulfillment of requirements for the award of the degree of Master of Science in Zoology with special paper Entomology

Submitted to

Amrit Campus

Department of Zoology

Tribhuvan University

Kathmandu, Nepal

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DECLARATION

I hereby declare that the work presented in this thesis has been done by myself, and has not been submitted elsewhere for the award of any degree. All sources of information have been specifically acknowledged by reference to the author(s) or institution(s).

Date: 9th April 2023

Meena Shrestha

Tribhuvan University
Institute of Science and Technology
AMRIT CAMPUS
P.O Box No:102, Thamel, Kathmandu, Nepal
E-mail:amritcampus@nfe.net.np

RECOMMENDATIONS

This is recommended that the thesis entitled **"Insect pests of Japanese pear (*Pyrus pyrifolia* Nakai, 1926) in the Central Horticulture Centre, Kirtipur, Nepal"** has been carried out by **Ms. Meena Shrestha** for the partial fulfillment of the requirements for the award of the degree of Master of Science in Zoology with a special paper Entomology. This is her original work and has been carried out under my supervision. To the best of my knowledge, this thesis work has not been submitted for any degree in any institution.

.....

Supervisor

Asst. Professor Mrs. Urmila Dyola

Patan Multiple Campus

Patan Dhoka, Lalitpur, Nepal

Date 9-04-2023

Tribhuvan University
Institute of Science and Technology
AMRIT CAMPUS
P.O Box No:102, Thamel, Kathmandu, Nepal
E-mail:amritcampus@nfc.net.np

Coordinator
M. Sc. Program
Department of Zoology
Amrit Campus
IOST, Tribhuvan University

LETTER OF APPROVAL

On the recommendation of supervisor **"Assistant Prof. Urmila Dyola"** this dissertation submitted by **Ms. Meena Shrestha** entitled **"Insect pests of Japanese pear (*Pyrus pyrifolia* Nakai, 1926) in Central Horticulture Center, Kirtipur, Nepal"** is approved for the examination of the requirements for Master's degree of Science in Zoology with special paper Entomology.

.....

Barun Panthi
M.Sc. Programme Co-ordinator
Department of Zoology
Amrit Campus

Date: April 9, 2023

Tribhuvan University

Institute of Science and Technology

AMRIT CAMPUS

P.O Box No:102, Thamel, Kathmandu, Nepal

E-mail:amritcampus@nfc.net.np

CERTIFICATE OF ACCEPTANCE

This thesis work submitted by **Ms. Meena Shrestha** entitled **"Insect pests of Japanese Pear (*Pyrus Pyrifolia* Nakai, 1926) in the Central Horticulture Centre, Kirtipur, Nepal"** has been accepted as partial fulfillment for requirements of Master's Degree of Science in Zoology with special paper "Entomology".

EVALUATION COMMITTEE

.....

Supervisor

Asst. Prof. Mrs. Urmila Dyola

Lecturer

Patan Multiple Campus

Patan Dhoka

.....

Co-ordinator

Asst. Prof. Mr. Barun Panthi

Lecturer

Department of Zoology, Amrit campus

Tribhuvan University

Kathmandu, Nepal

.....

External Examiner

.....

Internal Examiner

Date of Examination.....11-04-2023

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Meena Shrestha

shresthameena691@gmail.com

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LIST OF ABBREVATIONS

CHC……Central horticultural Centre

SDI……Shannon diversity index

YSSB……Yellow-spotted stink bug

ABSTRACT

Insect pests cause serious damage of Japanese pear (*Pyrus pyrifolia* Nakai, 1926) plant at Central Horticulture Centre (CHC), Kirtipur, Kathmandu. The current study was focused on the identification and diversity of insect pests in CHC. The study was conducted for three months; July, August and September of 2019. Handpicking, knockdown, beating and sweeping were the techniques used, depending upon the type and size of insect pests to sample them. Shannon Diversity Index (SDI) was used to calculate the statistical analysis. During the study period, 1820 insect pests belonging to 14 species, 6 orders and 13 families were collected. Among these pests, San Jose Scale (*Quadraspidiotus perniciosus*), has the largest population density i.e., n=425, followed by Aphid (*Aphis gossypii*) n=225 and Oriental fruit fly (*Bactrocera dorsalis*) n=200. The present study showed Moth (*Nyctemera adversata*) as the least counted pest with 16individuals. The insects pest population density was seen high during fruiting season (September) compare to July and August. The overall Shannon diversity Index of Insects pests of pear was 2.18 and Species dominance index was 0.47which refer having diverse Scale of insect pests.

Key words: Insect Pests, Shannon Diversity Index, Species Dominance.

1. INTRODUCTION

1.1 Background

Pears, commonly referred to as green apples, are a very popular fruit in Nepal. In Nepal, two different varieties of pears are produced i.e., the Asian pear and the European pear (*Pyrus communis*). Asian pears are local species such as Pharping Naspati (*Pyrus phasia*) and Japanese pear (*Pyrus pyrifolia)* (Beutel, 1990; Devkota, 1990 and Riegel, 2006,). The pear, any of the various tree and shrub species of the genus *Pyrus*, is a member of the Rosaceae family. The pomaceous fruit of these trees also goes by that name. While some pear varieties are grown as aesthetic trees, others are prized for their palatable fruit. Within tribe Pyreae, the genus *Pyrus* is categorized in sub tribe Pyrinae (CHC Annual Report 2011/12). The pear is a native of the Old World's coastal and somewhat temperate regions, which stretch from Western Europe and North Africa all the way east to Asia. Because of pear wider climate and soil tolerance, pear is grown in temperate and subtropical conditions above <1000 meters above from the sea level. Pear plantations can be found growing anywhere throughout the region, from warm subtropical valleys to temperate highland regions (Sharma, 2015). Due to a number of factors, including a lack of transportation for import and export, yield losses from natural disasters, and pest infestation, Nepal's agriculture has only been able to supply 40% of the country's total food consumption. The pear fruit can be either raw or prepared in a variety of desserts. For juice, the fruit can also be pressed. The tree's wood is excellent for carpentry and may be used to make colors from its leaves.

