STATUS OF ARTHOPODAN PEST OF COFFEE AND ITS MANAGEMENT TECHNIQUES IN ORGANIC FARMING IN GULMI DISTRICT OF NEPAL

A Dissertation

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BY

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DECLARATION

I hereby declare that the work presented in this thesis has not been submitted elsewhere for the award of any degree. All sources of information have been specially acknowledged by references to the authors or institutions.

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LETTER OF RECOMMENDATION

This is to recommend that **Mrs. Goma Chetry** has successfully completed the dissertation work entitled "**Status of Arthopodan Pest of Coffee and its Management Techniques in Organic Farming in Gulmi District of Nepal**" for the partial fulfillment of the Master's Degree in zoology with Entomology as special paper under my supervision. It is her original work and has not been submitted for any degree earlier. So, I recommend this dissertation for approval.

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ABSTRACT

The research was done at Ruru, Thanapati and Digam VDCs of Gulmi district of Nepal in the year 2010. The research work was focused on insect pest of coffee plant in field, their management practices followed by farmers and attitude of coffee growers towards pesticide use. The methods adopted were questionnaire method and direct field observation method. Farmers perception on coffee pest and its management practices was explored through questionnaire method while arthropod pest, its problems and infestation was done by direct field observation.

Field observation was done in eight orchards in each site. The observation was focused on the arthropod pests of coffee and damage done by them. The field visit revealed that the major problem of coffee cultivation is White stem borer (*Xylotrechus quadripes* Chevr.) followed by red stem borer (*Zuezera* sp.); various defoliators like *Catantops* sp., *Calaposoma semicostatum* Jac., *Aspidomorpha sanctai crucis* Fab., *Anomala sp.*; Various sap suckers like *Toxoptera aurantii* Boyer, *Leptocorisa* sp., Scale insects, *Aspangopus* sp.; and white grub (*Holotrichia* sp.) as root destroyer. According to farmers perception White stem borer followed by Red stem borer was the most problematic insect pests of coffee while other insect pests were the minor one because their loss were negligble as compair to the stem borers. White stem borer (*Xylotrechus quadripes* Chevr.) usually attack older plants. If the white stem borer problem could not managed propely it will destroy the coffee plant in district totally.

For the control of pest locally available botanical based pesticides are made by all farmers themselves having pesticidal propeties. Other management practices such as insect sex pheromone trape, light trape and other mechanical methods were also being used by some of the farmers in their coffee orchards. Generally farmers uproot whole infested plants and destroy them when all the management strategies are failed. Although 8.33 % of farmers have negative attitude towards the organic farming while 91.67 % of farmers have positive attitude towards the organic farming.

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ABBREVIATION AND ACRONYMS

%	Percentage
$	Dollar
ABSTRACO	Agri Business and Trade Promotion Multi Purpose Cooperatives
AD	After Death
AEC	Agro-Enterprise Center
ADO	Agriculture Development Office
ARS	Agriculture Research Station
BS	Bikram Sambat
CCBP	Coffee Cooperative Business Plan
CoPP	Coffee Promotion Project
Cm	Centimeter
CDZ	Central Department of Zoology
DADOs	District Agriculture Deveiopment Offices
DCAU	District Cooperative Association Union
DCPA	District Coffee Producer Association
DNA	Deoxyribonuclic Acid
FAO	Food and Agricultural Organization
FNCCI	Federation of Nepal Chamber of Commerce and Industry
GIS	Geographic Information Survey
GOs	Govermental Organisations
Ha	Hacter
ICO	International Coffee Organization
INGOs	International Non Govermental Organisations

IPM	Integrated Pest Management
IRMC	Integrated Resource Management Consultancy
Kg	Kilogram
msl	Mean sea Level
Mt.	Metric Ton
m	Meter
mm	Millimeter
NARC	Nepal Agriculture Research Council
NAST	National Academy of Science and Technology
NGOs	Non Govermental Organisations
NHS	Nepal Horticulture Society
NTCDP	Nepal Tea and Coffee Development Policies
NTCDB	Nepal Tea and Coffee Development Board
PRA	Pest Risk Annalysis
Rs.	Rupees
Sq. km.	Square Kilometer
Sq. ft.	Square Feet
VDC	Village Deveopment Committee

1. INTRODUCTION

1.1 Background

Coffee is one of the most important and widely consumed beverages in the world. It is produced from plant *Coffea arabica* belonging to family Rubiaceae. It is distinctly a tropical cash crop and requires a hot moist climate with an average rainfall of at least 1250 mm and prefers 1875 mm to 3000 mm of annual rainfall. The optimum temperature for the coffee plant is ranges from 15-20 °C which is a condition found between 1000-2000 in equatorial area (Sharma 1996).

There are three species of coffee grown commercially in the world these are Arabica, Robusta and Liberica (Khadge et al., 2004). The commercial cultivation of coffee was started by Arabian and Dutch from the beginning of the 17th century (Krug et al., 1968).

The knowledge of coffee and its use is not certainly known. It seems to be discovered by accident (Sharma, 1996). Coffee has played a crucial role in many societies throughout history. The energizing effect of the coffee bean plant is thought to have been discovered in the northeast region of Ethiopia, and the cultivation of coffee first expanded in the Arab (FAO, 2009). Arabia supplied the world for two centuries and was gradually introduced elsewhere in tropics and reached Sri Lanka and Indonesia by 1700, West Indies in 1720 and brazil in 1770. Coffee has been in generally use as beverage for about 300 years only. (Sharma, 1996)

The Dutch and French introduced the cultivation of coffee plant during their possession in South America. They also introduce it in Netherlands, East Indies and Philippines. Coffee gradually spread in the several part of the tropical area. According to author major coffee producing area are in Central and South America, Central Africa, South East Asian countries and India. Brazil is one of the largest producer country, in 1971 more than half of the world coffee were grown in Brazil so the Brazil is called as the lord of the coffee world. (Sundaram et al., 1971).

1.2 Production and Consumption of Coffee in the World

Some 70 countries produce coffee. Of these, 45 are responsible for over 97 % of world production and supply in the world markets. These countries are affiliated into the International Coffee Organization (ICO) (IRMC, 2007).

In 2009 Brazil was the world leader in production of green coffee, followed by Vietnam, Indonesia and Colombia (ICO, 2010). There are three species of coffee grown commercially in the world these are Arabica, Robusta and Liberica (Khadge et al., 2004). Arabica coffee beans are cultivated in Latin America, Eastern Africa, Arabia, and many Asian countries. Robusta coffee beans are grown in Western and Central Africa, throughout Southeast Asia and to some extent in Brazil (ICO, 2010).

Table1: Coffee production in world

Country	**Tonnes**
Brazil	2,249,010
Vietnam	961,200
Colombia	697,377
Indonesia	676,475
Ethiopia	325,800
India	288,000
Mexico	268,565
Guatemala	252,000
Peru	225,992
Honduras	217,951
Côte d'Ivoire	170,849
Uganda	168,000
Costa Rica	124,055
Philippines	97,877
El Salvador	95,456
Nicaragua	90,909
Papua New Guinea	75,400
Venezuela	70,311
Madagascar	62,000
Thailand	55,660
World	7,742,675

(Source: FAO, 2009)

The United States leads in coffee consumption using about half the world's supply and the supply is mainly imported from Brazil and Colombia. Other important coffee consuming countries are Sweden, Cuba, Canada, Denmark, Belgium, Norway, France, Germany and United Kingdom (Sharma, 1996).

1.3 Coffee in Nepal

Coffee plantation is still a new adventure in Nepal. Approximately the Year 1938 AD, a hermit Mr Hira Giri had bought some seeds of coffee from Sindu Province of Myanmar (the then Burma) and had planted in Aapchour of Gulmi District for the first time in Nepal. Then it spread from one farmer to another as a curiocity plant for about 4 decades (NTCDB, 2010).

There are three species of coffee grown commercially in the world these are Arabica, Robusta and Liberica. Among three species only Arabica grown in hilly condition of Nepal (Khadge et al., 2004).

Coffee (*Coffea arabica*; Rubiaceae) is a potential and emerging commercial crop, which is believed to uplift the livelihood of rural farmers in mid-hills of Nepal. There is great potentiality for coffee cultivation in hills due to suitable climate, soil structure, relative humidity, temperature and rainfall for Arabica coffee. (Panthi et al., 2008).

It is commercially grown mainly in the western and central mid hills. Coffee production in the mid hills has the opportunity to sell particularly of organic as specialty coffee in foreign countries. In 2007, area under coffee plantation in Nepal is reported to be 1,285 ha. (NARC, 2007).

1.3.1 Present status of coffee cultivation and plantation in Nepal

Presently, coffee is cultivated in around 40 districts, but it has been producing commercially in about 20-22 hill districts. In Nepal, coffee is predominately grown by resource poor and small scale farmers under marginal upland condition (Shrestha et al., 2008), and mostly they don't use chemical fertilizers and pesticides in the production process. In most of cases, coffee cultivation is using unproductive, fallow and the lands prone to degradation and thus it helps to conserve soil erosion, degradation of land and also provides 20-25 percent extra income than traditional cereal crops like maize and millet. Coffee cultivation has an enormous potential to provide farmers a good employment and income generation opportunities especially in the mid-hills regions where there is a huge amount of land and suitable climatic condition for growing the coffee successfully (Chaudhari, 2008).

In terms of area coverage and production, Nepalese coffee has tiny presence in comparison with the world production and area (Poudel, 2009). The area under coffee cultivation is increasing and its concentration is more in western development region followed by central and eastern development region (Giri, 2010).

Table2: Coffee plantation area and production (in last 10 years)

Fiscal Years		**Coffee plantation area (In Hectares)**	**Production (Dry Cheery In M.T.)**
In B.S.	**In A.D.**		
2056/057	1999/00	314.3	72.40
2057/058	2000/01	424	88.70
2058/059	2001/02	596	139.20
2059/060	2002/03	764	187.50
2060/061	2003/04	952	217.50
2061/062	2004/05	1078	250.00
2062/063	2005/06	1285	391.00
2063/064	2006/07	1396	460.00
2064/065	2007/08	1145.0	265(production parchment)
2065/066	2008/09	1531	334(production parchment)

(Source: NTCDB, 2010)

Available statistics indicate that coffee is grown in more than 41 districts of Nepal but cultivated in 25 districts in commercial point of view (NTCDB, 2010). Some Districts like Gulmi, Palpa, Argakhanchi, Lalitpur, Tanahu, Kavre, Sindhupalchowk, Lamjung, Kaski, Gorkha, Syangja, Parbat and Baglung are successfully growing and producing Coffee beans and is increasing gradually. This will certainly help in diversifying process and will increase the income of the farmers as well as other individuals involved in coffee processing and marketing enterprise (Poudel, 2009).

1.3.2 Marketing of coffee

Among the different agricultural products produced and exported from Nepal, coffee is growing as a competitive one with 7.3% share of country's total of 15% agricultural export share (FAO, 2009).

Nepal produced coffee is sold both at domestic as well as overseas markets. However due to lack of information and adequate publicity about Nepalese coffee

and the prevailing taste preference in behalf of the important instant coffee, its consumption level is not encouraging in the domestic market (FNCCI, 2006).

At present, more than 65% of Nepalese coffee is exported especially to Japan, Europe and USA in the form of parchment by the coffee mills and 35% of the total product is processed and supplied in the domestic market. Nepal exports only super quality green bean to overseas markets. Medium and low quality green beans are roasted, grinded and sold in the domestic markets (Gautam, 2008). The main international markets of Nepalese organic coffee are Japan, Holland, USA, Europe and China (NTCDB 2010).

1.3.3 Important of coffee cultivation in Nepal

Coffee is an emerging commercial crop for Nepal due to suitable agro-climatic conditions and market access. Nepalese coffee is virtually free from inorganic fertilizers and harmful pesticides so it has occupied a good position among the organic coffee in the world. Today Nepalese organic coffee is exported to different part of the world. Holland, Japan, USA, Europe and China are its main market. Organic coffee is getting higher price in international market (Tiwari, 2010).

Coffee has shown an important source of income of rural communities in Nepal. Status of poor farmers having steep land as a source of income and low employment are getting better income and employment without being bounded for labour. Since coffee is grown in more shade plants thus conserving the soil, maintaining biodiversity and watershed balance in the mid hills of the country (Giri, 2010).

Given the vast potential areas for coffee production coffee could grow as one of the major export commodity for Nepal and large number of small and marginal families, particularly, the women, children, dalits, and other minority ethnic community groups who possess small poor quality land for cultivation of other crops and generally remain unemployed or under employed for most of the months of a year could get potential options for income generation at their own home (CCBP, 2007).

1.4 Pest of coffee

There are many pests that have an impact upon the growth of *Arabica* trees, these include birds, mammals, insects, worms and mites, but the coffee tree pests that have the greatest impact on coffee production are insects. The coffee trees are threats of many insects. It is estimated that at least 900 different species of insects feast upon the coffee tree (Diez, 2007).

Varieties of coffee pests inhabited the coffee plant in different season with different damage pattern. As coffee grown under shade trees provide shelter to numbers of pests (De la Mora et al., 2008).

Over 900 species of insect have been recorded as pests of coffee crops worldwide. Of these, over a third is beetles, and over a quarter are bugs. Some 20 species of nematodes, 9 species of mites, several snails and slugs also attack the crop. Birds and rodents sometimes eat coffee berries but their impact is minor compared to invertebrates. In general, Arabica is the more sensitive species to invertebrate predation overall. Each part of the coffee plant is assailed by different animals. Nematodes attack the roots and borer beetles burrow into stems and woody material, the foliage is attacked by over 100 species of larvae (caterpillars) of butterflies and moths (Bardner, en.wikipedia.org/wiki/Coffee).

In, Generic PRA (Pest risk analyses), 44 diseases have been reported in coffee (*Coffea* spp.). However in Nepal 7 disease has been found in coffee. Moreover 42 diseases in coffee have been identified to be a potential threat in future which has been likely to be occurred as regulatory pest in Nepal. Mostly fungal diseases have been identified in coffee in Nepal. Coffee growers are facing many problems including diseases and pests (Mahto et al., 2005).

Among the various insects of coffee, white stem borer (*Xylotrechus quadripes*) has been found to be the most important one causing extensive economic damage in Nepal (Khadge et al., 2004). Similarly nematodes are also important pests. Farmers lack knowledge of combating these pests. Organic methods of combating the pest may be useful, but their knowledge at present in Nepal is limited (Jaiswal, 2004).

1.5 Problems

Coffee is a plant of wide adaptability, disease of coffee is numerous. Coffee is a perennial plant and requires shade for its proper growth; varieties of pest inhabited the plant in different part and in different season with different damage pattern and intensity depending on climate, altitude and cultural practiced. In addition, coffee is planted under different shade plant also shelter a number of pests. The causal factors for loss in coffee production are as below:

- Physical factors like fog, humidity, light, moisture, temperature etc.
- Microbial pathogens like bacteria, virus, fungi, algae, nematodes etc.
- Insect pests like scales insects, mealy bug, stem borer, thrips, beetles, cattepillars etc.

