1. INTRODUCTION

1.1 Background

Coffee is one of the most important and widely consumed beverages in the world. It is produced from the plant *Coffea arabia* belonging to family Rubiaceae. It is distinctly a tropical cash crop and requires a hot moist climate with an average rain fall of at least 1250 mm and prefers 1875 mm to 3000 mm of average annual rainfall. The optimum temperature for coffee ranges from 15 - 25 ^{0}C which is a condition found between 1000-2000 m in equatorial area. (Sharma 1996, Goto et al. 1994)

Coffee is grown throughout the tropic belt in Brazil and Mozambique in the southern and Taiwan in the northern hemisphere. It is found at an elevation ranging slightly above the sea to altitude of 2400 m in Ecuador. The soil in which coffee is grown also varies widely for example brown red lateritic loam or clay loam of volcanic origin in Ethiopia, latosols in Liberia alluvial schist in New Caledonia, Metamorphic schist in Portuguese Timor.(Krug et al., 1968)

The knowledge of coffee and its use is not certainly known. It seems to be discovered by accident. It is considered to be a native of Ethiopia and carried to Arabia in 15th century. 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 1770. Coffee has been in general use as beverage for about 300 years only(Sharma, 1996)

Coffee consist an alkaloid called caffeine which is of medicinal value acting as a diuretic and nerve stimulant. It is the most important beverage plant from commercial standpoint. Coffee drinks is considered as one of the prestigious beverage as most business deals are discussed on a “cup of coffee” in government and private offices of Western countries even labour group fight for coffee break where important events of the day are common subject of discussion. Media men get into their days beat from “coffee talks” A farmer prides himself in the early dawn with streaming black, coffee before he meets the vagaries of nature. These are only few things that make coffee important whenever if it is found and used. [Shrestha, 2004]

1.2 Production and consumption of coffee in the world

The chief area of coffee production has changed during the years. At first Arabia led but replaced by West Indies, Indonesia and Brazil. Sri Lanka was an important producer from 1830-1875 but the industry was destroyed by blight. Today Brazil stands pre-eminent and alone producers 25% of total world supply. Colombia, Indonesia, Mexico and Vietnam are next to Brazil. Coffee is the principal crop and chief source of revenue and economic structure of the country is dependent on coffee trade. 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 the United Kingdom (Sharma, 1996).

1.3 Coffee in Nepal

Agriculture is the backbone of Nepal. According to the 2001 census about 67% population is engaged in this sector. The main source of production income and employment generation heavily depends upon this sector. There are two main branches of agricultural production, food crops and cash crops. Due to differences in geographical areas, soil and climatic condition, single pattern of agricultural activity is not suitable. In the hilly region and higher mountain area cultivable land for food production is limited so greater emphasis is given for the development of animal husbandry and horticulture whereas food grain and cash crops are more suitable in mid hills, valley and Terai. Similarly specific cash crop should be developed on the basis of geographical climate, soil condition etc. Hence crops are produced in typical area where geographical setting is favorable. Such as tea is produced in the eastern part of Nepal and coffee is produced in the western part of Nepal. Coffee is comparatively new cash crop grown commercially in Nepal.

It was introduced by a saint Hira Giri in Aapchaur VDC of Gulmi district in 1944 AD (Shrestha, 2004). Coffee is now planted in 25 districts. Gulmi, Kaski, Palpa, Syangja, Kavrepalanchowk and Lalitpur are commercially significant districts. Nuwakot, Parbat, Tanahun, Gorkha and Lamjung are the area with commercial orientation. Ilam Sankhuwashava, Dhading, Baglun, Makawanpur, Jhapa, Panchthar, Surkhet,

Terhathum and Sindhupalchowk are new emerging coffee producing area of Nepal (FNCCI, 2006).