The *Pyrus pyrifolia*, known as the pear tree, is a small deciduous tree with a tall, narrow crown and alternately positioned simple leaves. The elliptical leaves have distinct ends, coarsely serrated margins, and a length range of 2–12 cm (0.7–4.7 inch). The tree bears juicy green pyriform fruits and white blooms with a diameter of 2.5 cm (1 in). Pear trees have a height of 9 meters (30 feet) and can bear fruit for 20 years. A deciduous small to medium-sized tree with a pyramidal-shaped crown, *Pyrus pyrifolia* grows to a height of 10 m (often 3-5 m in cultivation). The little, reddish-brown, narrow-angled branches grow from the conical, upright stem (Riegel, 2006).

Insect Organisms that affect plants, food, crops, or their hosts are considered pests. By devouring crops or parasitizing livestock, it harms agriculture. Farmers and horticulturists have been implementing a range of techniques to prevent pests and lessen their impact,

including precise pest identification, pest monitoring, choosing pest control alternatives, and other biological and mechanical treatments for a damaging animal or insect that preys on animals, food, crops, etc. It could be an annoying person, thing, or irritation. Insects contribute significantly to the growth of fruits, seeds, vegetables, and flowers (James *et al*., 2008), enhance the physical attributes of the soil, and increase fertility by digging and consuming flesh. Because they are at the base of the food chain and have an effect on agro ecosystems and human health, insects are crucial to the health of the environment.

In many instances, larvae like as sawflies and Lepidoptera feed on the plants to build up a nutrition reserve that will be used by the fleeting adult. While beetle larvae typically reside below and feed on roots, or tunnel into stems or under the bark, larvae of other insects prefer to feed mostly on the aerial parts of plants (Husain *et al.,* 2018).

The cultivation of pears faces numerous dangers. Pests of many kinds, including mites, aphids, thrips, and Scale insects, commonly attack pears (CHC Annual Report 2011/12). Aphids are well-known pear pests that feed on sap (Sharma, 2000).

Pear aphid (*Eriosonia pyricola)* is a serious pest of young pear trees, both in the nursery and the orchards. *P. phasia* native to Nepal, Pakistan and India is uniformly susceptible to root aphid. It is an exception; in that it is the only Asiatic species susceptible to aphid (Swirski; 1954 and Sharma; 2000).

Even though insects have a significant impact on ecosystems by spreading pollen, decomposing organic debris, and recycling nutrients, some have developed into dangerous pests. Pest problems have been made worse by the effects of long-term use of chemical fertilizers and pesticides as well as the growth of monocultures. Habitat modification is crucial for improving biological pest control (Odum, 1996).

1.2 Rationale

Japanese Pear (*Pyrus pyrifolia*) is most important delicious and commercial fruit of Nepal including some Asian countries (Beutel 1990 and Rigel 2006) and in Nepal too (Devkota,1990). The commercial pear growing center of Nepal is located in several temperate regions, including the Kathmandu Valley and horticultural centres (CHC Annual Report 2011/12). Only a few studies have been done on insect pests and how to manage them in pear orchards, thus the current study was done to identify the unique insect of pear in those orchards.

1.3 Research Objectives

The general objective is to find the insect pest of Japanese pear (*Pyrus pyrifolia)* in central horticultural Centre Kirtipur (CHC).

Specific objectives

- To list the pests of Japanese pear (*Pyrus pyrifolia)* in Central Horticultural Centre Kirtipur
- To find out diversity, dominance and species richness of pests.

1.4 Limitations of the study

- Pheromone is not used.
- Field observation was carried out during day time only, so nocturnal pests were not collected.
- Bagging of fruits made difficult in field observation.
- Field collection could not be carried out in rainy season.

2. LITERATURE REVIEW

2.1 In context of Global

The pear, from the genus *Pyrus*, grows on medium-sized trees that range in height from 10 to 17 meters in temperate climates (Riegel, 2006). Over 5,000 different varieties of pears are grown in temperate climates across the globe, with the European Pear (*Pyrus communis*) and the Asian Pear (*Pyrus pyrifolia*), often known as the Japanese Pear or Oriental Pear, being the two most significant species for commercial production (Beutel 1990, Riegel 2006). Western Pale arctic psyllids of the genus *Cacopsylla pyricola* (Homoptera: Psyllidae) are known to feed on pears. It is the primary insect pest affecting the production of pears in North America, necessitating precise and timely information about dispersal, the beginning of egg-laying in the spring, and densities in the orchards. With increasing tree levels, pear psyllids have been shown to directly harm pear fruit (Husain *et al.,* 2018).

Pests only cause financi al harm during a specific period of the growth seasons. Around the world, scarab beetles are among the most devastating and pervasive omnivorous insect pests in horticulture, forestry, and agriculture (Zhang *et al.,* 2020). Effects of herbs on insects in pear orchards interplanted with aromatic plants, both repellent and enticing.

Hemiptera: Aphididae's *Dysaphis pyri* (Boyer de Fonscolombe Mohommad *et at.,* 2012) is a serious pest of the ecology of pears. The aphid has been brought into the United States and is widespread throughout Central Asia, South-West Asia, Europe, North Africa, Nepal, Northern India, and Pakistan (Blackman and Eastop, 2000).

Early in the summer, pesticide sprays are necessary to control the aphid numbers in pear orchards. However, the use of pesticides raises the expense of production in addition to interfering with natural biological control and reducing their potential effectiveness. Since host plants frequently influence the growth, survival, and fertility of insect herbivores, using resistant or less favorable plants is considered to be a crucial component of pest management efforts (Painter *et.al*., 1951). Examples of these traits include size and structure, nutritional value, secondary compounds, and phenology. The developmental responses of a pest species affect how quickly its population expands on a particular host plant.

Around the world, several species of Pear *Psylla* are significant pear pests. *Psylla pryicolla* (Forster), often known as pear Psylla, was originally found in Israel in 1935 (Swirski,

1954). Later, the species was given the new name *Cacopsylla bidens* (Sulc), (Halperin, 1988).

Caliroa cerasi, sometimes known as the "Pear Slug," is a pear sawfly that can be easily controlled by insecticides. According to Brewer *et al.,* (2002), seedling pears have a high level of pear slug infestation. Due to pest resistance development, pesticide control frequently fails. Additionally, the Pear Psyllids significant natural enemies are adversely affected by insecticide use, which enables the pest to quickly rebound following application.