The coffee trees are threats of many insects. It is estimated that at least 900 different species of insects feast upon the coffee tree (Diez, 2007).

Beside of arthopodan pest many coffee diseases are also found which can reduce the production and consumption of coffee. Coffee Berry Disease (CBD), *Colletotrichum Khawae*; Coffee Wilt Disease (CWD), *Gibberella Xylarioides* and Coffee Leaf Rust (CLR), *Henzileia vastatrix* are the major diseases reducing production and consumption of coffee in Ethiopia (Zeru et. al., 2009).

Major factors responsible for low production and productivity of Nepalese coffee are unscientific plantation, poor management of orchard (disease, insect pests, shade and nutrient management) and regular maintenance of coffee orchard (trimming, pruning, irrigation, and cultural operation) (Giri, 2010)

Despite producing coffee for the last several years, the country in fact lacked coffee policy until lately. Research and extension facilities and support services are lacking and also the availability of quality samplings; organic manure, irrigation and insect (stem borer) control are observed as the problems at the field level (ABTRACO, 2004).

Therefore, it becomes necessary to impart proper knowledge about disease, pest and their control measures to reach the set goal.

1.6 Objectives

The main objectives of this study is to find out the insect pest infesting the coffee plant, the control measures being followed against the pest in the coffee orchards and to know overall situation of coffee cultivation in Nepal.

1. To identify the insect pests of coffee.
2. To know the nature of damage by the pest.
3. To study the management practices done by farmers in pest control.
4. To know the farmers attitude on pesticide use.

1.7 Justification

Despite having ample opportunity of coffee as a cash crop of Nepal proper study and research work are still lacking because studies on coffee have been limited to the feasibility, marketing systems and socio economic aspects. Although, pest of coffee are directly related with the economic loss of the farmers, very few fact about insect pest have reported in association with other studies. Thus, present study will definitely provided valuable information regarding the pest and management practices for sustainable cultivation in promising potential area of Nepal.

1.8 Limitations

The study covers a limited physical area within Gulmi district, as in Gulmi district the coffee cultivation is introduced in 18 VDCs but in this study only 3 VDCs are included. Time factor, budget, one man research work and small study area are the major constraint of the study. One of the limitations of the study is accessibility to the study site due to rugged topography of the study area above 1000m; there were some problems to visit the study area at required and desirable time.

2. LITERATURE REVIEW

2.1 Origin and dispersion of coffee

The origin of coffee remains shrouded in the legends and myths of the Middle East. One legend tale of Kaldi, an Abyssinian Ethiopian goatherd who one day found his heard frolicking at around a cluster of shiny, dark-leaved- shrubs bearing red berries. When Kaldi tested the berries himself, he realized what had prompted the goats uncharacteristic behavior. Kaldi shared his discovery with the inhabitants of the nearby monastery, who developed the fondness for the fruits and its seeds, the coffee bean encased in each berry. By drinking the beverage that resulted from boiling the berries, the monk found they could stay awake during evening prayers. Another legend attributes the discovery of coffee to Omar, an Arabian dervish a Muslim mystic. Exiled by his enemies to the wilderness where he faced certain starvation. Omar survived by making a broth from water and the berries he plucked from coffee trees. Where it was Kaldi or Omar who first discovered it, coffee is considered native to the African country of Ethiopia. At least 1000 years ago, some enterprising traders brought coffee across the Red sea into Arabia modern-day Yemen where Muslim monks began cultivating the shrubs in their garden (Souza, 2008).

By the early 1500s, coffee seed had already made their way to Turkey, Egypt and Syria, Constantinople, Damascus and other near Eastern Cities all boasted their Arabian influenced coffee houses – essentially places where patrons lingered over coffee, conservation, games of backgammon and chess. The Dutch were the first to transport and cultivate coffee commercially, beginning in 1616 with a coffee plant obtained from Yemen. Imagine the trader loving care these first coffee tree seedlings received. In 1658 the Dutch had begun cultivation in Ceylon their East Eastern colony of Java (Meyers, 2007).

The Dutch and French introduce the cultivation of coffee plant during their possession in South America. They also introduce it in Netherlands, East Indies and Philippines. Coffee gradually spread in the several part of the tropical area. According to author major coffee producing area are in Central and South America, Central Africa, South East Asian countries and India. Brazil is one of the largest producer country, in 1971 more than half of the world coffee were grown

in Brazil so the Brazil is called as the lord of the coffee world. (Sundaram et. al., 1971)

The knowledge of coffee and its use is not certainly known. It seems to discovered by accident. It is considered to be a native of Ethiopia and carried to Arabia in 15^{th} century. Arabia supplied the world for two centuries and was gradually introduced elsewhere in tropics and riches Sri Lanka and Indonesia by 1700, West Indies in 1720 and brazil in 1770 coffee has been in generally use as beverage for about 300 years only. (Sharma, 1996)

Coffee is grown throughout the tropic belt in the Brazil and Mozambique in the southern and Taiwan in the northern hemisphere. The soil in which coffee is grown also varies widely for example brown red lateritic loam or clay of volcanic region in Ethiopia, latosols in Liberia, alluvial schist in New Caledonia, Metamorphic schist in Portuguese Timor. (Krug et al., 1968)

2.2 Ecological requirement

Coffee is one of the tropical crops but it could be grown under several climatic conditions outward of its native homeland. It is mostly grown in tropical high slope land area at 550 to 855 m. above sea level. Coffee needs warm and humid climate with 20^0c to 25^0c annual temperature and more than 5 cm rainfall per month. Coffee cannot tolerate frost and snow. In practice most of the world coffee is grown in upland of tropical climate and a small amount in lower humid portion of tropical rain forest and warmer marginal land of humid subtropical climate (Yates, 1966).

High temperature (>28^0c) induce abnormalities such as star flowers and reduce yield while cold temperature (>7^0c), especially associated with wide diurnal fluctuation, can produce malformation of shoots known as hot and cold diseases. Robusta grows best under warmer conditions typically of the lowland tropics. It is less tolerant of the cool temperature (>10^0c is damaging). The plant can tolerate low temperatures, but not frost, and it does best when the temperature hovers around 20°C (68°F) (Walker et al., 2007).

The climatic and edaphic features of site where coffee is grown need to be suitable for crop and as far as possible to meet its ecological requirements. Arabica is

shade loving plant. Shade trees are helpful in reducing the pest and diseases but the intercrop and leguminous shade trees are attacked by number of defoliators which may move on to coffee when its food supply is exhausted. Shade trees can also be sources of scales and mealy bugs. Interplanting arable crops are damage feeder roots of stem bases of plant to soil born pathogen. However mixed perennial cropping is common for the high yield from the field. Mulching is desirable practices that reduces weed growth retains soil moisture provides organic matter and nutrients to the rooting zone. Pruning is another practice that encourages and controls the production of plagio-tropical shoots that will bear the following season of and to control the density of canopy (Walker et al., 2007).

Arabica coffee thrives in almost sea level to an altitude up to 2350m. and is therefore subject to a great variety of climate. Volcanic soil is more suitable for coffee cultivation. But in general moisture absorbing forest soil is suitable for nice cultivation. The slope land is better rugged sloppy high land (Krug et. al., 1968).

Plants need many nutrient elements. Carbon, hydrogen, oxygen are non-mineral elements. Nitrogen, phosphorus, potassium are primary mineral elements required in higher amounts. Calcium, magnesium, and sulphur are secondary mineral elements required lesser than the primary elements. While iron, zinc, manganese, copper, boron, molybdenum, chlorine, are tertiary or micronutrients, required in very less amount, but equally essential to plants (Clarke, 1988).

2.3 Coffee cultivation

Coffee plants spend their first six weeks in a seed bed. Once the seed germinates and grows out of the soil, it is transplanted to a seedling nursery. The nursery helps protect the young plants from harsh sunlight and bed weather. Coffee plant spends in seedling nursery for 4 to 12 months, depending on the environment. Once the seedling, reach maturity, the coffee grower will plant them in his coffee field. Coffee plants usually have a life-span of thirty to fifty years. *C. arabica* takes about seven years to mature fully but it gives fruits in three to four years. *C. arabica* prefers to be grown in light shade. Each tree can produce anywhere from 0.5–5.0 kg of dried beans, depending on the tree's individual character and the climate that season. (www.burundicoffee.com).

Annually, total production and production area of coffee in Nepal is increasing by 35% and 28% respectively. And within two years, a rapid increase is expected as there are many potential zones for coffee production and farmers residing these zones have realized that coffee cultivation is more beneficial than the customary cereal production & livestock rearing (FNCCI, 2006).

2.4 Coffee tree pest and their impact upon coffee production

Many beetles lay their eggs in the bark of the *Arabica* coffee tree, once these hatch the larvae bore and cause havoc to the tree. Perhaps the most serious coffee tree pest in the field is the white stem borer. The larvae of this beetle bore into the taproot of the coffee plant and work their way up the stem, emerging approximately a year and a half later. Another major pest in East Africa is the yellow-headed borer, with this beetle the eggs are laid on primary branches as opposed to the base of the stem. The larvae then eat their way down the branch and into the stem, where they eject the frass and create large exits (www.coffee-tea.co.uktree-pests).

Coffee cherry/ berry borer or "Broca" (*Hypothenemus hampei*), native to Central Africa, but now found in many coffee-producing nations. The female of this tiny beetle bores into the coffee cherry and lays about 15 eggs; the larvae feed into the developing bean. Usually, the cherry drops from the tree. the best defense is making sure there are no unpicked beans left on trees or laying on the ground, because they spend much of their life inside the cherry, controlling borers with insecticides can be difficult or downright ineffective (www.coffeehabited.com). *H. hampei* is the most important pest of coffee throughout the world, causing losses estimated at US $ 500 million/ year (Jaramillo et al., 2010)

According to a surveys of coffee plantations in Chiapas, Mexico, for three years to assess the distribution and damage caused by the coffee berry borer, prior to parasite introduction, levels of infestation were greatest near the Guatemalan border and varied with altitude, the borer was most numerous between 500-1000 m above sea level, corresponding to a mean annual temperature of 23 to 25 °C. Many berries are left on the tree and ground after harvest and high levels of attack were found in both places (Baker et. al, 2009).

White grubs are among the most difficult soil pest insects to control in cash crops grown in upland areas as a major limiting factor affecting soil productivity. They are reported to be an increasing nuisance in cash crops from eastern to western parts of Nepal (GC, 2009)

In addition to beetles many moth larvae are also pests of the Arabica coffee tree, these generally enter through the green shoots near the tips of the coffee tree and bore themselves down the shoot, this results in wilting of the tips (www.coffee-tea.co.uktree-pests). *Zeuzera coffea* belonging to family Cossidae of order Lepidoptera has proven serious pest of different crop plant. It is polyphagus pest widely spread in orient whose main host is coffee plant, the young larvae which are stout bodied and dark reddish in colour with black head, after hatching bore into the branches of coffee plant forming cylindrical tunnel along the branch in the trunks usually killing the branches distally (Hill, 1993).

The Coffee hawk moth *Cephonodes hylas* is one of the main Lepidopteran pests of coffee plant, whose larvae eats leaves and cause heavy infestation by defoliating the host tree. It was very serious pest in Malaya. It is a wide spread species frequently encountered in different part of the world (Hill, 1993). the caterpillar of this moth are green laterally with two conspicuous red spiracles a dorsal lateral stripe of white separates the green flank from the blue coloured back and measured abut 5-6 cm on maturity. Larval development takes 20-22 days. The adult is a smallish hawk moth with a wing span of 5-6 cm and characteristics hyaline wings. It is one of the few diurnal species. The species is quite distinctive because of midrange red band on two yellowish segments (Hill. 1993).

The coffee leaf miners *Leucoptera* spp. is the major pest of coffee in Africa and South America. The small white caterpillar of *Leucoptera* spp. infested leaves of plant and produce brown irregular blotch mine, the mined leaves are shed prematurely (Hill. 1993). Coffee leaf miner, *Leucoptera coffella* is a pest in many New world coffee growing areas. Its population dynamics were strongly affected by natural enemies, particularly of larvae, and physical environmental conditions (Lomeli et al., 2010).

Other pests of stems and branches of coffee are mealy bugs and scales; these are able to attack mature wood. Mealy bugs are among the most serious sucking pest

of Robusta and Arabica coffee. These damage coffee plant by sucking the sap from the tender parts of the plant. If heavily infested, the young plants succumb. Infested leaves become chlorotic. Infestation on spikes results in blossom abortion or poor development of fruit initials. When bugs attack blossom and subsequently the berries, the latter get reduce in size and aborted with considerable reduction of the crop. Sooty mould (black fungus) develops on the 'honey dew' excreted by the mealy bugs. The leaves of attacked plants become black in colour. In some localities when the roots are infested with mealy bug, a fungus develops on mealy bug and protecting the mealy bug and preventing the roots from absorbing nutrients. This results in weakening or death of the plant (www.coffee-tea.co.uktree-pests).

Different species of ants feed on the 'honey-dew'. Ants protect the bugs from natural enemies. Ants are providing favorable conditions for breeding and protection from negative effect of rains. Occasionally ants carry the mealy bugs from one branch to another or even from plant to plant. The attendance of ants is much higher on coffee mulched with crop residues than with coffee husks and even less when using cow dung. Mulch is favorable for ants to breed in. The mealy bug population increase at least three times as fast on coffee trees when ants attend. If ants are not associated with the bugs, the progeny of the bugs get caught in the 'honey-dew' and many die. Research in Uganda concluded that crop residues and mulch in coffee enhanced activity of ants. When access of the ant to the tree is prevented, the bug breeds more slowly, and the numerous predators bring the bug under control. So control of ants is very important (www.oisat.org).

Planococcus kenyae had been a major pest of Arabica coffee in the East Rift area of Kenya between 1923 and 1939 but since the liberation of paradites from Uganda in 1938, it has been reduced to a minor pest. *Saissetia coffeae* is considered as minor pest of Arabica and Robusta, very occasional several outbreaks have been recorded specially on unhealthy bushes. These are immobile insects which are green when young and dark brown when older, found clustered on shoots leaves and green berries. They are often arranged in an irregular line near the edge of leaf blade. *Asterplecanium coffeae* is the major pest of Arabica coffee grown below 1700m in Africa. *Planococcus citri* which is also known as citrus mealy bug is a polyphagous pest whose main host is coffee, citrus and

cocoa. These are pan tropical in distribution extending well into sub-tropical reasons. These are regarded as minor pest of Arabica and Robusta coffee but very rarely cause serious damage. It is known to be the vector of Swollen Shoot Disease of cocoa (Hill,1993).

Mealy bugs are the vectors of banana streak virus; a bacilliform shaped DNA virus that causes banana streak diseases. It was first detected in Australia in1992 in banana cultivars Mysore, now been detected in a range of cultivar in Queensland New South Wales (www2.dpi.qld.gov.au/horticulture/5047.html).