1.3.1 Present status of coffee cultivation and plantation in Nepal

The area coverage of coffee plantation today is 1285 hectare (ha) and the bean production has reached 391metric ton (mt). About 1500 farmers are involved in coffee cultivation in Nepal

Table 1: Coffee plantation area and production (in last 5years)

Fiscal year	Plantation area (ha)	Production of Dry cherry (mt)
2058/059	596.00	139.20
2059/060	764	187.50
2060/061	952.20	217.60
2061/062	1078	250
2062/063	1285	391

Source Tea-A-Tea, NTCDB 2064

It is known from the above table that coffee is gaining popularity day by day. Annually total production and production area is increasing by 35% and 28% respectively. And within two years a rapid increase is expected as here are many zones for production. The farmers residing these zones have realized that coffee cultivation is more beneficial than customary cereal production and livestock farming.

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 on behalf of the important instant coffee, its consumption level is not that encouraging in the domestic market. However, about 25-30% of the domestic demand is estimated to be fulfilled by the local production. The major consuming domestic markets are Kathmandu, Lalitpur and Bhaktapur. Nepal exports only super quality green beans to overseas markets. Medium and low quality green beans are roasted, grinded and sold in the domestic market (FNCCI, 2006).

In Nepal coffee is grown organically. Organic coffees are in great demand in the developed countries because of awareness, health of consumers and protection of environment. This is one of the main reasons for Nepalese coffee to be in high demand in the developed countries. The export import figure of coffee in Nepal is given below.

Table 2: Export import figure of coffee in Nepal (2058/59-2062/63)

Fiscal year	Export		Import
	Amount(kg)	Price(NRs)	Price(NRs)
2058/059	9075	2455250	4621057
2059/060	16861	5204526	141968
2060/061	24295	5946890	409972
2061/062	6500	-	168341
2062/063	91500	-	2264991

Source: Tea-A-Tea, NTCDB 2064

Nepal had imported instant coffee worth NRs 2.2 million and exported 91500kg in a fiscal year. The above data indicate that coffee export is a promising means of earning foreign currencies and can be an aid to increase country's economy. The main international markets of Nepalese organic coffee are Japan, Holland, USA, Europe and China.

1.3.2 Importance of coffee cultivation in Nepal

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.

There are varieties of coffee but Arabica coffee has got the preference in Nepal as per its suitability. Coffee consumption is mainly confined in urban area and high level society however its demand is increasing because of rapid urbanization and increase in the number of tourists.

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 bonded for labour. Since coffee is grown under shade if provides an ample scope to grown more plants thus conserving the soil, maintaining bio-diversity and watershed balance in the mid hills of the country.

1.4 Problems

Coffee is a plant of wide adaptability, diseases of coffee are numerous. Coffee is a perennial plant and requires shade for its proper growth; varieties of pests inhabit the plant in different part and in different season with different damage pattern and intensity depending on climate, altitude and cultural practices. In addition, coffee is planted under different shade plant also shelter a number of pests. The casual 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, mealy bug, stem borer, thrips, beetles, caterpillars etc.

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

Information of 290 species of Coleopteran belonging to families Melolonthidae, Scarabeidae, Trogidae, Pssalidae collected in Mexican localities with coffee plantations traditionally cultivated under tree shadow (Angel, 2004).

The coffee industry in Ceylon offers a striking example of the damage which a fungus disease can do to an industrial crop. By 1867, about 50,000 ha were planted to coffee and exports were considerable. In 1869 the coffee leaf rust, *Hemileia vastatrix*, was first noticed and within 20 years it had caused the complete collapse of the coffee industry. By 1953, less than 20 ha were left mainly in peasant's gardens at higher altitudes where leaf rust is less damaging.

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

1.5 Objectives

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

1. To collect and identify the insect pests and study their status.
2. To find out the current management practices in the orchards.

1.6 Justification

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

1.7 Limitations

The present study was carried with limited time and financial resources. 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

A brief review of literature on various studies related to the present study was done till the completion of this work to achieve clarity in the discussion that follows.