By boosting the number, variety, and richness of natural enemies, intercropping is a useful technique that can help with pest management. Aromatic plants are commonly utilized against blood-feeding arthropods and those that feed in crops due to their insecticidal, antifeedant, and repellant properties on annoyance insects (Song Bei Zhou *et al*., 2011). Evaluations were done on the efficacy and appropriateness of aromatic plants as intercrops for enhancing insect control. In pear orchards intercropped with aromatic plants, the composition and temporal dynamics of arthropod communities were investigated.

Another important insect pest *Bactrocera dorsalis* commonly known as oriental fruit fly firstly identified in China. It has affected fruits and vegetables having great economic loss (Carrillo *et. al*., 2019). The control of this most destructive insect pest depends on chemical insecticides pyrethroid and organ phosphorus (Wei *et al*., 2017).

In a similar vein, the San Jose Scale (*Quadraspidiotus pernicious*), a sporadic insect pest of commercial fruit orchards and a member of the Hemiptera order, is well known. It primarily affects limbs, fruit, or leaves where it suckers plant sap, resulting in fruit with poor color, lowered yields, and eventually tree death (Alston, G. D *et al.,* 2011). Prior to the development of agriculture, grasslands and forests were home to the wheat wireworm, an additional insect pest beetle (*Agriotes mancus*). As a result of their capacity to bounce into the air when placed on their backs, they later came to be known as click beetles or skip jacks. They are most active on warm days and seek refuge in the crowns of plants and dirt crevices. They are omnivorous feeders that consume humus, plants (roots, tubers, transplants, and seedlings), as well as soil-dwelling creatures (Rawlins, 1940). The yellow-spotted stink bug (YSSB), *Erthesina fullo* Thunberg (Hemiptera: Pentatomidae), is one of the most common phytophagous pests in Asia and is present in Bangladesh, China, India, Indonesia, Japan, Burma, Sri Lanka, and Vietnam. It consumes a variety of

fruit that is significant to the economy, including kiwifruit, cherries, pears, and apples (Zhang, 2020). YSSB is a hitchhiker pest that has been introduced into regions outside of its present distribution through a number of different means, including on people or their luggage, containers, general cargo, second-hand equipment, and automobiles. The fruit fly *Drosophila melanogaster* (Diptera: Drosophilidae) is one of the most prevalent and destructive primary pests of Prunus (plums, cherries, peaches, nectarines, apricots, almonds), pear, walnuts, and chestnuts (Julio Alarcon-Enos and Carlos, 2020).

Although, Teresa Joan noted the existence of the "Pear thrips" *Taeniothrips inconsequens* in Argentina in 1921 (Carlos and Maria, 2022). In Florida, the citrus mealy bug is a frequent pest of citrus, mostly in greenhouses, as well as of various ornamental plants. Since 1813, when it was known as the greenhouse mealy bug in Europe, and since 1879, when it was first identified as a difficult-to-control pest in the United States (Anonymous 2007). Citrus mealy bug feeding causes slowed growth, premature leaf drop, wilted, deformed, and yellow chlorotic leaves, as well as the occasional mortality of infected plants or plant components. Sooty mold develops as a result of citrus mealy bugs' release of sugary honeydew, which drips onto the fruits and foliage below (Gill and Goyal, 2012).

Bactrocera dorsalis (Hendel), known as the oriental fruit fly, is an extremely destructive pest of fruit that was originally discovered in the 1930s. It is indigenous to the island of Taiwan and significant portions of tropical Asia. It has spread to most of sub-Saharan Africa and is frequently apprehended in the United States, occasionally leading to eradication operations (Schutze *et al*., 2015).

2.2 In Context of Nepal

The most significant dedicated and commercial fruit in Nepal and various Asian nations are the pears (*Pyrus pyrifolia*) (Beutel 1990; Devkota1990 and Riegel, 2006). The cultivation of pears faces numerous dangers. Pears are frequently attacked by pests of all kinds, such as mites, aphids, thrips, and Scale insects (CHC Annual Report 2011/12). The well-known pear pest known as aphids feeds on sap (Sharma 2000). Rana and Sharma, (1965) recorded fourteen different types of aphids on agricultural crops, and in his "Contribution on aphid fauna from Nepal" from 1967, Sharma alone listed fifty-five species under thirty-four genera.

Tetranychus species of Spider mite, Aphid species, and Thrips (*Taeniothrip*s spp.) The most prevalent pest species were the Spider mite (*Tetranychus* spp.), the tortoise beetle

(*Metrona* spp.), and fruit flies (*Dacus* spp) (Bajracharya and Dyola, 2015). A mite pest called *Bryobia rubrioculus* damaged numerous young leaves on pharping local pears. Both the Japanese pear and the pharping have more mites since the buds are also afflicted. Phase II of the horticulture development project started in 1992 with a focus on pest management, the selection of fruit tree strains, and technological advancements in seedling production. (Adhikari *et al.,* 2000).

The commercial pear growing center of Nepal is located in several temperate areas, including the Kathmandu Valley and horticulture centers (CHC Annual Report 2011/12). Only a few studies have been done on pear pest insects and how to handle them, thus the current study was carried out to identify the particular pear bug in the pear orchard of CHC. The pears fruit can be either raw or prepared in a variety of desserts. For juice, the fruit can also be pressed. The tree's wood is excellent for carpentry and may be used to make colors from its leaves. Although numerous studies identified *Cacopsylla pyri* as the primary pest of pears, it is not present in Nepal.

3. MATERIALS AND METHODS

3.1 Materials

- Forceps
- Vials
- Brush
- Entomological pin of different size (2.0mm and 0.5mm)
- Paper envelope
- Stereoscopic microscope
- Sweeping net
- Ziplock bag
- Entomological box

3.2 Chemicals

- Alcohol series (10%, 30%, 50%, 70% and 100%)
- Glycerol
- 70% ethanol
- Naphthalene ball

3.3 Study area

Central Horticulture Centre (CHC) lies in Kirtipur Municipality, Kathmandu. It is 1,320 meters above sea level and is located between 27 40' N latitude and 85 17' E longitude (CHC Annual Report 2011/12). The station's mild climate reaches highs of 32 C in the summer and lows of 0 C in the winter. 1,025 mm of rain falls on average per day during the monsoon season (CHC Annual report, 2011/2012).