The coffee root mealy bugs *Dysmicocous texens* (Tinsley) attacks the roots of the coffee plant and causes serious damage to crops and consequent losses in production (Alres et al., 2010)

Green scale (*Coccus viridis*), sucks sap from the coffee plant and excretes a sweet substance referred to as honeydew that covers the leaves and supports growth of a black sooty mold that reduces photosynthesis, coffee trees will become stunted and sometimes die. The pests are as a result of prolonged drought and have attacked many small scale farms in Nyeri and Othaya areas of Kenya which are considered major coffee producing areas of Kenya The pests suck fluids from the coffee tree and excrete black droppings on the leaves, leaving charcoal black In some areas, the effect is very severe the farmers are cutting down their plants and instead planting maize. (www.demotix.com). Young tree with black sooty mold on leaves heavily infested with ants and protect the scale insects. The adult scale is oval, bright pale green, and legless, with short, curved black markings on the back. They are found on coffee leaves, stems, and cherries but most commonly on the underside of leaves, along the veins. Sometime as many as 500 scale insects can be found on one leaf. When infestation is severe, leaves and fruits drop, growth is stunted, and young plants can even be killed. Females reproduce without males (www.ctahr.hawaii.edu).

Ant and homopterean mutualism are complex because they depend on the behavior, abundance and predation level of both insect species. According to the study done in population dynamics of *Coccus viridis* the green coffee scale over two year period with and without the protection of the ant, *Azteca instabilis*, the

result reveal that parasitization, predation and fungal infection governing *C. viridis* population growth and survivorship in the absence of ants (Jha et al., 2010)

Aphids are of great economic importance since they suck up plant sap, hamper plant growth as well as spread several plant viral diseases, they by causing loss of output in agriculture, horticulture, floriculture, silviculture and wild plants. Aphids are seen in colonies. They secrete honey dew through anus, which attacks sooty moulds, a fungus. They reproduce parthenogenesis or by bullints. Adult females are viviparous. Some aphids are vector of viral diseases of some plants (Tamrakar et.al. 2000).

The main host of *Toxoptera aurantii* is citrus. Tea, coffee, cocoa and other plants are alternative hosts. Adults are shiny black, winged or apterous measuring 1.2-1.8mm have relatively short antenna. Only females are formed. They produce living young, which are dark brown in colour. At 25^{o}c, single generation completes in 6 days but above 30^{o}c aphid population decline sharply (Hill, 1993)

In Nepal major arthropodan pest found associated with coffee are White stem borer (*Xylotrechus quadripes*), Mealy bug (*Planococcus* sp.), White grub (*Holotrichia* spp.), Red stem borer (*Zeuzera coffeae*) and Coffee berry borer (*Hypothenemus hampei*) (Paneru et. al. 2010).

According to a study done by National Agriculture Research Council (NARC) of Nepal in 2008 in Kavre and Syangja district of Nepal the average yield loss of coffee caused by the insect pest was 5-10% in Kavre and Syangja district of Nepal. White stem borer, White Grub, Scale insect, Termite, Red stem borer were major insect pest. Two species of white stem borer *Chlorophorus annulatus* and *Xylotrechus smei* were reported for the first time from Kavendanda (Syangja District). Snail was also a problematic in coffee plants.

According to Maharjan (2008) the attack of white stem borer was high in low altitude this is because borer are more severe at lower altitude and high temperature.

The Mites *Brevipalpus phoenicis* is found on Coffee plantation in Brazil since the 1950s. Responsible for indirect lossess due to its role as vector of a virus diseases,

the mites species often require control measures, the most common based on miticide spraying (Fernandes et al., 2010).

2.5 Management of Pest

In most countries the coffee pests are controlled by insecticides, however, in the Ethiopian highlands, where coffee *Arabica* evolved there is a natural equilibrium between coffee pests and their predators making it very rare that insects and other pests spread to epidemic proportions. (Diez, 2007).

Coffee is the third most heavily chemically treated crop in the world (Zonis, 2006).

Current recommended pest control measures include a combination of cultural, resistant/tolerant cultivars and the use of broad spectrum chemical pesticides. Chemical pesticides are far more popular at the farm level than any of the other recommended pest control measures. the use of chemical pesticide resulted in increased pest pressure on coffee and some of its companion crops, outbreak of new pests of coffee, development of pest strains resistant to the cheap and commonly available chemical pesticides, increased environmental problems, increased health risks to man and livestock and an overall increase in the costs of coffee production, thus forcing many farmers to neglect their coffee plantations (Vandenborre et. al., 2009).

Without chemical intervention the white borer causes havoc on coffee trees in Eastern African countries; it is controlled by applying a solution of 0.05% dieldren to the base of the stem. Yellow-headed borer these pests can again be controlled by the use of dieldrin solution; in this case the solution is applied through the lowest frass hole, made by larvae of the beetle (www.coffee-tea.co.uktree-pests).

Endosulphan (brand name Thiodan) used against coffee berry borer which is not readily dissolved in water and steaks to soil particles; it takes years to break down. The breakdown products are more persistent than the parent compound. It is toxic to mammals, birds and fish, affects the central nervous system. Columbia has considered endosulphan worse than coffee berry borer as more than 100 human poisoning and 3 deaths were reported in 1994. Similarly Chloropyriphos which is

a broad spectrum organophosphate used against berry borer and leaf miner is a contact poison. It has caused human death and had been linked to birth defects (Coffee and conservation, 2007).

The investigation on pest reduction services by insectivorous birds on a coffee farm in Jamaica, West Indies, resulted that birds reduced insect pests and the infestation level of Coffee Berry Borrer (H. hampei), the world most damaging insect pest in coffee (Johnson et al.,2010).

The CCRI (2000), Karnataka of India has been conducting several experiments on the control measures of the pest like plastering the trunk and thick primaries with the pest prepared by crushing equal parts of neem, bakaino, marigold, and garlic and mixing in castor oil. This remedy checks the egg laying activity of the white stem borer.

A study on the evaluation of botanicals against mealy bug *Planococcus citrii* Risso and its effect on natural enemies parasitoid (*Leptomastix dactylopii*) and attendant ant (*Anolplolepis longipes*) found that the biopestcide treatments were effective against the mealy bug by causing direct mortality and to some extent also by acting as repellant and the parasitoid was relatively safe from its effect. The treatments included extracts of Tulsi (*Ocimum sanctum*), Bilwa (*Aegle marmelos*), Milky weed (*Calotropis gigantea*), Marigold (*Tagetes erecta*). Hence, these bio-pesticides could be used under situations where coffee is originally cultivated (Dinesh et. al., 2003).

There are 324 species of plants having pesticidal properties (Rai, 2004).

Neupane (2000) reported 23 species of plants with special pesticidal value in Asian farming system. Neem (*Azadirecta indica*), banmara (*Eupatorium odoratum*), bakaino (*Melia azadirach*), dungri phool (*Lantana* sp.), tobacco (*Nicotiana tobbacum*), gandhe jhar (*Ageratum* sp.) etc. are some of the examples which could be used in the control of insects pest.

Neem is known to contain over hundred biological active constituents that can be used in various agricultural formulations like insecticide, bactericides, antiviral compound. Research data suggests that more than 300 species of insects can be controlled with the help of neem products. In India neem has been evaluated

against 125 species of pest of agricultural importance. All the parts of trees are known to be biologically active the maximum insecticidal activities in seed kernel (Titus et al., 2005).

The thrips *Karnyothrips flavipes* was observed for the first time feeding on immature stages of *H. Hampei* (coffee berry borer) in Kissi area of Western Kenya (Jaramillo et. al. 2010).

One of the most efficient ways of controlling scales and mealy bugs is by use of biological control. The mealy bug once devastated Kenyan coffee plantations but was able to be controlled by the introduction of *Anagyrus kivuensis*, its natural predator from Uganda. Another way of controlling these pests is by growing small bushes along road verges, this helps in preventing the spread of dust; *Asterocalanium coffeae* thrive in dusty environments (www.coffee-tea.co.uktree-pests).

Beauveria bassiana is a generalist entomopothogenic fungus widely used by coffee farmers to control *Hypothenemus hampei* (Coffee berry borer) and *Phymastichus coffea* (Hymenoptera: Eulophidae) is an African endoparasite of *Hypothenemus hampei* (Coffee berry borer) adults, recently imported to several Latin America and Caribbean countries to aid in the coffee berryborrer control (Castilo et.al., 2010). When the use of both organisms the fungus *Beauveria bassiana* and endoparasite *Phymastichus coffea,* in the field at same time the fungus resulted in reduction of adult longativity and mortality of 100% of immature stages of this parasitoid. *P. coffea* was capable of disseminating spores of *B. bassiana* to non infected *H. hampei* adults, which could indirectly cause the death of its own progeny (Castilo, et.al., 2010).

The best control is maintaining healthy trees. Infested laterals should be pruned behind the last entrance hole as soon as wilting is observed, because new adults will emerge in a few weeks. Pruned laterals should immediately (the same day, if possible) be chipped, burned, or buried to kill the beetles and young. Simply cutting off the wilted lateral and leaving it in the orchard will not kill the adult or young-they will leave the lateral and move to another tree. No insecticide registered for coffee is effective against this pest (www.coffee-tea.co.uktree-pests).

According to the study report done by ABSTRACO in Nepal the insect (stem borer) control are observed as the problems at the field level in coffee farm (ABTRACO, 2004).

The farmers of Syangja district of Nepal have been using plants like garlic, chinaberry, neem, siru weed, ash, malabar nut tree, marigold, tobacco etc. in order to prepare plant based organic pesticides to control insect pest (NARC, 2008).

Several botanical formulations like Armorex and Azatin are effective in controlling White grubs. The Armorex was one of the most active formulations against *Popillia japonica* Newman, *Rhizotrogus majalis*, *Anonuda orientalis* and *Cyclocephala borealis*. Armorex is composed of extracts from 84.5% sesam oil, 2.0% garlic oil, 1.0% rosemary oil, and 0.5% white pepper extracts. The product Azatin composed of 3% azadiractin also exhibit high toxicity to *Popillia japonica* and *Rhizotrogus majalis*. Azatin is composed of extract from diverse botanical sources but this product shows lowest toxicity to other species of white grub (Ranger et al., 2009).

The entomopathogenic nematodes (EPNs) are effective agents in controlling pests found in soil, which suggests a likely effectiveness in controlling the coffee root mealy bug (Alres et. al. 2010)

Use of indigenous fungal pathogens in the genera *Metarhizium* and *Beauveria* are excellent candidates for the control of white grubs. Beside this insect, they are reported to be useful against red ants (*Dorylus orientalis*) (GC, 2009).

2.6 Effect of botanical pesticides on soil fertility of coffee

The soil type of coffee orchards ranged between clayey loam to sandy loam in Lalitpur and Gulmi district of Nepal. The subsoils from botanical used and not used orchards showed absolutely no difference in sand,silt and clay content, but there was some difference in physical characteristics of topsoil. The pH of top soil from botanical used and not used sites was slightly acidic ranging from 5.5 to 6.5. Locally prepared botanical pesticides (jaibik bishadi) used to control the coffee pests due to their allomones were found to contribute significantly in the soil fertility (Panthi et al., 2008).

In agricultural ecosystems under coffee cultivation soil management is based on limiting fertilizers and weed control. Alternatives that preserve or increase soil organic matter content are considered when the sustainability is the goal (de Alcantara et. al., 2009)

2.7 Knowledge, attitude and experience in use of pesticide in coffee cultivation

The studied have shown that farmers in coffee growing areas have managed to produce coffee over the years with minimum supervision and guidance from the agricultural extension service. The farmers showed creativity and motivation in dealing with the pest problem; however, they were constrained by the lack of appropriate (Ngowi, 2003)

A study done by NARC in 2008 in Kavre and Syangja districts of Nepal shows that the farmers have been using plants like garlic, chinaberry, neem, siru weed, stinging needle, smart weed, mug wort, prickly ash, Malabar nut tree, marigold, tobacco etc. in order to prepare plant based organic pesticides to control insect pest.

In Madanpokhara V.D.C. of Palpa district of Nepal the farmers were intended to grow coffee organically, use of chemical pesticides was not found in practice. For the control of insect pests a locally prepared organic pesticide called "Jaibic Bisadi" was found in practice. Locally available "Neem tel" was also use in practice for the control of insect pests like aphids, scale and mealy bugs. The organic pesticides was prepared by mixing the crushed leaves of locally available odorous plants and cattle urine is a drum and allow to ferment for about 45-65 days. This formulation was then diluted in the ratio of 1:8 for small plants and 1:4 for big plants. The formulation was used 2 times in the orchards annually after pruning (Maharjan, 2008).

3. STUDY AREA

3.1 Background

The study area, Ruru, Digam and Thanapati are the three Village Development Committees (VDCs) among seventy nine VDCs of Gulmi district falls under the Western Development Region of Nepal, lies in Lumbini zone. The district comes under mid mountain topographical zone with total area of 124937.97 hectare (ha) which includes 34102 ha cultivated agricultural land. Of the total cultivated land 240348 ha is upland (70.47%) and 10068 ha is irrigated Khet (29.53%). The three VDCs are lies near to Ruru kchetra (Ridhi) and Headquater of Gulmi (Tamghas). Since road is being constructed but there is no good facilities of transportation. These three VDCS are situated along Palpa Gulmi highway but the coffee orchards are some distance away from highway which takes 4-5 hours by foot walk.

3.2 Location

Gulmi District is located in central Mahabharata range of the Nepal. It is attached with Baglung in north, Parbat in northeast, Shyangja in east, Palpa in south, Arghakhanchi in South west and Pyuthan in west. Gulmi lies below 83^0 to $83^0$40' east longitude and $27^0$55' to $28^0$20' north latitude. The headquater of this district is Tamgahs. Topographically the three VDCs Ruru, Digam and Thanapati are extended from $27^0$57' to $27^0$58' and longitude extends from $83^0$24' to $83^0$26'.

3.3 Soil and topography

Topographically the study area lies in a hilly district Gulmi. Most of the area is covered by hills, besides these few plain land and rivers valleys. The elevation ranges from about 425 m. in the valley to 2570m. Average height of Ruru, Thanapati and Digam are 940m, 1044m, and 1268m from sea level respectively, likewise area of Ruru, Thanapati, and Digam are 11 sq. km, 7 sq. km and 14 sq. km respectively (Survey Department, Nepal). Major area has gravel mixed red loam soil followed by sandy loam. Minor categories of soils areas are red loam and red clay loam.

3.4 Climate

As the climatic data of Ruru, Digam and Thanapati VDCs was not available so the climatic record of the nearest metrological station, Tamghas (elevation 1530 m) was used. The climate of these three VDCs is sub-tropical type.

According to Climatic data of 2005-2009 collected from nearest station of these VDCs at Tamghas, the mean monthly maximum temperature ranged from 16.8°C in December to 27.16°C in June. Similarly, the mean monthly minimum temperature ranged from 5.04°C in December to 17.72°C in June (fig 1).

The average monthly relative humidity of morning is ranged from 65.92% in April to 90.94% in August. Similarly average monthly relative humidity of evening is ranged from 64.48% in April to 90.38% in August. The most humid month was June, July, August, September and October (fig 2).