2.1 Origin and dispersion of coffee

The origin of coffee remains shrouded in the legends and myths of the Middle East. One legend tells 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 tasted the berries himself, he realized what had prompted the goats' uncharacteristic behavior. Kaldi shared his discovery with the inhabitants of a nearby monastery, who developed a fondness for the fruit and its seeds, the coffee beans encased in each berry. By drinking the beverage that resulted from boiling the berries, the monks 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. Whether it was Kaldi or Omar who first discovered it, coffee is considered native to the African country of Ethiopia. At least 1,000 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 (www.baldmountaincoffee.com).

By the early 1500s, coffee seeds had already made their way to Turkey, Egypt and Syria, Constantinople, Damascus and other near Eastern Cities all boasted their Arabian influenced coffeehouses - essentially places where patrons lingered over coffee, conversation, 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 tender loving care these first coffee tree seedlings received. By 1658 the Dutch had begun cultivation in Ceylon and their East Indian colony of Java (www.baldmountaincoffee.com).

The credit for bringing coffee to the New World goes to Gabriel Mathieu de Clieu, a French Naval Officer who believed the plant would do well in Martiniques warm temperature and rich soils in about 1720 (www.baldmountaincoffee.com).

2.2 Ecological requirement

The evergreen nature of the coffee plants requires it to have access to water for transpiration throughout the year, but it also requires a dry period to initiate authesis. Therefore, the moisture regimes under which coffee is grown can be critical. An annual rainfall between 1100 and 2000mm, with a 3-4 month dry season, is ideal for Arabica coffee, but longer dry season can be tolerated if weather conditions are conductive to low evapo-transpiration (i.e. cool, cloudy, with low wind speeds) or if supplementary irrigation is applied. The crop will also tolerate wetter conditions providing there is adequate drainage. Coffee grows best in deep, friable soils with pH 5.5-27 typical of the volcanic soils in many parts of tropics. (Walker et al., 2007)

Arabica grows best in cool climate with avg. temp in the 15-25^{0}C range, conditions usually found between 1000-2000m equatorial areas. However, it is grown at low altitudes at the edge of the tropic where winters are cool and dry, providing there is no frost. Pest and disease incidence is greatly affected by the prevailing temperatures at different altitude with rust, leaf miners and stem borer more severe at lower altitude/higher temperature and coffee berry disease worse under the cooler wetter conditions at higher altitudes. (Walker et al., 2007)

High temp.(>28^{0}C) induce abnormalities such as star flowers and reduce yield while cold temp.(<7^{0}C), 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^{0}C is damaging). (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 also can be source of scales and mealy bugs. Inter-planting arable crops can damage feeder roots or stem bases of plant to soil born pathogen. However, mixed perennial cropping is common for the high yield from the field. Mulching is desirable practice that reduces weed growth retains soil moisture and provides organic matter and nutrient to the

rooting zone. Pruning is another practice that encourages and controls the production of plagio-tropical shoots that will bear the following seasons of and to control the density of canopy. (Walker et al., 2007)

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 bad weather. Coffee plants stay in the seedling nursery for 4 to 12 months, depending on the environment. Once the seedlings reach maturity, the coffee grower will plant them in his coffee field. Coffee plants usually have a life-span of thirty to fifty years. (www.burundicoffee.com)

2.4 Coffee tree pest and their impact upon coffee production

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

Angel, 2004 has presented a brief review on available information of 290 species of Coleopteran belonging to families Melolonthidae, Scarabeidae, Trogidae, Pssalidae collected in Mexican localities with coffee plantations traditionally cultivated under tree shadow.

There are many beetles that lay egg on the bark of Arabica coffee tree. Once these hatch the larvae bore and cause havoc to the tree. Perhaps the most serious coffee tree pest 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. These pests can again be controlled by the use of dieldrin

solution; in this case the solution is applied through the lowest frass hole (Coffee and Conservation, 2007).

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 on the developing bean. Usually, the cherry drops from the tree. The best defense is making sure there are no unpicked beans left on the 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.coffeehabitat.com).