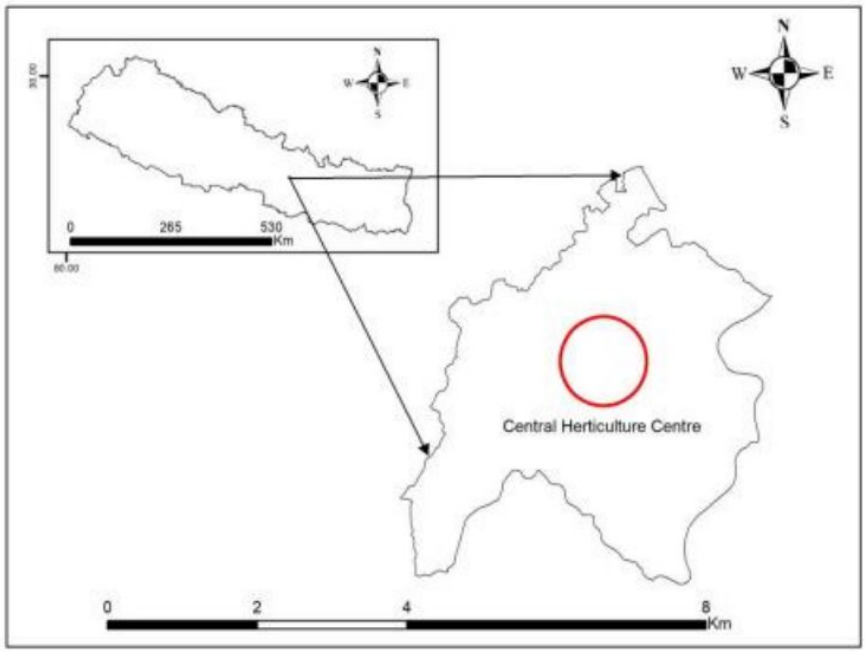

Figure 1 Map of Central Horticultural Centre, showing orange orchard (study area)

3.4 Sampling Design

According to the CHC Annual Report 2011/2012, the entire area covered by CHC is 20 ha, of which 11 ha are taken up by various orchards, including pear (*Pyrus pyrifolia*) orchards. Four different locations I, II, III and IV were selected from Site A, B and C at locations approximately 15–20 m from each site. From each location, 10 different pear plants were randomly selected and tagged. After that, from July to September 2019, we conducted a pest survey by observing parts of the plant such as stems, branches, leaves, flowers, fruits, and flowers. The field survey was conducted from 10:00 am to 3:00 pm. They were viewed with the naked eye and with a handheld lens when necessary. The site was visited once a week

3.5 Collection, Identification, Preservation& Specimen Deposition

The ocular observation (Sutherland 1996) method was followed during the active period between 10 AM - 3 PM for the first source of data collection. Adult pests were collected by using a sweep net and they were transferred to the killing jar filled with alcohol (100%). After killing they were kept in a triangular envelope prepared by the special tracing paper. For dry preservation, the collected specimens were pinned by spreading their wings and followed by labeling in the wooden insect box. For protection naphthalene balls were used. In addition, photos of the insects were captured in the natural position. Insect pests were

examined Stereoscopic Microscope and were identified by following literature; Borror and DeLong's, 1971; Gupta, 1985 and Sharma, 2000. The specimens were pinned, labeled and transferred in the entomological box for permanent preservation, and safely deposited into the laboratory of Amrit science Campus, Tribhuvan University, Kathmandu, Nepal

3.6 Data analysis

- The data were statistically analyzed using Microsoft Office Excel, 2007.
- The Shannon-wiener diversity index (H') was calculated by using the formula,
- Shannon-wiener index of diversity (H') = $-\sum \frac{pi}{\ln (pi)}$
- Where, H'= Shannon-Weiner diversity index.
- n = Abundance of each species.
- N= Total number of individuals observed.
- pi = $\frac{n}{N}$ = Relative abundance of each species, calculated as the proportion of individuals of a given species to the total number of individuals in the community.
- Similarly, the index of dominance (C) was calculated as, Index of dominance (C) = $\sum(pi)^2$

4. RESULTS

4.1 Diversity and Populations Status

A total of 1820 individual insect pests from 14 species belonging to 6order and 13families were recorded during the study period. Hemiptera was the most dominant order that contributed four species Aphid (*Aphis gossypii),* San Jose Scale *(Quadraspidiotus perniciosus)*, Yellow marmorated stink bug (*Erthesina fullo)* and Mealy bug (*Planococcus citri),* whereas Thysanoptera has been reported single individual. In terms of a total number of individuals, *Quadraspidiotus perniciosus* (n=425) was the most abundant species recorded followed by *Aphis gossypii* (n=400), *Bactrocera dorsalis* (*n=225), Drosophila melanogaster* (n=200), *Aspidomorpha milliaris* (n=190), *Caliroa cerasi* (n=68), *Planococcus citri* (n=55), *Erthesina fullo* (n=48), and *Vespa crabro* (n=48), *Agriotes mancus* (n=45), *Vespa mandarinia (n= 39),Syntomoides imaon* (n=34), *Taeniothrips inconsequens* (n=27) and *Nyctemera adversata* (n=16) respectively.

Classification of Pear Pest Species

SN	Order	Family	Scientific name	Common name
1	Hemiptera	Aphidiae	*Aphis gossypii*	Aphid
2	Hemiptera	Diaspidiae	*Quadraspidiotus pernicious*	San jose scale
3	Coleoptera	Elateridae	*Agriotes mancus*	Click beetle
4	Hemiptera	Pentatomidae	*Erthesina fullo*	Yellow marmorated stink bug
5	Diptera	Tephritidae	*Bactrocera doraslis*	Dacus (Oriental fruit fly)
6	Thysanoptera	Thripidae	*Taeniothrips inconsequens*	Thrips (leaf minor)
7	Hemiptera	Pseudococcidae	*Plannococcus citri*	Mealy bug
8	Lepidoptera	Erebidae	*Syntomoides imaon*	Black moth
9	Coleoptera	Chrysomelidae	*Aspidomorpha milliaris*	Tortoise beetle
10	Hymenoptera	Tenthridinidae	*Caliroa cerasi*	Sawfly
11	Hymenoptera	Vespidae	*Vespa mandarinia*	Vespa
12	Hymenoptera	Vespidae	*Vespa crabro*	Hornet
13	Diptera	Drosophilidae	*Drosophila melanogaster*	Fruitfly
14	Lepidoptera	Erebidae	*Nyctemera adversata*	Moth

Table 1 Composition of Pear Pest Species

4.2 DIAGONASTIC CHARACTERS

Aphis gossypii (Glover, 1877)

Aphis gossypii are fusiform**,** oval, winged or wingless. Aphids are small, pear-shaped, soft insects 1 to 3 mm long. They range in color from tan, brown, green, or black. Head tuber between inconspicuous antennae with several dark streaks behind abdomen (Figure 2).