The average annual rainfall ranged from 1.1 mm. to 462.98 mm. The mean annual precipitation recorded in this station was highest during the month of July and lowest during the month of November. June, July and August was the precipitous month (fig 3), (Source: Dept. of Metrology and Hydrology, 2011).

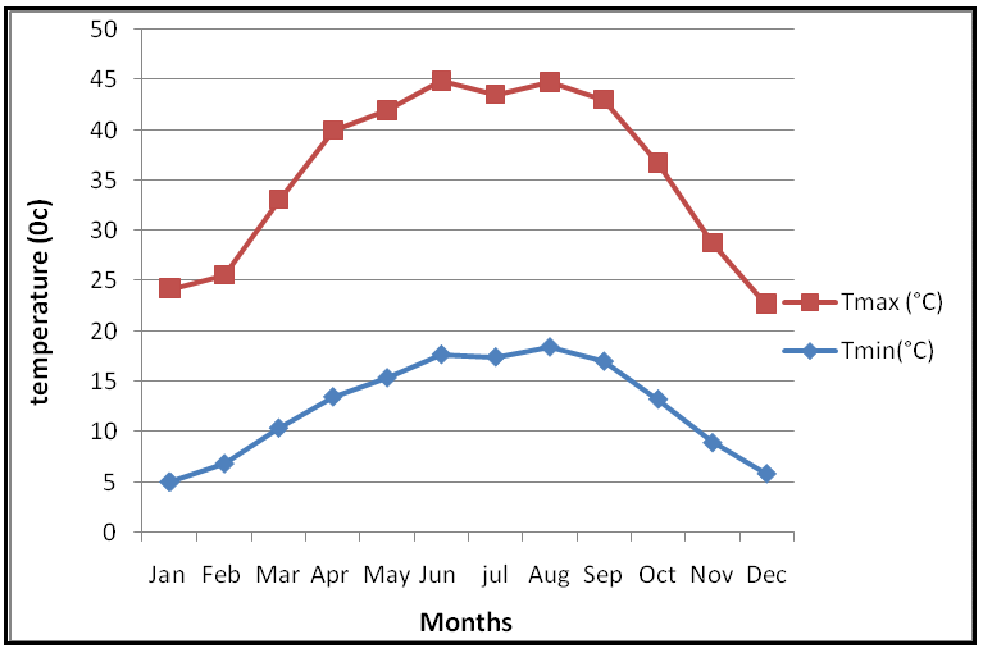


Fig 1: Monthly Average (Five Yearly, 2005-2009) Maximum and Minimum Temperature for Tamghas

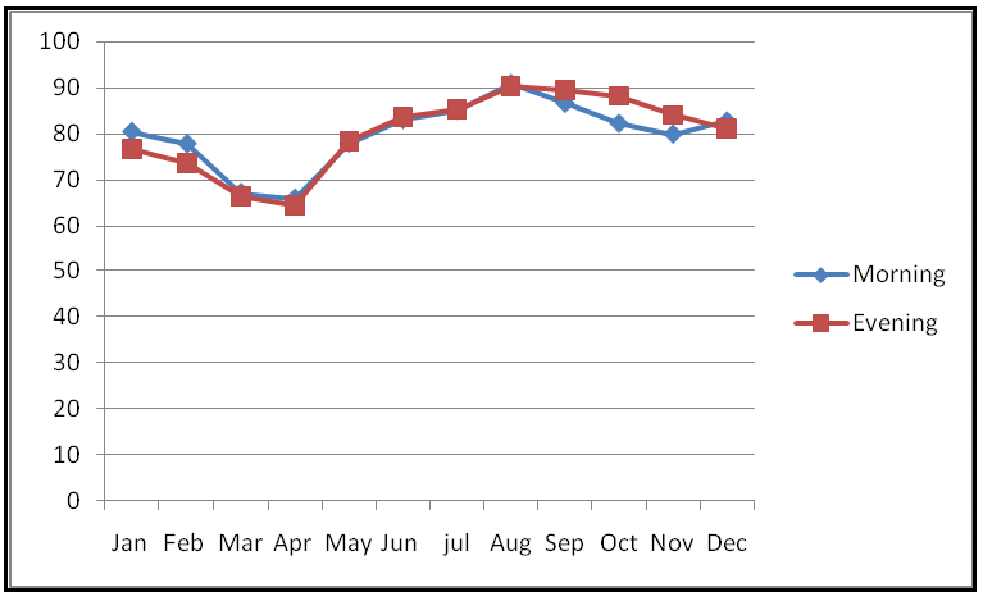


Figure 2: Monthly Average (Five Yearly, 2005-2009) Relative Humidity of Morning and Evening (%) for Tamghas

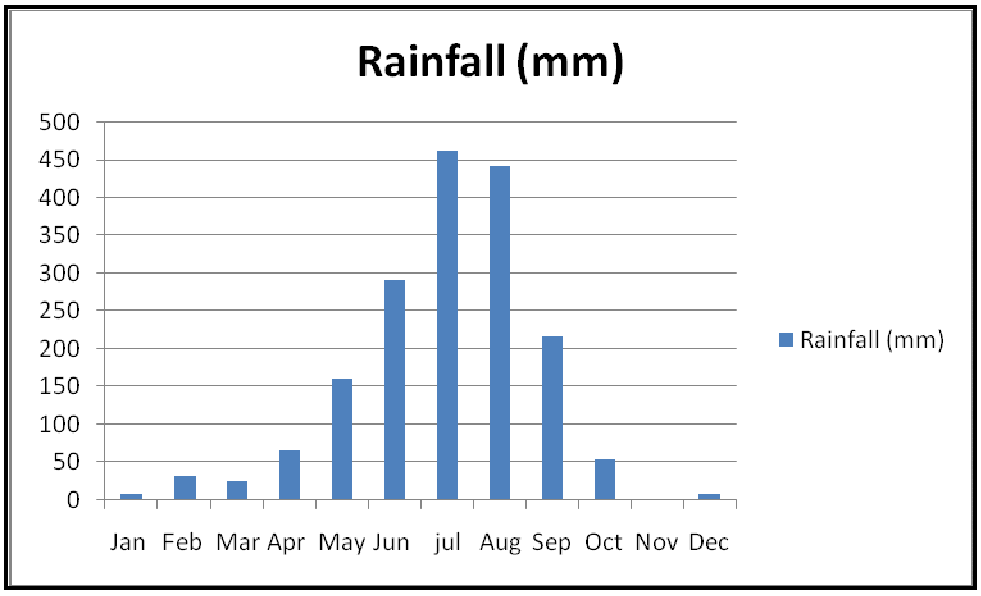


Figure 3: Monthly Average (Five Yearly, 2005-2009) Rainfall (mm) for Tamghas

3.5 Coffee history in study area

The area under coffee cultivation in Gulmi is 102 ha. Ruru, Digam and Thanapati VDCs are the main commercial coffee cultivation area within the district. Coffee growers of Gulmi District are organized in different coffee growers groups. Total

groups involved in coffee cultivation are 47 and total household number is 141 (DCPA staff's personal communication). The organizations involved in coffee cultivation and improvement are, District Coffee Producers Association (DCPA), Agriculture Development Office (ADO) Gulmi, Coffee Co-operative Gulmi, Coffee Development Board, Ugyalo and SIMI programme of Winrock International and Coffee Promotion Programme (CoPP/Helvetas). These organizations are primarily involved in coffee promotion and development programees whereas Agricultural Research Station (ARS) Malepatan and, Entomology Divison of Nepal Agricultural Research Council (NARC) and Institute of Agriculture and Animal Science (IAAS), Rampur has involvement in research activities of coffee over the recent months (Anonymous, 2062/63).

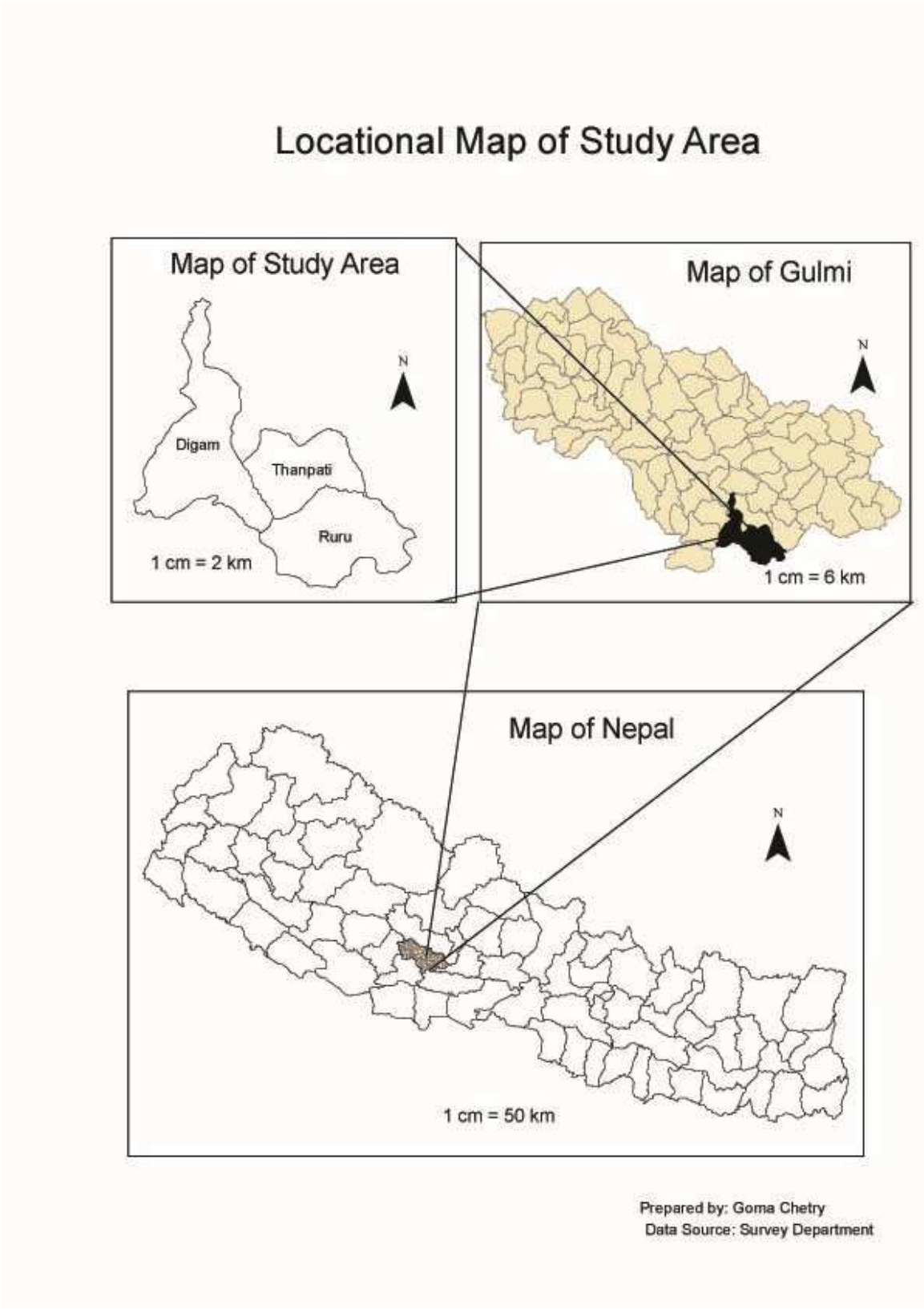


Figure 4: Location map of study area

4. METHODOLOGY

4.1 Data collection

The study was based on primary as well as secondary data collection. The secondary data has been collected from both published and unpublished literature from different sources like related publication, journals, different libraries, scientific papers, websites, government and non-government institutions.

The primary data has been collected by visiting the study sites. Interview with structured questionnaire and field observations are the two major tools for data collection. The data was collected from January and February month in 2010 which is the fruiting period of coffee and the second visit was done during monsoon i.e. June 2010.

The three VDCs of the District were taken purposively based on the criteria of highest production static's. Ruru, Thanapati and Digam VDCs of Gulmi district were selected as the study sites. The farmers involved in the production of the high value food production have been selected for the study purpose. Then enlisting of all commercial farmers in the selected VDCs was done and at least 10% of the sample population was taken for study purpose and questionnaire survey.

In addition, the coffee orchards have also been visited for direct observation of plants and insect pest collection. The information on coffee production has been taken from District Coffee Production Association (DCPA) of Gulmi and the information on pesticide used was also taken from farmers, agro-vet dealers, Government Agencies and related Associations.

4.2 Pest collection

For collecting the pest and studying their incidence level a random sampling method was applied which covered 10-15 percent of the total coffee plants of the respective orchard. The pests which were large enough to be seen readily with necked eyes were collected by hand picking method with the help of forceps and were put in bottle containing 70 percent alcohol.

Soft specimens which occurred in cluster were collected with the help of soft brush and kept in the preservatives. Beating process was also applied for collection of small insects. Sweeping net was applied for collecting the flying insect pests.

Each specimen was then labeled including date of collection, condition of host plant and location. The collected specimens were then brought for identification.

4.3 Identification

The collected specimens were identified by referring books of Joshi et. al. (2001) and Hayashi (1981). The identification was also made by comparing with existing specimens at laboratory of Entomology Department of Central Department of Zoology (CDZ), museum in Entomology Division NARC and expertise of entomology from Natural History Museum was also consulted.

4.4 Photography

The specimens photographs were then taken by Nikon 8.0 digital camera. The photography of nursery plants and infestations of pest in natural state were also done.

4.5 Two- Way-ANOVA (Analysis of Variance)

Seasonal variations in total number of insects collected in three different sites (Ruru, Thanapati and Digam VDCs) and in two seasons were analyzed by using two-way ANOVA. This allows observing whether there is significant difference in number of specimens in three different sites in two different seasons. Also the significant difference in number of species collected in three different sites in two different seasons was tested.

4.6 Damage level of white stem borer

Damage level of white stem borer was determined by random sampling method. Eight coffee orchards were observed in each sites and level of infestation was done by counting plants infested by White stem borer among the total plants. The infestation done by white stem borer was determined by visual observation and by excavating the stem. Correlation analysis was done to explore relationship

between age of coffee plant and damage done by white stem borer. For the analysis, null hypothesis: there is no significant relationship between years of coffee plant and damage done by white stem borer.

4.7 Geographical Information Survey (GIS)

GIS was applied for the map of study area i.e. Ruru, Thanapati and Digam VDCs of Gulmi District of Nepal.

5. RESULT

5.1. Land holding of the respondent farmers in coffee cultivation

Mean land holding size under coffee cultivation of the respondent farmers of the study area were different in different VDCs. It was the highest in Thanapati and the lowest in Digam. The respondent farmers are commercial growers of the study area. Very few of the commercial coffee farmers of the study area have as much as 8 Ropani and some of them have as low as 1 Ropani land under coffee cultivation. The data shows that more land has been used for coffee cultivation in Thanapati VDC than Ruru and Digam VDCs, where as in Digam VDC lesser land has been used for coffee cultivation than Ruru and Thanapati VDCs (Table 3). Regarding the number of coffee plants planted in the orchard varies according to the farmers purpose of cultivating coffee. Average number of coffee planted by majority of coffee growers of the study area ranges from 350-700 plants per orchard and the highest plantation was upto1400 plants in a single orchard.