Figure 2: *Aphis gossypii*

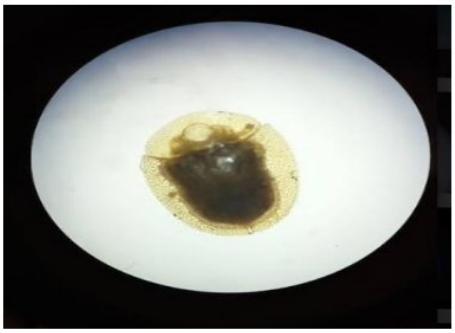

Figure 3 *Quadraspidiotus pernicious*

Quadraspidiotus perniciosus (Comstock, 1881)

Quadraspidiotus perniciosus is bright yellow, grey, wingless and legless, soft globose, about 1.5 to 2.0 mm long. Females are round and gray, about 2mm in diameter. (Figure 3).

Agriotes mancus (Say, 1823)

Agriotes mancus is an elongated, flat-tipped insect with a large, mobile prothorax, and posterior horns usually pointed. The body often tapers sharply towards the back. Body length 7-9 mm, color blackish brown. Deep groove in wing sheath, dorsal horn of prothorax and dense coarse punctures on sides of wing sheath Dull yellow, short dull yellow hairs (Figure 4).

Figure 4 *Agriotes mancus*

Figure 5 *Erthesina fullo*

Erthesina fullo (Thunberg, 1783)

Erthesina fullo, also known as the yellow-spotted stink bug or yellow marble stink bug, is native to Asia. It grows to 1-1.5 cm in length and has protruding antennae and a mouth. Life stages are completed with egg and first instar, nymphal cataract, and adult stages.

Figure 6 First instar of stink bug

Figure 7 Second instar of stink bug

Bactrocera dorsalis (Hendel, 1940)

Bactrocera dorsalis, commonly known as the oriental fruit fly, was formerly known as Dax dorsalis. Adult fruit flies are slightly larger than house flies, about 8 mm long, pale yellow in color, and have a dark 'T' mark on the abdomen (Figure 8).

Figure 8 *Bactrocera dorsalis*

Figure 9 *Taeniothrips inconsequens*

Taeniothrips inconsequens (Uzel, 1895)

The wings are relatively narrow, the ovipositor is directed downward, and the antennae are eight-membered. 1.2–1.3 mm long, brown or black, grayish wings, protarsal with apical teeth, row of small crest-like bristles on 8th ventral spine (Figure 9).

Planococcus citri (Risso, 1813)

Adult mealybugs range in size from 3 mm (females) to 4.5 mm (males). Females are wingless and white to light brown in color with brown legs and antennae. The male is similar in color to the female and has her two long white waxy threads sticking out behind her (Figure 10).

Figure 10 *Planococcus citri*

Figure 11 *Syntomoides imaon*

Syntomoides imaon (Cramer,1779)

This moth is about 1-1.5 cm in size and has a yellow collar on the hind thorax. The forewings have large translucent spots, one filling the cell and the other occupying almost the entire intermediate space. They have a pair of antennae and one eye; males are slender and females are elongated. (Figure11).

Aspidomorpha milliaris (Fabricius,1775)

Aspidormporpha is asian spotted tortoise beetle which elongates about 0.5cm in length. The body is like tortoise shaped so known as tortoise shaped having hard covering in abdomen (Figure 12).

Figure 12 *Aspidomorpha milliaris*

Figure 13 *Caliroa cerasi*

Caliroa cerasi (Linnaeus,1758)

Caliroa cerasi commonly known as sawfly or pear slug measures about 1.5cm-2cm in length. These are the important pest of pear having larval stage leaf minor. It has a pair of antennae and eyes having black-brown body colour (Figure 13).

Vespa mandarinia (Smith,1852)

Vespa mandarinia is known as Asian giant hornet native to Asia, known as the largest hornet of the world. It measures upto1-1/2inches in length. It has smooth yellow -orange head, yellow-black bodies and a pair of grey wings (Figure 14).

Figure 14 *Vespa mandarinia*

Figure 15 *Vespa crabro*

Vespa crabro, (Linnaeus,1761)

The Vespa crabro is known as the European Wasp, native to Europe and Asia. Adults can reach up to 1cm x 20mm. The body is slender, with brown and dark yellow bands on the abdomen. Wings reddish brown (Figure 15).

Drosophila melanogaster (Meigen, 1830)

The fruit fly, *Drosophila melanogaster* is 3 mm long and yellow-brown overall. Drosophila has feathery aristae on the antennae, large vertical bristles on the columns, and a ridged face. The main diagnostic features of *Drosophila melanogaster* are dark abdominal bands and red eyes (Figure 16).

Figure 16 *Drosophila melanogaster*

Figure 17 *Nyctemera adversata*

Nyctemera adversata (Schaller,1788)

Nyctemera adversata is a mottled white medium-sized moth with a wingspan of 35-45 mm. Wings are usually dark with light spots. Larvae are leaflets (Figure 17).

4.3 Species diversity of pests

Altogether 1820 species of insect pest of pear were collected from 3 sites (A, B and C). These all pests belong to 6 orders Coleoptera, Diptera, Hemiptera, Hymeoptera, Lepidoptera, Thysanoptera. These six orders include altogether 13 Families. The highest no. of pest was from family Diaspidiae (425) which is followed by Aphidiae (400). Whereas the lowest no. of pest was in family Thripidae (27).

Among them San Jose scale (*Quadraspidiotus perniciosus*) was the most common pest of pear followed by Aphid (*Aphis gossypii*), Oriental fruitfly (*Bactrocera dorsalis*) Fruitfly (*Drosophila melanogaster)* and Tortoise beetle (*Aspidomorpha milliaris*) respectively. Here, Moth (*Nyctemera adversata*) was collected least in number in pear field during study.

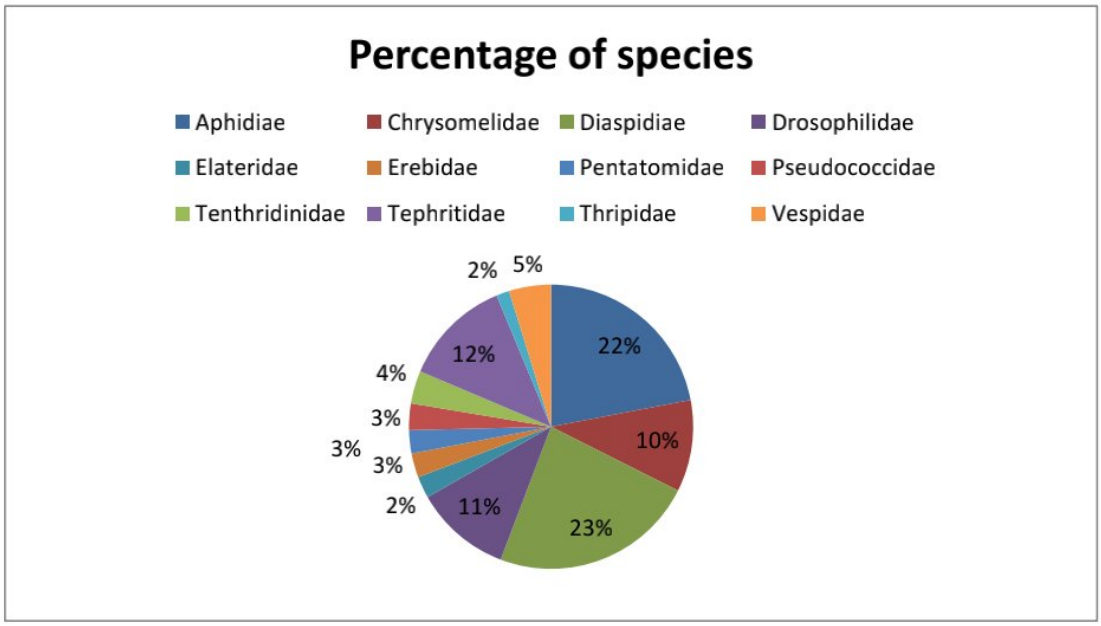

Figure 18 Percentage of pest according families collected during study period

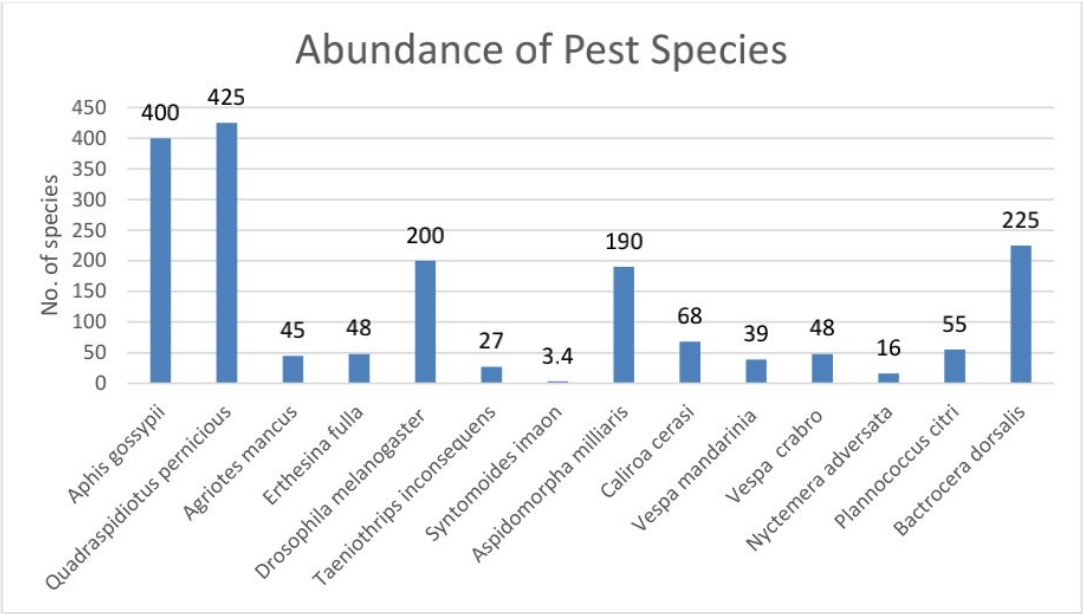

Figure 19 Abundance of Pest Species

Table 2 Species Diversity of Pests

Scientific name	No. of species (ni)	ni/N	ln(pi)	Shannon Index - Σ(pi)x(ln(pi))	species Dominance $\Sigma(pi)^2$
Aphis gossypii	400	0.2198	-1.5151	0.3330	0.1109
Quadraspidiotus pernicious	425	0.2335	-1.4545	0.3397	0.1154
Agriotes mancus	45	0.0247	-3.6999	0.0915	0.0084
Erthesina fulla	48	0.0264	-3.6354	0.0959	0.0092
Bactrocera dorsalis	225	0.1236	-2.0905	0.2584	0.0668
Taeniothrips inconsequens	27	0.0148	-4.2108	0.0625	0.0039
Plannococcus citri	55	0.0302	-3.4993	0.1057	0.0112
Syntomoides imaon	34	0.0187	-3.9802	0.0744	0.0055
Aspidomorpha milliaris	190	0.1044	-2.2596	0.2359	0.0556
Caliroa cerasi	68	0.0374	-3.2871	0.1228	0.0151
Vespa mandarinia	39	0.0214	-3.8430	0.0824	0.0068
Vespa crabro	48	0.0264	-3.6354	0.0959	0.0092
Drosophila melanogaster	200	0.1099	-2.2083	0.2427	0.0589
Nyctemera adversata	16	0.0088	-4.7340	0.0416	0.0017
	1820			2.1822	0.4785

The diversity index of Pear pests was high; i.e.,2.18, however, regarding individual species diversity index, San Jose scale (*Quadraspidiotus perniciosus*) had higher diversity index (0.339) followed by *Aphis gossypii* (0.333), *Bactrocera dorsalis* (0.258), *Dorsophila melanogaster* (0.242)) and so on. Among 14 species of Pear pests, moth (*Nyctemera adversata*) had the lowest diversity index (0.04). Similarly, the index of dominance was also higher in San jose scale (*Quadraspidiotus perniciosus*), which is 0.115, followed by *Aphis gossypii* (0.008), *Bactrocera dorsalis* (0.06) simultaneously. The moth (*Nyctemera adversata*) was the lowest dominant pest species having index of dominance only 0.001 (Table 2).