Table 3: Land holding by the respondent farmers in the study area

VDC	Mean Land holding
Ruru	1398.98
Digam	1017.44
Thanapati	1844.18

5.2. Cropping pattern

Majority of the farmers planted coffee in upland and sloppy upland. Coffee was planted in different pattern such as under intensive multi cropping pattern, under forest, coffee mixed with fodder and fruit, coffee in kitchen garden, coffee in edge of the upland and solo coffee with shade. Among these pattern the coffee mixed with fodder and fruit pattern was mainly found in Ruru VDC were as the intensive multiple cropping pattern was found dominant in Thanapati and Digam VDCs which consist of three layers of plant with coffee in middle layer, fruit trees in the upper layer and supplementary crop in the lower layers. Legume, vegetables, spices and cereals were the supplementary crops.

5.3. Shade management in coffee orchards

Management is the prerequisite for coffee plantation. Majority of the coffee was planted in the shade provided by indigenous fruits and fodder plants, which were already existed in the plantation sites. Coffee cultivation requires good shade in order to get good production and also for protection from pests and diseases. There are many reasons for using shade. The primary reason is to protect coffee plants from direct sun so that it can be saved from over-exposure to long period heat and drought. It reduces evapotranspiration of the coffee plants, to prevent overbearing, subsequently physiological dieback, to avoid or reduce biennial bearing (similar to alternate bearing in mango) and extend the productive life of the tree, to reduce soil erosion by intercepting the down slope movement of soil and by direct impact of raindrops and by anchoring the soil, to increase or maintain soil fertility of orchard by providing organic matter from leaf litters and by incorporation of nitrogen fixed by leguminous shade trees, to suppress weeds, to reduce infestation of certain pests like borer, to diversify the agro-products from the orchard and to reduce damage due to frost, hailstone and wind.

Shade management was not found properly managed in the orchards. The farmers were well aware of the consequences of poor shade management still there was no good practice on it. Both heavy and medium shades were essential in the orchard with respect to small and big coffee plants.

Majority of shade were provided by fruit trees and fodder trees. The coffee orchards in study area were found under many types of shade trees like Orange, Lemon, Guava, Banana, Banyan and Jack fruit trees which are found mostly used by farmers for shade management. Almost all shade trees were there long before coffee planting. Farmers just planted coffee under existed trees. The farmer responded that the best option for heavy shade management was Jack fruit. Many coffee orchards observed do not have any shade. But few coffee orchards were found under too heavy shade. Because of temperature and light interaction, the shade requirement may vary with altitude and aspect of the orchard. At high altitude (+1000msl), orchards-facing north is growing fine without any shade. Therefore, shade may not be necessary at all condition. A list of shade plant used in the orchard is given in Annex1.

5.4. Weeds in coffee orchard

Weeds are more problematic during first and second years of coffee planting however; losses decreases with increasing growth of the plants. Yield losses due to weed was considered negligible by coffee growers. The weeds in coffee orchards were not considered as problem by the farmers though there were numerous such weeds associated with the coffee plants sheltering different species of insects. Among the weeds Cogon grass (Siru) and Goat weed (Gandhe jhar) were much abundant and considered as major weeds but not as a problematic.

The farmers used some of the weed species as source of plant pesticide and some of the weeds used as livestock feed. Hand weeding, digging and incorporation weeds into soil were major techniques of weed management practiced by the farmers. The list of weeds in coffee orchards is given in the table below.

Table 4: List of common weeds in coffee orchard

S. No.	Local name	Common	Scientific name	Family
1.	Banmara	Siam weed	*Eupatorium adoratum*	Asteraceae
2.	Gandhe	Bill goat weed	*Ageratum conizoides*	Asteraceae
3.	Chari Amilo	-	*Oxalis latifolia*	Asteraceae
4.	Armale	-	*Anagalus armelensis*	
5.	Dubo	Bermuda grass	*Cynodon dactylon*	Gramineae
6.	Banso	Knot grass	*Paspalum disticum*	Gramineae
7.	Siru	Cogon grass	*Imperata cylindrical*	Gramineae
8.	Kuro	Beggar's stick.	*Bideans pilosa* L	Gramineae
9.	Dudhe Jhar	Snake weed	*Euphorbia hirta*	Euphorbiaceae
10.	Banmasa	Crofton weed	*Eupatorium adenophorum*	Asteraceae

5.5. Arthopodan pest infesting coffee plant in three different sites

Different arthropod pest were found in the coffee orchard during the field visit. Altogether 25 types of insects were recorded from coffee orchard in the study area. A total of 22 types of arthropod pests and 3 types of predators were recorded from the study site during the study period. Different types of arthropod pest recorded from study site are presented in Table 5. The arthropod pests were

belonging to 6 orders i.e. Coleoptera, Lepidoptera, Ortoptera, Hemiptera, Homoptera and Hymenoptera. The predator species were of order Coleoptera and Hemiptera.

Table 5: List of insects infesting coffee plant in three different sites in two seasons

S. No.	Common name	Scientific name	Site A		Site B		Site C		Total species
			1st visit	2nd visit	1st visit	2nd visit	1st visit	2nd visit	
1.	White stem borer	*Xylotrechus quadripes* Chevr.	14	11	12	11	8	8	64
2.	Red stem borer	*Zuezera* sp.	2	-	4	-	2	1	9
3	Aphid	*Toxoptera aurantii* Boyer	17	2	11	-	22	-	52
4	White grub	*Holotrichia* sp.	3	-	1	-	2	-	6
5	Short horn grasshopper	*Catantops* sp.	3	6	6	8	5	17	45
6	Long horn grasshopper	-	-	4	-	5	-	3	12
7	Hairy caterpillar	-	-	1	-	-	-	-	1
8	Rice bug	*Leptocorisa* sp.	-	-	-	2	-	5	7
9	Field cricket	*Gryllus* sp.	1	-	-	2	-	-	3
10	Red ant	-	32	5	-	-	-	7	44
11	Scale insect	-	-	16	-	-	-	5	21
12	Black ant	-	12	33	23	4	28	9	120
13	Leaf beetle	*Calaposoma semicostatum* Jac.	-	15	-	-	-	11	26
14	Leaf beetle	*Calaposoma metallicum* Clark.	3	-	-	-	-	-	3
15	Darkling beetle	*Gonocephalum* sp.	-	2	-	-	-	-	1
16	Mealy bug	*Planococcus* sp.	7	-	4	-	-	-	11
17	Stink bug	*Aspangopus* sp.	5	-	5	1	6	-	17
18	Tortoise beetle	*Aspidomorpha sanctai crucis* Fab.	1	-	-	-	-	-	1
19	Leaf beetle	*Anomala* sp.	1	2	-	1	-	-	4
20	Ear wig	*Forcipula* sp.	-	-	2	-	-	-	4

21	-	*Dalader acuticosta* Amy	-	1	-	1	-	-	2
22	Lace bug	_	-	1	-	2	-	-	3

Table 6 : Pest collected, time of collection and nature of damage

Pest	**Time**	**Nature of damage**
White stem borer (*Xylotrechus quadripes* Chevr.)	1st visit/2nd visit	Stem borer
Red stem borer (*Zuezera* sp.*)*	1st visit/2nd visit	Stem borer
Aphid (*Toxoptera aurantii* Boyer)	1st visit/2nd visit	Sap sucker
White grub (*Holotrichia* sp.)	1st visit	Root destroyer
Short horned grasshopper (*Catantops* sp.)	1st visit/2nd visit	Defoliator
Long horned grasshopper	2nd visit	Defoliator
Hairy caterpillar	2nd visit	Defoliator
Rice bug (*Leptocorisa* sp.)	2nd visit	Sap sucker
Field cricket (*Gryllus* sp.)	1st visit/2nd visit	Root destroyer
Red ant	1st visit/2nd visit	Fruit pest
Scale insects	2nd visit	Sap sucker
Black ant	1st visit/2nd visit	Fruit pest
Leaf beetle (*Calaposoma semicostatum* Jac.)	2nd visit	Defoliator
Leaf beetle (*Calaposoma metallicum* Clark.)	1st visit	Defoliator
Darkling beetle (*Gonocephalum* sp.)	1st visit	Bark feeder
Mealy bug (*Planococccus* sp.)	1st visit/2nd visit	Sap sucker
Stink bug (*Aspangopus* sp.)	1st visit/2nd visit	Sap sucker
Tortoise beetle (*Aspidomorpha sanctai crucis* Fab.)	1st visit/2nd visit	Defoliator
Leaf beetle *(Anomala* sp.)	1st visit/2nd visit	Defoliator
Dalader acuticosta Amy	2nd visit	Sap sucker
Lace bug	2nd visit	Sap sucker

5.5.1. Constituent of insect associated with coffee

Order Coleoptera constituted nine types: *Xylotrechus quadripes* Chevr., *Holotrichia* sp., *Calaposoma semicostatum* Jac., *Calaposoma metallicum* Clark.,

Gonocephalum sp., *Anomala* sp., *Coccinella* sp., *Ciccindela sexpunctata* L. and *Aspidomorpha sanctai crucis* Fab.

Order Lepidoptera constituted two types: *Zuezera* sp. and Hairy caterpillar.

Order Orthoptera Constitute three types: *Catantops* sp., *Gryllus* sp. and long horn grasshopper.

Order Hemiptera constituted five types: *Leptocorisa* sp., *Anpangopus* sp., *Dalader acuticosta* Amy, Assassin bug and Lace bug.

Order Homoptera constituted three types: *Toxoptera aurantii* Boyer, Scale insect and *Planococccus* sp.

Order Hymenoptera Constituted two types: Red ant and Black ant.

Order Dermaptera constituted one types: *Forcipula* sp.

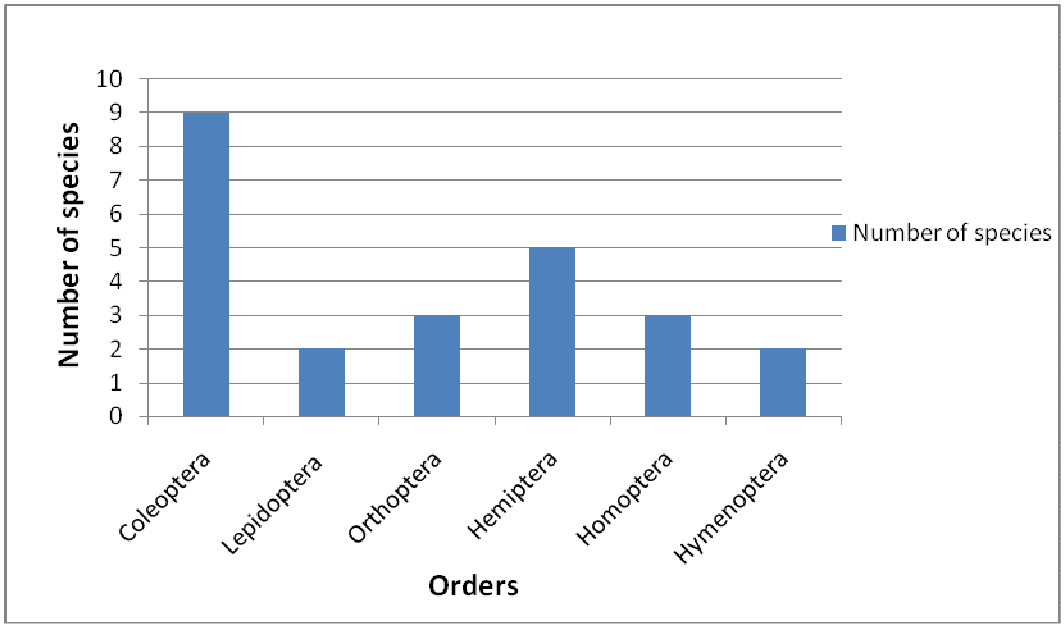


Figure 5: Number of species belonging to different orders.

5.5.2. Pest identification character

Table 7: Pest identification character

INSECT PEST	IDENTIFICATION CHARACTER
White stem borer (*Xylotrechus quadripes* Chevr.)	White bodied black headed larvae inside old stem or root. Adult with White and black patches in body with long anteena
White Grub (*Holotrichia* sp.)	Whitish grub with brownish head, C- shaped body, found in soil associated with root of coffee plant
Leaf beetle (*Calaposoma semicostatum* Jac.)	Small shiny green coloured beetle, measure about 2-4 mm long, oval in outline
Darkling beetle (*Gonocephalum* sp.)	Dusty brown beetle with brownish-black in colour, measure about 6- 8 mm long, oval in outline and flattened
Lady bird beetle (*Coccinella* sp.)	Rounded beetle, 6-8 mm long, reddish in colour. Elytra is marked with a series of black spots
Red stem borer (*Zuezera* sp.)	Red bodied black headed larvae within stem
Hairy caterpillar	caterpillar with hairs, associated with coffee leaves
Short horn grasshopper (Catantops sp.)	The antenna is shorter than body, tarsi are 3 segmented. Grey and brownish in colour. the ovipositor not conspicuous
Field cricket (*Gryllus* sp.)	Dark brown or black in colour, long ovipositor, the antenna is long
Long horn grasshopper.	The antenna is longer than body, pronotum extend backward over the abdomen and narrow posteriorly. ovipositor frequently attains a great length.
Rice bug (*Leptocorisa* sp.)	Slender bodied 10-15 mm long, brownish colour
Aphid (*Toxoptera aurantii* Boyer)	Shiny black adult, winged or apterous, body length ranges from 1.3 -1.8 mm long
Scale insect	Brownish scales occur in branches, leaves and fruits of plant, incrust foliage
Mealy bug (*Planococccus* sp.)	Flat and oval bodied, foud attached with surface of staiks of young berries or buds sometime wax secreation also found associated with ants
Stink Bug (*Anpangopus* sp.)	Scutellum shorter, more or less triangular, broad hemielytra

Tortoise beetle (*Aspidomorpha sanctai crucis* Fab.)	Head largely concealed under protjorax, prothorax and elytra widen, circular in shape

5.5.3. Number of types of insect pest found in different sites and in different seasons

The numbers of types of insect pest found in different sites and in different season were variable. The data shows that site A constituted the highest number with a total of 20 types whereas site C constituted the lowest number with a total of 12 types. Similarly site B was with total of 15 types.

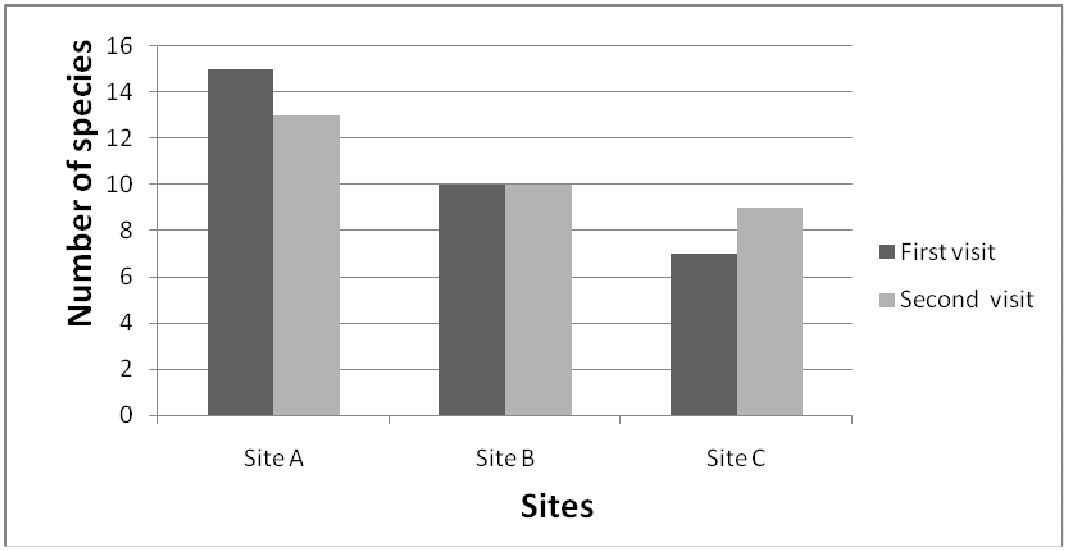


Fig 6: Number of types of insect pests found in different sites and in different seasons

In site A White stem borer (*Xylotrechus quadripes* Chevr.), Red stem borer (*Zuezera* sp.), Aphid (*Toxoptera aurantii* Boyer), White grub (*Holotrichia* sp.), Short horned grasshopper (*Catantops* sp.), Long horned grasshopper, Hairy caterpillar, Field cricket (*Gryllus* sp.), Red ant, Scale insects, Black ant, Leaf beetle (*Calaposoma semicostatum* Jac.), Leaf beetle (*Calaposoma metallicum* Clark.), Darkling beetle (*Gonocephalum* sp.), Mealy bug (*Planococcus* sp.), Stink bug (*Aspangopus* sp.), Tortoise beetle (*Aspidomorpha sanctai crucis* Fab.), Leaf beetle (*Anomala* sp.), Lace bug and *Dalader acuticosta* Amy were found. Among the total types of insect pests found in site A, Black ant was found higher in

number where as Field cricket (*Gryllus* sp.), Hairy caterpillar and Tortoise beetle (*Aspidomorpha sanctai crucis* Fab.) were lesser in number.

In site B White stem borer (*Xylotrechus quadripes* Chevr.), Red stem borer (*Zuezera* sp.), Aphid (*Toxoptera aurantii* Boyer), White grub (*Holotrichia* sp.), Short horned grasshopper (*Catantops* sp.), Long horned grasshopper, Rice bug (*Leptocorisa* sp.), Field cricket (*Gryllus* sp.), Black ant, Mealy bug (*Planococccus* sp.), Stink bug (*Aspangopus* sp.), Leaf beetle (*Anomala* sp.),Ear wig (*Forcipula* sp.), Lace Bug and Tiger Beetle (*Cicindela sexpunctata* L.) were found. Among the total types of insect pests found in site B, Black ant was found higher in number where as White grub (*Holotrichia* sp.), Rice bug (*Leptocorisa* sp.) and Ear wig (*Forcipula* sp.) were found lesser in number.

Similarly in site C White stem borer (*Xylotrechus quadripes* Chevr.), Red stem borer (*Zuezera* sp.), Aphid (*Toxoptera aurantii* Boyer), White grub (*Holotrichia* sp.), Short horned grasshopper (*Catantops* sp.), Long horned grasshopper, Rice bug (*Leptocorisa* sp.), Red ant, Scale insects, Black ant, Leaf beetle (*Calaposoma semicostatum* Jac.) and Stink bug (*Megymenum* sp.) were found. Among the total types of insect pests found in site B, Black ant was found higher in number where as White grub (*Holotrichia* sp.) was found lesser in number.

5.5.4. Two way ANOVA

The two way ANOVA showed that there was no significant difference in total types of insect pests found in different sites and in the two seasons. Fc(2,2)=0.12 and Fr(1,2)=1.32 which is lesser than tabulated value.

5.5.5. Distribution of total number of specimens in different sites and in different seasons

The distributions of total number of specimens were the highest in site A with a total number 194 whereas the lowest in site B with the total number 110. The distributions of total number of specimens are shown in the following figure.

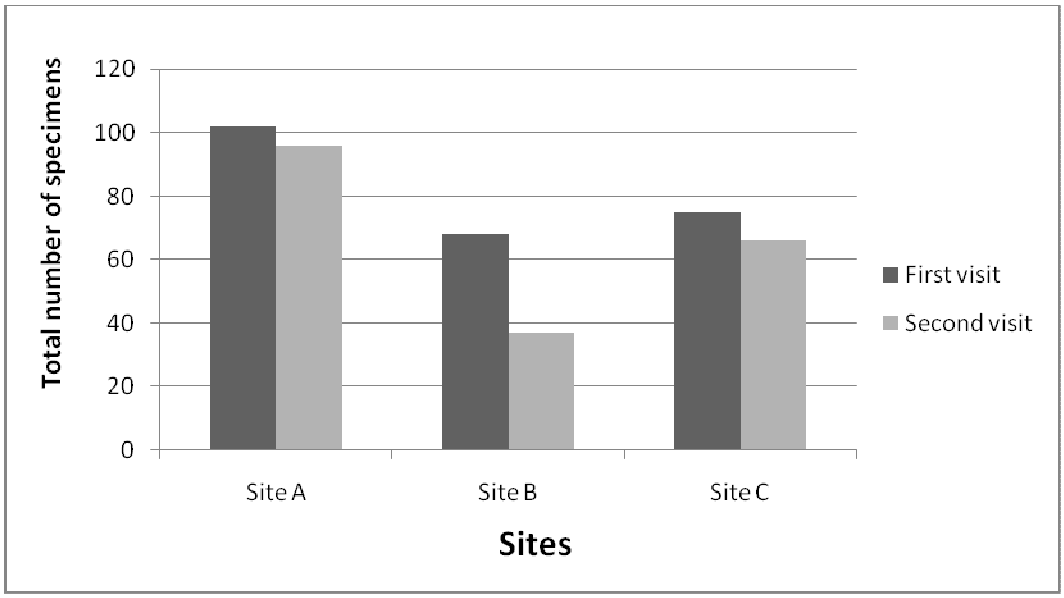


Figure 7: Distribution of total number of specimens in different sites and in different seasons

5.5.6. Two way ANOVA

The two way ANOVA showed that there was no significant difference in total number of insects in different sites and in different seasons. Fc(2,2)=0.038 and Fr(1,2)=0.102 which is less than the tabulated value.

5.6. IPM practice

Integrated pest management means the careful consideration of all available pest control techniques and subsequent integration of appropriate measures that discourage the development of pest populations, keep pesticide use and other interventions to levels that are economically justified and reduce or minimize risks to human health and the environment.

Integrated pest management emphasizes the growth of a healthy crop, with the least possible disruption to agro-ecosystems, and encourages natural pest control mechanisms. Integrated pest management can be applied to both agricultural and non-agricultural settings, such as the home, garden and workplace.

Integrated pest management (IPM) strategy involves one or combinations of control techniques to optimize pest or vector management according to local conditions. Such strategies require careful consideration of all available pest

control techniques and subsequent integration of appropriate measures that discourage the development of pest populations and keep use of pesticides and other interventions to levels that reduce or minimize risks to human health and the environment.

5.6.1. Pest management practices done by farmers

Different practices were found in the study area for the management of pests. As the farmers were intended to grow coffee organically, use of chemical pesticide was not found in the study area. For the control of pest, locally prepared organic pesticide called as 'Jaibic Bisadi' was mostly found in practice, beside that other mechanical practices like manual clearing, pheromone trape, non poisonous sticky trape, light trape and electric trape were also found in practice. Different types of practices done by farmers in the study area for pest management are given in table below.

Table 8: Pest management practices done by farmers in the study area

Pest management practice	Percentage of farmers
Organic production	100%
Manual clearing	100%
Pheromone trape	25%
Non poisonous sticky trape	20.83%
Light trape	4.17%
Electric trape	4.17%

Out of total farmers almost all farmers apply organic production and mannual clearing to protect their coffee plantaion from the pest where as very few farmers were found to use pheromone trape and non poisonous sticky trape, but the use of light trape and electric trape were also found to be used very little. According to farmers the use of light trape and electric trape were not provided any type of benifit in controlling the pest but the used of organic production and mannual clearing was one of the best way of preventive measures against the pest than any other type of control measures, were as the use of pheromone trape and non

poisonous sticky trape was also helpful at some level for management of pest specially white stem borrer.

The organic production found in practice is prepaired by famers themselves locally which is called as 'Jaibic Bisadi' or 'Organic Pesticide'. The organic pesticide was prepared by using locally available plants, which are supposed to have pesticidal property and cattle urine. The organic pesticide are prepared by mixing chopped and crushed leaves of locally available odorous plant and cattle urine in a drum with covers. this solution is stirred time to time and allowed to ferment for about 15-30 days. This solution was then diluted in the ratio of 1:8 for young plants and 1:4 for mature plants. the formulation was used 2 times in the orchard annually. List of plants being used as raw materials to prepare local plant based organic pesticide are listed in Table 11.

Table 9: List of plants used to prepare organic pesticide

S. No.	Common name	Local name	Scientific name	Family
1	Ginger	Aduwa	*Gingiber officinalis*	Zingiberaceae
2	Garlic	Lahsoon	*Allium sativum*	Amaryllidace
3	China berry	Bakaino	*Melia azadirach*	Meliaceae
4	Neem	Neem	*Azedirechta indica*	Meliaceae
5	-	Khirro	*Sapium insigne*	Euphorbiceae
6	Hot pepper	Khursani	*Capsicum annum*	Solanaceae
7	Cactus	Siundi	*Opentia* sp.	Caeteceae
8	Stinking nettle	Sisnoo	*Utrica dioca*	Urticaceae
9	Tobacco	Surti	*Nicotiana tabacum*	Solacaceae
10	Mary gold	Sayapatri	*Tegetus* sp.	Asteraceae
11	Malabar nut tree	Asuro	*Justice adhatoda*	Alanthaceae
12	Mug wart	Titepati	*Artemesia vulgaris*	Compositeae
13	Goat weed	Gandhe Jhar	*Ageratum conyzoides*	Asteraceae
14	Prickly ash	Timmur	*Xanthoxylum armatum*	Rutaceae
15	Ginger	Aduwa	*Gingiber officinalis*	Zingiberaceae
16	Siam weed	Banmara	*Eupatorium adoratum*	Asteraceae
17	Pear	Aaru	-	-
18	Onion	Pyaj	-	-

(-)not known

for the borrer following local cultural practices were done

- Trimming and pruning of infested branches and burned.
- Plastering the infested part of plant by mixing properly Red soil, cattle urine and cattle dung in 1:1:1 ratio.
- Scrubbing of coarse bark of plant with gunny bag, Jute sack or other coarse materials.

5.6.2. Percentage of IPM training received by farmers in Ruru, Thanapati and Digam VDCs.

More than (50 %) of respondent farmers in the study area were found to be received IPM training from different organization. Among the coffee growers in three VDCs about 87.5 % respondent of Digam, 62.5 % of respondent Ruru and 50% respondent of Thanapati VDCs were received IPM training.

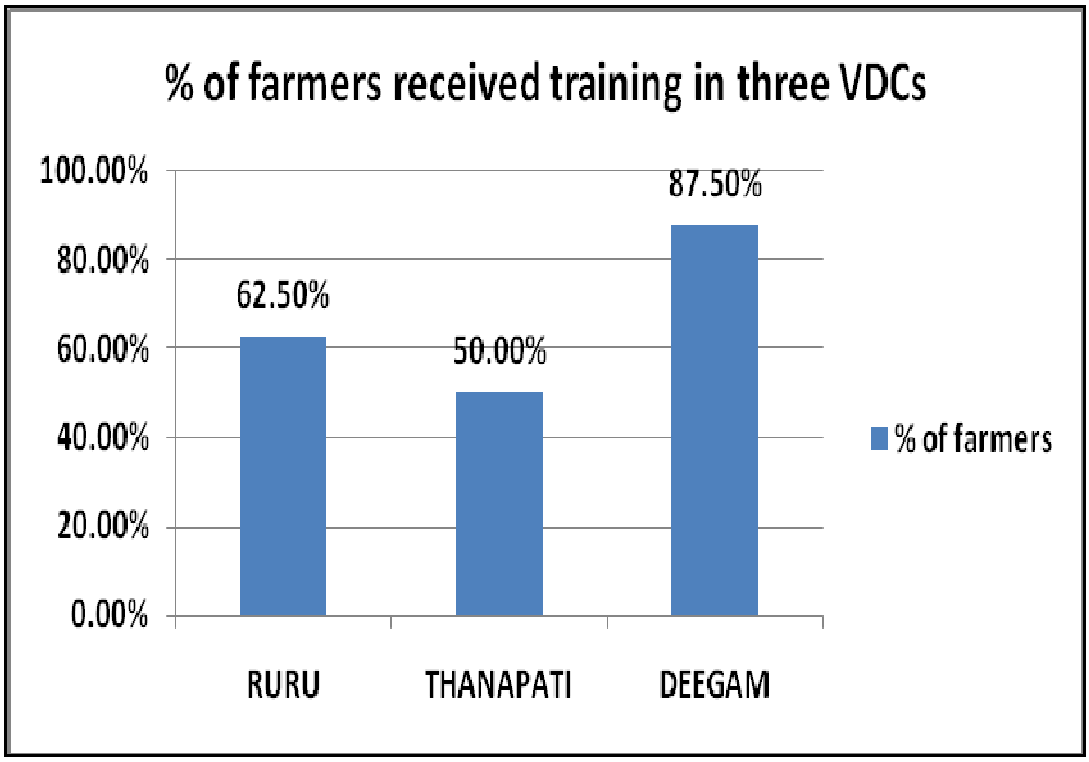


Figure 8: Percentage of respondent received IPM training in three VDCs

5.7. Tools used for application of pesticide

The use of hand sprayer, broom, brushes, and hajari were used for the application of botanical pesticide.

5.8. Time of application

The farmers advocated the application of pesticides to be used twice a year during August/September and December/ January.

5.9. Pesticide user among the coffee growers

Almost all pesticide poses hazards to human health and environment. All of the coffee growers that are 100 percent of study area do not apply pesticides to their coffee as pest control measure. Thus the coffees grown in the study area were found not using pesticide hence the coffee cultivation is found totally organic and not hazardous to grower, consumer, human health and environment.