5. DISCUSSION

The study has been carried out with the main objectives species diversity of insect pests of Japanese pear (*Pyrus pyrifolia*) in CHC, Kirtipur. During the course of the investigation, 1820 different pests from 6 orders, 13 families, and 14 genera were counted. San Jose Scale (*Quadraspidiotus perniciosus*), with n=425 count, was the most numerous insect pest, followed by the Aphid (*Aphis gossypii*), with n=400count. Simultaneously, Oriental fruit fly (*Bactrocera dorsalis)* recorded as third highest pest followed by another fruit fly, *Drosophila melanogaster*, had 200 species when it was gathered as an insect problem during the study.

There is little relevance in Nepal for the Pear Psyllid, despite the fact that Beutal, 1990; Riegel, 2006 found it to be the principal pest of the Japanese pear. Pfeiffer and Burts (1983) connected increased tree nitrogen availability to direct pear psyllids fruit damage, which led to recommendations to limit nitrogen fertilizer to the bare minimum needed for fruit production and healthy tree growth (Hull, 1993).

The aphids are also termed as important pest of pear. In Turkey, a major producer of pears, the *Dysaphis pyri* (Boyer de Fonscolombe) (Hemiptera: Aphididae) is a significant pest of the pear ecosystem (Anonymous 2012).Whereas in our study *Aphis gossypii* was seen as another main pest of pear. Higher intensity of *Aphis gossypii* infestation from many areas of Nepal during September to November and March to April (Basukala and subedi, 2014). Similarly, Pear sawfly (*Caliroa cerasi)* is a cosmopolitan pest referred as "Pear Slug" readily controlled by insecticides. Brewer *et. al.,* (2002) reported that heavy infestation level of pear slug is high in seedling pears. During field observation in CHC also seen sawfly as one of the major pests of pear fruit.

Another study by Bajracharya and Dyola, (2015) showed spider mite (*Tetranychus* spp.) as the most dominant pest species among other pest species like Fruitfly (*Dacus* spp), Tortoise beetle, Thrips and aphids. During the pear's fruiting season and in the current study, pests such as fruit flies (*Dacus* spp), hornets (*Vespa* spp.), and tortoise beetles (*Metriona* spp.) were more prevalent. Although bagging cannot completely avoid the damage to some pear fruits, the annual report of CHC (2011/12) also included Hornet (*Vespa* spp.) and Fruit fly (*Dacus* spp.) as harmful pests of pears during the fruiting period. This study seemed close to this annual report of CHC, where the density of Hornet (*Vespa* spp.), Fruit fly (*Dacus* spp.). As these species prefer fruits than other parts of plants, hence

this might be a cause for these species to occur more in fruiting trees of pear. Aphids are recognized pests of pear, sap sucking in nature (Sharma 2000).

The study shows thrips (*Taeniothrips inconsequens*) were more dominant in all 3 months of study (May, June and July). Similar to our findings Booth (2007) highlighted how pear is one of the host trees for thrips, which overwinters in the soil. In the early spring, adult thrips emerge from the earth and start feeding just as the buds start to open up. Thus, this may be the reason why there are so many Thrips during the spring. In addition, Gardescu (2008) explained how adult thrips emerge from their underground cells in the spring as the soil begins to warm up. As a result, the population of thrips appears to be higher in the spring than at other times of the year.

The overall result of the study shows that San Jose Scale (*Quadraspidiotus pernicious*) is the most dominant species among all the insect pests having highest diversity index 0.115. Results also showed Erebidae (*Nyctemera adversata*) and Thripidae (*Taeniothrips inconsequens*) having low diversity index0.001 and 0.003 respectively. The previous study by Bajracharya and Dyola (2015) showed *Metriona* species as main pest whereas in present study San Jose Scale become the main pest followed by the Aphid. Almost all the insect pests were active during fruiting season i.e., August and September which has caused serious damage in yield production.

6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

The study on the insect pests of Japanese pear of CHC showed altogether 14 species of pests were observed. This study shows San Jose scale (*Quadraspidiotus pernicious),* oriental fruit fly (*Bactrocera dorsalis)* and fruit fly (*Drosophila melanogaster)* as the main insect pests of Pear having high no. of individuals. The overall Shannon-diversity index of Pests was 2.18, which is said to be high. Similarly, the dominance index is 0.47.

6.2 Recommendations

The recommendations regarding to this study are given below:

- This Research was carried out only for three months and could not cover all seasons when pest gets active hence intensive work should be done to report overall pest of pear.
- Bagging of pear fruits, pheromone traps, sticky trap and intercropping of aromatic plants could be used to further describe the pest of pear

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APPENDICES

APPENDIX 1: LIST OF SPECIES OBSERVED

1) Aphid *(Aphis gossypii)*

Site A	Site B	Site C	Total	weeks
12	19	17	48	1st July
6	18	13	37	2nd July
9	16	15	40	3rd July
5	12	13	30	4th July
6	13	17	36	1st Aug
9	8	12	29	2nd Aug
14	15	19	48	3rd Aug
7	8	12	27	4th Aug
8	15	14	37	1st Sept
14	7	9	30	2nd Sept
3	12	10	25	3rd Sept
4	3	6	13	4th Sept
			400	

2. San Jose Scale (*Quadraspidiotus pernicious*)

Site A	Site B	Site C	Total	weeks
2	13	17	32	1st July
7	13	21	41	2nd July
9	17	13	39	3rd July
4	12	21	37	4th July
5	19	13	37	1st Aug
3	12	16	31	2nd Aug
9	13	14	36	3rd Aug
6	14	19	39	4th Aug
4	18	14	36	1st Sept
3	19	13	35	2nd Sept
6	10	19	35	3rd Sept
5	12	10	27	4th Sept
			425	

3. Black moth (*Syntomoides imaon)*

Site A	Site B	Site C	Total	Weeks
1	1	0	2	1st July
2	1	0	3	2nd July
1	2	1	4	3rd July
0	1	1	2	4th July
1	1	1	3	1st Aug
0	0	0	0	2nd Aug
0	1	1	2	3rd Aug
1	0	2	3	4th Aug
1	2	1	4	1st Sept
2	1	2	5	2nd Sept
0	1	1	2	3rd Sept
1	1	2	4	4th Sept
			34	