Table 10: Percentage of pesticide User and non user in study area

Pesticides user among coffee grower	Percentage
Yes	0%
No	100%

5.10. Reason of not using chemical pesticide, by coffee grower

As coffee farming in study area was done organically, the use of chemical pesticides was not found in practice to control of pests. The main reason of not using chemical pesticide by coffee grower was for the organic production. Among the coffee growers, most of the farmers (45 %) were in the intension of organic production, which helped them to increase the market value of coffee in both domestic and international markets. Very few farmers did not use pesticides in their fields because they knew that the use of chemical pesticide made economic loss and also because it has not been used by neighbours where as some of the farmers of the study area (20%) did not use chemical pesticide because they had knowledge of health hazard due to the use of chemical pesticides.

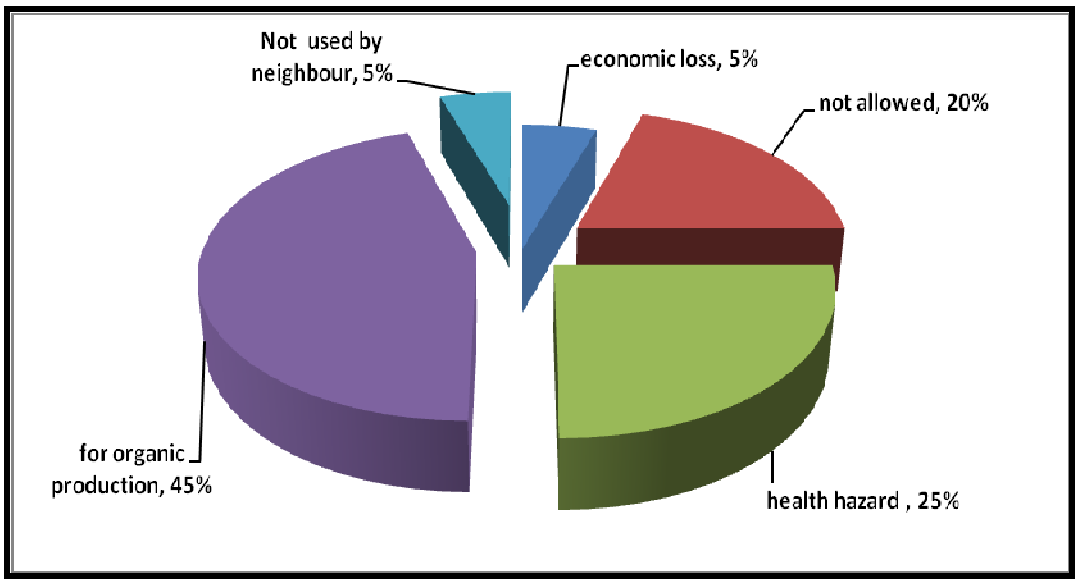


Figure 9: Reason of not using chemical pesticide, by coffee grower

5.11. Opinions of farmers on pesticide use

The opinion of farmers towards the use of pesticide was not found similar. Maximum percentage of the farmers of the study area (91.67 %) had negative opinion towards the use of pesticide and they suggested not to use pesticide at any level whereas a very few percentage of farmers (8.33%) had positive attitudes towards the use of pesticide, their opinion was that the use of pesticide should have been increased, this was because there could be heavy loss in coffee farming due to pest.

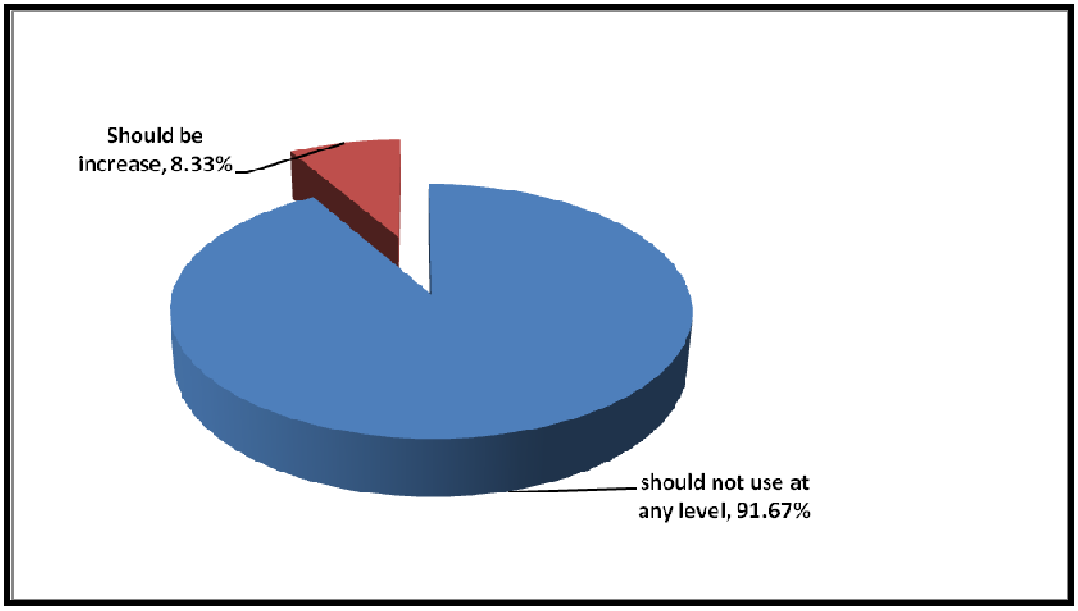


Figure 10: Percentage of opinions of respondent farmers on pesticide use

5.12. Percentage of plant infected by white stem borer

Major problem of coffee in study area was loss in coffee plants due to white stem borer. The percentage of plants infected by white stem borer was determined by random sampling method. Eight coffee orchards were observed in each sites and level of infestation was done by counting plants infested by White stem borer among the total plants. The infestation done by white stem borer was determined by visual observation and by excavating the stem.

Higher plants were found infected by White stem borer in Thanapati VDC, which was 19.75 % followed by 17.89 % in Ruru VDC and least infestation was found in Digam VDC Which was 15.49%.

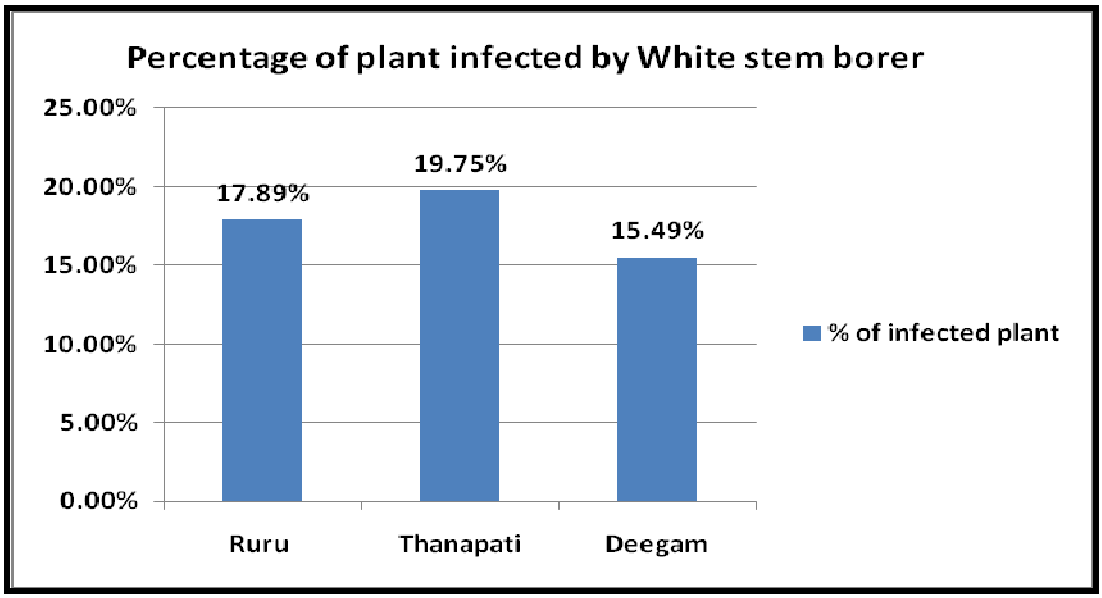


Figure 11: Percentage of Plant Infected By white stem borer

Correlation analysis between damage done by white stem borer and age of coffee plant shows positive correlation in all the three VDCs. In Ruru VDC there was high degree of correlation (0.94), in Thanapati there was low degree of correlation (0.12) where as in Digam VDC there was mid degree of correlation (0.52).

Name of VDC	Correlation Coefficient(r)	Remark
Ruru	0.94	High degree
Thanapati	0.12	Low degree
Digam	0.52	Medium degree

PLATE I

Xyloterchus quadripes Chev.

Gonocephalum sp.

Holotrichia sp.

Aspangopus sp.

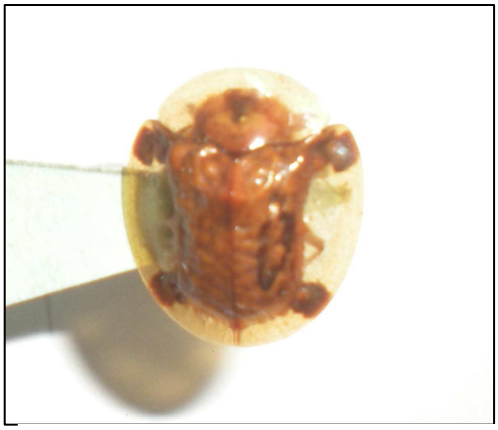
Anomala sp.

Calasposoma semicostatum Jac

PLATE II

Dalader acuticosta Amy

Catantops sp.



Aspidomorpha sanctai crucis Fab.

Forcipula sp.

Lace bug

Assassin bug

PLATE III

Larva of White stem borer with location of borer in twig

Larva of Red stem borer

Stem shows hole of emergence of the adult of white stem borer

Stem shows hole made by Red stem borer

Plant infected by White stem borer

Plant infected by Red stem borer

6. DISCUSSION

From the study it was observed that different pest belonging to different taxonomic groups were found in coffee plants, a total of 22 types of arthropod pests and 3 types of predators were recorded from the collected specimens which belongs to seven orders and 17 different families. The orders identified were Orthoptera, Coleoptera, Hemiptera, Homoptera, Lepidoptera, Hymenoptera and Dermaptera. Similarly, the families belonging to these orders were Acritidae, Grylidae, Tettigonidae, Coccinelidae, Cerambicadae, Scarabidae, Tenebrionidae, Pentatomidae, Tingidae, Coreidae, Reduviidae, Aphididae, Pseudococcidae, Coccidae, Cossidae, Formicidae and Forcipulidae.

Originally, coffee farming was done in the shade of trees that provided a habitat for many animals and insects (Janzen, 1983).

Among the recorded pest 16 species of arthropod pest were identified. The arthropod pest collected and identified were Short horned grassoper (*Catantops* sp.), Fieldcricket (*Gryllus* sp.), Leaf beetle (*Calaposoma semicostatum* Jac.), Leaf beetle (*Calaposoma metallicum* Clark.), Tortoise beetle (*Aspidomorpa sanctai crucis* Fab.), White stem borer (*Xylotrechus quadripus* Chevr.), White grub (*Holotrichia* sp.), Leaf beetle (*Anomala* sp.), Darkling beetle (*Gonocephalum* sp.), Stink bug (*Aspangopus* sp.), Rice bug (*Leptocorisa* sp.), Aphid (*Toxoptera aurantii* Boyer), Red stem borer (*Zuezera* sp.), *Dalader acuticosta* Amy, Mealy bug (*Planococcus* sp.) and Ear wig (*Forcipula* sp.).

Among the natural enemies of the pest, the arthropod predators Lady bird beetle (*Coccinela* sp.), Assassin bug and Tiger beetle (*Cicindela sexpunctata* L) were also recorded from the study area.

Among the collected specimens, Maximum were collected from family Formicidae and Cerambicadae similarly minimum number were collected from family Tenebrionidae. The coleopteran was found to be dominant which was comparable to the research work that had been carried out by Maharjan (2008).

From the study, it was found that the major problem of coffee cultivation of the study area was infestation of white stem borer increase. The White stem borer (*Xylotrechus quadripes* Chevr.) was regarded as the major pest in the study area

because their damage were found comparatively high during the study period which was comparable with the research work that had been carried out by Maharjan (2008).

Maharjan (2008), found that the attack of white stem borer was high in low altitude below 800 m from the sea level than between 800-1000 m from the sea level where as no infestation was found above 1000 m from the sea level.

But during the field survey the attack of White stem borer was also observed above 1000 m from the sea level but the infestation above 1000 m from the sea level was found lowest then the lower altitude, this might be because stem borer are most numerous between 500-1000 m above sea level and higher temperature (Walker et. al., 2007 and Baker et, al, 2009).

A number of defoliators were found during the study period of which *Catantops* sp. and *Calaposoma semicostatum* Jac. were fond with considerable number. *Anomala* sp, *Aspidomorpha sanctai crucis* Fab., *Calaposoma metallicum* Clark. , Long horn grasshopper and Hairy caterpillar were also among the species that damaged the leaves.

Khadge et. al. (2004) reported two species of grasshopper which were identified as *Euparatettix*? *personatus* of family Tettigidae, *Catantops pinges pinges* from family Acrididae in coffee orchards of Kavre district. *Catantops melonosticus* was mainly the pest of pulse (Bohlen 1979), and *Catantops spissus spissus* is vector of cowpea mosaic virus (anonymous 1972).

Wyniger (1962) has included *Calaposoma Coffeae*, to be pest of coffee. The adult devour the leaves where as its grub was known to feed on root. This was small beetle about 12-15 mm long.

Among the soil pest white grub (*Holotrichia* sp.) and Field cricket (*Gryllus* sp.) were found. White grubs were among the most difficult soil pest affecting soil productivity. They were reported to be an increasing nuisance in cash crops from eastern to western parts of Nepal (GC, 2009).

Aphid (*Toxoptera aurantii* Boyer) was found in cluster but in lesser number in coffee plant. *T. aurantii* had been reported to be a vector of citrus (Rai, 2004). It

was a minor pest of coffee. Since this aphid transmit disease in citrus. As citrus tree were also used as shade plant in coffee orchards, it is possible that they may transmit disease in coffee plant.

Among the stem borer, White stem borer and Red stem borer were found most problematic borer of coffee in the study area, because heavy losses were observed during the field visit by Coffee white stem borer followed by Red stem borer. In 2009 Entomology division NARC had carried out a preliminary field research on coffee at Thanapati and Digam VDCs of Gulmi district of Nepal, where Coffee white stem borer followed by red stem borer was the most problematic pest of coffee.

According to NARC (2008) Study done in Kavre and Syangja district of Nepal Green Scales, Mealy bugs, Termites and Mites were also considered as major insect pests of coffee plant. But, this study recorded only few species of scale insects and mealy bugs and it did not observe any Termites and Mites which may be due to short period of study and also due to differ in environmental conditions of the study areas.

Beside insect pests some non insect pests like snail and blight disease were also found problematic in the surveyed area which is comparable to the study done by Entomology division NARC (2009).