4. Yellow stink bug (*Erthesina fulla*)

Site A	Site B	Site C	Total	Weeks
3	3	2	8	1st July
3	2	1	6	2nd July
2	0	1	3	3rd July
2	1	1	4	4th July
0	2	1	3	1st Aug
1	0	2	3	2nd Aug
2	1	3	6	3rd Aug
0	1	1	2	4th Aug
2	0	0	2	1st Sept
3	2	0	5	2nd Sept
0	1	1	2	3rd Sept
0	2	2	4	4th Sept
			48	

5. Tortoise beetle (*Aspidomorpha milliaris)*

Site A	Site B	Site C	Total	Weeks
12	3	7	22	1st July
9	3	8	20	2nd July
8	5	4	17	3rd July
7	9	6	22	4th July
5	6	9	20	1st Aug
4	5	4	13	2nd Aug
7	3	5	15	3rd Aug
8	5	2	15	4th Aug
9	3	6	18	1st Sept
3	5	2	10	2nd Sept
3	4	2	9	3rd Sept
2	5	2	9	4th Sept
			190	

6. Click beetle *(Agriotes mancus)*

Site A	Site B	Site C	Total	weeks
1	1	0	2	1st July
2	0	1	2	2nd July
2	2	1	5	3rd July
1	2	1	4	4th July
1	0	1	2	1st Aug
1	2	0	3	2nd Aug
2	1	1	4	3rd Aug
3	1	2	6	4th Aug
2	2	1	5	1st Sept
1	2	0	3	2nd Sept
2	1	0	3	3rd Sept
3	1	2	6	4th Sept
			45	

7. Fruitfly (*Drosophilla melanogaster*)

Site A	Site B	Site C	Total	Weeks
2	3	4	9	1st July
3	8	7	18	2nd July
10	7	10	27	3rd July
10	9	14	33	4th July
9	10	13	31	1st Aug
5	9	8	22	2nd Aug
6	8	4	18	3rd Aug
3	4	5	12	4th Aug
2	3	2	7	1st Sept
2	2	3	7	2nd Sept
1	4	3	8	3rd Sept
0	5	3	8	4th Sept
			200	

8. Thrips (*Taeniothrips inconsequens*)

Site A	Site B	Site C	Total	Weeks
0	0	0	0	1st July
0	1	1	2	2nd July
1	2	1	4	3rd July
0	2	0	2	4th July
0	2	1	3	1st Aug
1	2	1	4	2nd Aug
1	0	0	1	3rd Aug
0	0	1	1	4th Aug
0	1	1	2	1st Sept
1	0	1	2	2nd Sept
1	2	0	3	3rd Sept
0	2	1	3	4th Sept
			27	

9. Sawfly (*Caliroa cerasi*)

Site A	Site B	Site C	Total	Weeks
0	1	1	2	1st July
2	3	3	8	2nd July
1	2	2	5	3rd July
0	3	4	7	4th July
0	4	4	8	1st Aug
0	3	4	7	2nd Aug
1	2	5	8	3rd Aug
0	1	2	3	4th Aug
1	2	2	5	1st Sept
0	2	3	5	2nd Sept
1	2	3	6	3rd Sept
0	2	2	4	4th Sept
			68	

10. Vespa *(Vespa mandarinia)*

Site A	Site B	Site C	Total	Weeks
0	0	1	1	1st July
1	1	0	2	2nd July
1	1	1	3	3rd July
2	2	1	4	4th July
1	3	2	6	1st Aug
0	2	1	3	2nd Aug
0	3	1	4	3rd Aug
0	3	0	5	4th Aug
0	1	1	2	1st Sept
1	2	0	3	2nd Sept
0	1	2	3	3rd Sept
1	1	1	3	4th Sept
			39	

11. Hornet (*Vespa Crabro*)

Site A	Site B	Site C	Total	Weeks
1	1	1	3	1st July
1	2	1	4	2nd July
2	1	1	4	3rd July
0	3	1	4	4th July
3	2	0	5	1st Aug
0	2	0	2	2nd Aug
1	2	0	3	3rd Aug
2	4	0	6	4th Aug
0	2	1	3	1st Sept
1	3	4	7	2nd Sept
0	1	2	3	3rd Sept
0	2	2	4	4th Sept
			48	

12. Moth (*Nyctemera adversata*)

Site A	Site B	Site C	Total	Weeks
1	0	1	2	1st July
0	1	1	2	2nd July
0	1	1	2	3rd July
0	1	0	1	4th July
0	0	0	0	1st Aug
0	0	1	1	2nd Aug
1	0	0	1	3rd Aug
1	1	0	2	4th Aug
1	0	0	1	1st Sept
0	1	1	2	2nd Sept
0	0	1	1	3rd Sept
1	1	0	1	4th Sept
			16	

13. Mealy bug *(Planococcus citri)*

Site A	Site B	Site C	Total	Weeks
1	0	1	2	1st July
2	1	1	4	2nd July
1	2	3	6	3rd July
1	3	1	5	4th July
1	0	1	2	1st Aug
1	3	3	7	2nd Aug
2	2	3	7	3rd Aug
1	2	3	6	4th Aug
1	1	3	5	1st Sept
0	1	3	4	2nd Sept
0	2	1	3	3rd Sept
2	2	0	4	4th Sept
			55	

14.Oriental fruitfly (*Bactrocera dorsalis*)

Site A	Site B	Site C	Total	Weeks
3	5	10	18	1st July
4	9	6	19	2nd July
3	9	9	21	3rd July
2	6	8	16	4th July
3	7	5	15	1st Aug
4	8	6	18	2nd Aug
1	12	11	24	3rd Aug
0	10	11	21	4th Aug
1	9	8	18	1st Sept
2	12	14	28	2nd Sept
3	10	5	18	3rd Sept
1	5	3	9	4th Sept
			225	

APPENDIX II: PHOTOGRAPHS

Photograph 1 Damage by thrips

Photograph 2 Collection of Sawfly in ziplock bag

Photograph 3 Collection of aphids

Photograph 4 Damage by Fruit fly

Photograph 5 Pear attacked by Hornet

Photograph 6 Pear Production block

Photograph 7 Collection of Aspidomorpha in vial

Photograph 8 Pheromne trap

Photograph 9 Damage by Scale insects

Photograph 10 Collection of Insects by brush

Photograph 11 Bagging of fruits to prevent damage of fruit from insect pest