Since most of the pests associated with coffee were polyphagous, the two-way ANOVA showed no significant difference in both the cases, total number of insect specimen collected from all the three sites in two seasons and also total types of insect found in three different sites in two seasons. This was possible because coffee is grown in integration with different fruit plants, fodder plants and cereals. Polyphagous pest inflict greater injury to plant in mixed vegetation system compared with monophagous pest changes in microclimate in a land unit on which tree and crops were co-cultivated influence activity within the system. Integration of tree and crops or vice versa may affect colonization of plants by insect pest.

As coffee farming in the study area was done organically the use of botanical pesticides were in practice to control the pests. Botanical pesticides plays

significant role in control of insects like Thrips, Mite, Leafhoppers and Beetles. Most of the pesticides in the past were plant derivatives. Rotenone which is contact poison is found in the root of derris plant; Chrysanthemum is known from hundreds of years for its pesticidal properties and has paralyzing effect in the insects. Neem is known to be the most used plant for the control of pest. There are 125 species of pest of agricultural importance controlled with the help of neem products (Titus et. al., 2005 & Devidson et. al. 1979). Botanical pesticides used to control the coffee pests significantly contributed in the soil fertility also, which could be seen in high positive correlation between organic matter and nitrogen in the soil (Panthi et. al., 2008).

Beside the used of Botanical based pesticides manual clearing was also found in practice for destruction of pest habitat, other management practices such as pheromone traps, light traps, sticky traps and other mechanical methods were also being used by some of the farmers in their coffee orchards with a view to manage Coffee white stem borer and other insect pests. Such methods were also found in practice in the study done by Entomology division NARC (2009). However no use of Bordex mixture was found during the study period as it was observed in the study done by Maharjan (2008) and Khdge et al.(2004) for the control of fungal diseases. It might be because the fungal diseases are less problematic in their coffee orchards.

IPM training had been found provided in three sites of the study area, which was more than 50 %, and provided by different Gos, NGOand INGOs. But due to lack of proper implementation of different strategies it was not found successful.

Maximum coffee growers of the study area were not in view to use pesticides in their field, but very few farmers were in view to use pesticides it might be due to heavy loss in their farm due to pest.

7. CONCLUSION AND RECOMMENDATION

7.1. Conclusion

This study was conducted in three VDcs Ruru, Digam and Thanapati of Gulmi District of Nepal.

A total of 22 types of arthropod pests and 3 types of predators were recorded from the collected specimens during the study period which belongs to seven orders and 15 different families. The orders identified were Orthoptera, Coleoptera, Hemiptera, Homoptera, Lepidoptera, Hymenoptera and Dermaptera. Similarly, the families belonging to these orders are Acritidae, Grylidae, Tettigonidae, Coccinelidae, Cerambicadae, Scarabidae, Tenebrionidae, Pentatomidae, Coreidae, Aphididae, Pseudococcidae, Coccidae, Cossidae, Formicidae and Forcipulidae. Among the recorded pest 16 species of arthropod pest were identified.

On the basis of present investigation it can be concluded that, the major problem of coffee cultivation of the study areas is increasing infestation of White stem borer. Major problematic insect pests were white stem borer followed by Red stem borer. However other insects such as White grubs, Grasshopper and various other defoliators and sap suckers are present on the coffee orchards, but their loss are negligible as compared to the stem borer. The presence of natural enemies helps in establishment of various insect pest populations.

Attack of white stem borer was high in low altitude below 800 m from the sea level than between 800-1000 m from the sea level where as very little was found above 1000 m from the sea level.

Other insect pests like *Leptocorisa* sp., *Aspangopus* sp., *Anomala* sp., *Forcipula* sp., *Dalader acuticosta* Amy, lace bug, and Hairy caterpillar are regarded as minor pest and can be said as visitor on coffee plant. Beside the arthropod pest crop loss is also due to Snails and various fungal diseases. Among the fungal diseases blight disease was consider as major problem.

There is no significant difference between the total numbers of specimens found in three different sites in two different seasons. Similarly, significant difference was not found between numbers of species in three different sites in two different seasons.

As coffee was grown organically use of inorganic fertilizers and chemical pesticides are not found in practice. Plant nutrients are supplied mainly by compost manure. For the control of pest, locally prepared botanical pesticides are found in practice. The botanical pesticides are made by farmers themselves from locally available plants having pesticidal properties.

The shade management practices were not found in proper way in coffee orchards by farmers. High infestation of white stem borer is common where orchards are maintained with insufficient shade.

Various training has been found provided to farmers by various public and private sectors for coffee improvement but they are not focused on white stem borer management, which is the main problem in the study sites of coffee growers. If the problem of white stem borer is not solved properly the coffee farms are completely destroyed by this pest.

Farmers of the study sites are very keen to support and participate research study of White stem borer management. More than 90 % of coffee growers has positive attitude towards organic farming, but very few farmers which is less than 10 % are in view to use chemical pesticides. The use of chemical pesticide was not found in practice and the coffee cultivation in the study area was found totally organic.

Different management practices were used by farmers to control the pest problem in field. Among different management practices organic production and manual clearing were found applied by almost all farmers. Other management practices like pheromone trape, non poisonous sticky trape, light trape, electric trape and various cultural practices were also found in practice.

7.2. Recommendation

On the basis of this study following points are recomended

- Study of white stem borer management should be conducted immediately to tackle the present burning problems of the coffee growers. This can be done by conducting research and development activities to manage the white stem borer in organic way which includes efficacy test of locally available botanicals, efficacy of pheromone traps and efficacy of cattle urine.
- There is the possibility of using predators, parasitoids and microbials for management of White stem borer and determination of traditional host plants on White stem borer in order to avoid the infestation in new orchards.
- Plants infested by stem borer should be uprooted and burned immediately, storing of infested stem is dangerous because it becomes a source of continuous infestation.
- Loose scaly bark of the trunk of coffee plant should be removed by scrapping it with the help of gunny bag or other course materials until the bark is completely smooth and free of crevices. Smoothening of trunk avoid successful oviposition of female as they fall down due to lack of encourage on the trunk.
- Since application of chemical pesticide is not recommended for organic production, use of alternates of chemical pesticides need to explore for control measure of insect pest can be done.
- Since no intensive research covering all aspect of environmental and social parameters has been yet done, so these parameters should be incorporated while doing further research on pest effect on coffee farming.

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Annex 1

List of shade plants commonly used in orchard

S.N.	Local name	Common name	Scientific name
1	Litchi	Litchi	Litchi chinensis
2	Mausam	Mausam	Citrus reticulate
3	Suntala	Orange	Citrus aurantum
4	Kera	Banana	Musca paradiciacal
5	Amba	Guava	Psidium guajava
6	Mewa	Papaya	Carica papaya
7	Naspati	Pear	Pyrus pyrifolia
8	Kimbu	Mulberry	Morus alba
9	Katahar	Jack Fruit	Atrocarpus heterophyllus
10	Anar	Pomegranate	Punica granetum
11	Katus	Chest nut	Castanopsis tribuloids
12	Dalchini	Cinnamon	Cinnamomum vernum
13	Aaru	Peach	Prunus persica
14	Rahari	Pigeon pea	Cajanus cajon
15	Sal	-	Sorea robusta
16	Amliso	Ipil ipil	Leucaena leucocephala
17	Khainyu	Fig	Ficus semicordata
18	Avocado	Avocado	*Avocado* sp.
19	Amilo	-	-
20	Kagati	Lemon	-
21	Asuro	Malabar nut tree	*Justice adhatoda*

(-) not known

Annex 2

List of Questions

Survey questionnaire

Central Department of Zoology, Tribhuvan University, Kathmandu

Survey ID number:……..

Date of interview:…….

Do you agree to participate in the survey 1. Yes 2. No

District:……

Village:……

Ward No.:……

Name of respondent:……

1. How much area of cultivated land do you have?
2. In how much area do you cultivate coffee?
3. How many coffee plants did you planted in your field?
4. What is the age of coffee plants?
5. How many years, you have been doing coffee farming?
6. How much do you earn by selling coffee?
7. Which cropping pattern have you adopted for coffee cultivation?
8. What are the plants you have grown for shade?
9. Pest related informations:

9.1. Have you noticed pest incidence in coffee orchard?

S. No.	Pest	Type of pest problems	Time

9.2. What are the major insects that are harmful to coffee plant?

10. Knowledge and practice of pesticide

10.1. Do you use pesticides in your field? If yes which pesticides have are used and why do you use it?

10.2. How long you have been using pesticide?

10.3. How many times do you have been using pesticide in coffee field?

10.4. Do you think pesticide have adverse effect on human health?

10.5. What do you think about the use of pesticides?

a. Should not use at any level
b. should be decreased
c. Should be increased
d. Use in same trend

11. Integrated pest management

11.1. Do you heard about integrated pest management?

11.2. If yes do you currently practice any IPM, management?

11.3. If yes which method do you use for management of pest?

a. Organic production
b. Biological control
c. Smoke
d. Light trape
e. Electric trape
f. Rotation Of crop
g. Mannual clearing
h. Enemy plants
i. Pheromone trape

11.4. If not why don't you practice IPM?

11.5. Did you receive any training related to IPM?

12. Do you have any opinion for the safe management and use of pesticides?

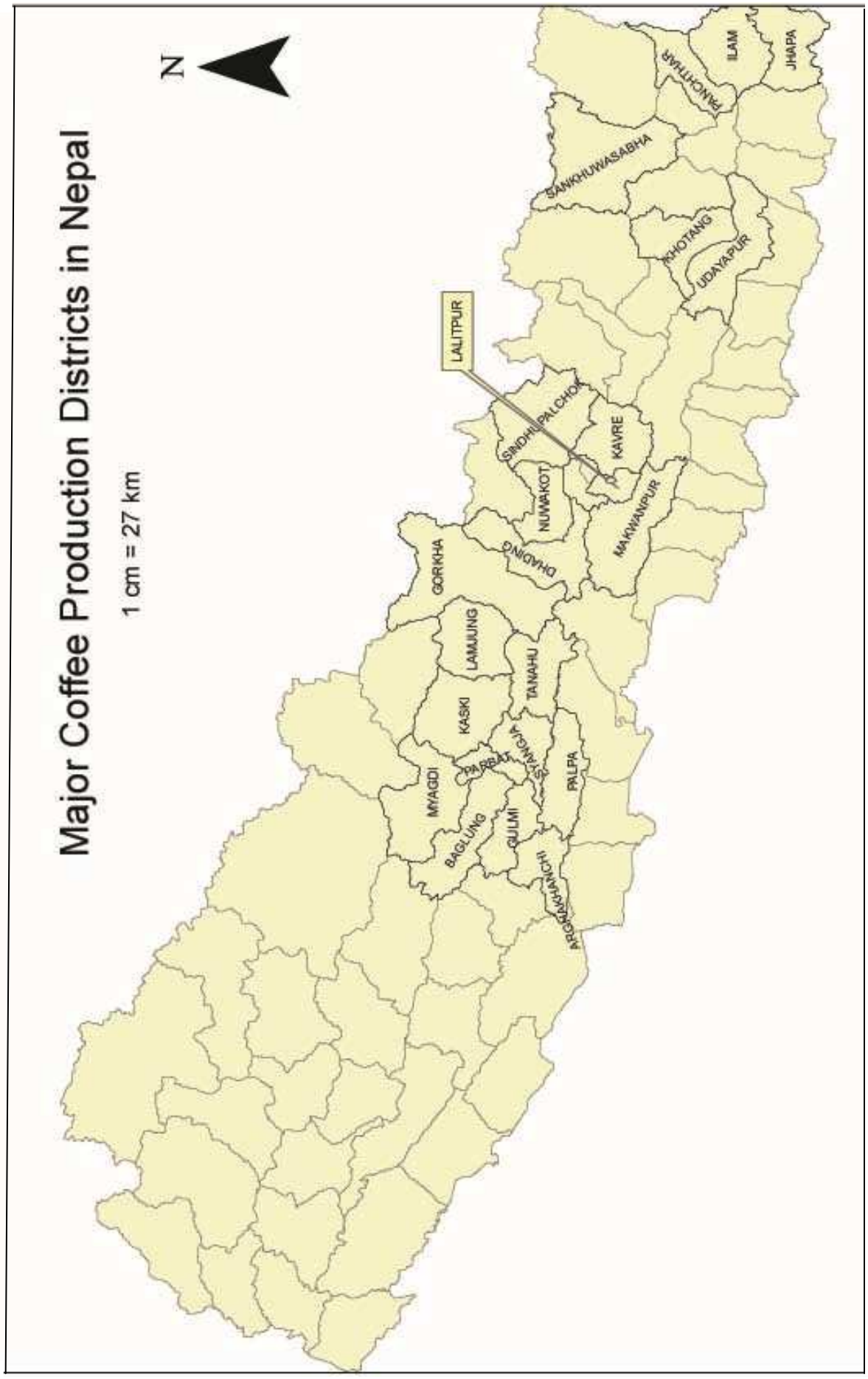
ANNEX 3

Classification of insects

S.n	Orders	Family	Genus	Common name
1.	Orthoptera	Acritidae	*Catantops* sp.	Short horned grassoper
		Grylidae	*Gryllus* sp.	Fieldcricket
		Tettigonidae	-	Long horned grassoper
2.	Coleoptera	Coccinelidae	*Coccinela* sp.	Lady bird beetle
			Calaposoma semicostatum Jac.	Leaf beetle
			Calaposoma metallicum Clark.	Leaf beetle
		Cerambycidae	*Xylotrechus quadripes* Chevr.	White stem borer
		Scarabaeidae	*Holotrichia* sp.	White grub
			Cicindela sexpunctata L	Tiger beetle
			Anomala sp.	Leaf beetle
		Tenebrionidae	*Gonocephalum* sp.	Darkling beetle
		Chrysomelidae	*Aspidomorpha sanctai crucis* Fab.	Tortoise beetle
3.	Hemiptera	Pentatomidae	*Aspangopus* sp.	Stink bug
		Tingidae	-	Lace bug
		Coreidae	*Leptocorisa* sp.	Rice bug
			Dalader acuticosta Amy	-
		Reduviidae	-	Assassin bug
4.	Homoptera	Aphididae	*Toxoptera aurantii* Boyer	Aphid
		Pseudococcidae	*Planococcus* sp.	Mealy bug
		Coccidae	-	Brown scale
5.	Lepidoptera	Cossidae	*Zuezera* sp.	Red stem borer
		-	-	Hairy caterpillar
6.	Hymenoptera	Formicidae	-	Red ant
			-	Black ant
7.	Dermaptera	Forcipulidae	*Forcipula* sp.	Ear wig

(-) not known

ANNEX 4


Major Coffee Production Districts in Nepal
1 cm = 27 km
N
ILAM
JHAPA
PANCHTHAR
TAPLEJUNG
SANKHUWASABHA
KHOTANG
UDAYAPUR
LALITPUR
SINDHUPALCHOK
KAVRE
NUWAKOT
MAKWANPUR
DHADING
GORKHA
LAMJUNG
TANAHU
KASKI
SYANGJA
PARBAT
MYAGDI
PALPA
BAGLUNG
GULMI
ARGHAKHANCHI