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. For example Red branch borer, *Zeuzera coffeea* belonging to family Cossidae of order Lepidoptera has proven serious pest on many different crop plant. It is a polyphagous pest widely spread in Orient whose main host is coffee plant. The young larvae after hatching bore straight into the branches forming cylindrical tunnel along the branch in the trunks of both woody and shrubs and tree usually killing the branch distally. The larvae are stout bodied and dark reddish in colour with a black head (Hill, 1993).

Similarly coffee is the main host of coffee hawk moth *Cephonodes hylas* belong to family Sphingidae of order Lepidoptera. The larvae eat leaves and heavy infestation may actually defoliate the host tree. It was a very serious pest in Malaya. It is a widespread species frequently encountered in different parts of the worlds (Hill, 1993).

The caterpillars 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 measures about 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 characteristic hyaline wings. It is one of the few diurnal species. The species in quite distinctive because of midrange red band on two segments followed by two yellowish segments (Hill, 1993).

The coffee leaf miners (*Leucoptera spp.*) are the major pest of coffee in Africa and South America. Infested plants have brown irregular blotches on the upper surface of the leaves; the blotch mine is inhabited by number of small white caterpillars. Mined leaves are shed prematurely (Hill, 1993).

Mealy bugs are among the most serious sucking pests of Robusta and Arabica coffee. These damage coffee plants by sucking the sap from the tender parts. 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 reduced in size and aborted with considerable reduction in 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 the mealy bug, protecting the mealy bug and preventing the roots from absorbing nutrients. This results in weakening or death of the plant.

Different species of ants feed on the 'honey-dew'. Ants protect the bugs from natural enemies. Ants are providing favourable conditions for breeding and protection from negative effects like direct sunshine and the effect of rains. Occasionally ants carry the mealy bug 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 favourable for ants to breed in. The mealy bug population increases 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 parasites from Uganda in 1938, it has been reduced to a minor pest. *Saissetia coffeae* is considered a minor pest of Arabica and Robusta, very occasional severe 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. It is sporadically serious pest of Arabica coffee grown below 1700 m. in Africa. *Planococcus citri* which is also known as citrus mealy bug or root mealy bug is a polyphagous pest whose main hosts are 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 disease. It was first detected in Australia in 1992 in banana cultivars Mysore, now been detected in a range of cultivar in Queensland land New South Wales (www2.dpi.qld.gov.au/horticulture/5047.html).

Aphids are of great economic importance since they suck up plant sap, hamper plant growth as well as spread several plant virus 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 budding. Adult females are viviparous. Some aphids are the vectors of viral diseases of some plants (Tamrakar & Singh 2000).

The main host of *Toxoptera aurantii* is citrus. Tea, coffee, cocoa 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 25^0, single generation completes in 6days but above 30^0 C aphid population decline sharply (Hill, 1993).

2.5 Management of pest

Coffee is second most-drunk beverage in the world after water. Coffee beans have become the most heavily-traded agricultural commodity. Conventionally produced coffee is the third most heavily chemically treated crop in the world (Zonis, 2006).

Endosulfan (brand name Thiodan) used against coffee berry borer which is not readily dissolved in water and stick to soil particle; 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 endosulfan worse than coffee berry borer as more than 100 human poisoning and one death were attributed during 1993 and more than 100 poisoning and 3 deaths in were reported in 1994. Similarly Chlorpyrifos which is a broad-spectrum organophosphate used against berry borer and leaf miner is a contact poison. It has caused human deaths and has been linked to birth defects (Coffee and Conservation, 2007).

Monoculture of coffee in a farm using large amount of pesticides and insecticides leads to the contamination of the beans. Poisoning cases, development of pesticide resistant, consumer concern about the pesticide residue on food and the effects of pesticide in the environment have triggered a search for alternative cultural, physical and biological methods. These alternative method have not been found effective in controlling pest when applied singly so concept of Integrated Pest Management (IPM) is a desirable control technique which also advocate minimal use of pesticides. Moreover cost of production is increased in conventional farming so farmer, especially the one with low holding all over the world are shifting back growing coffee under shade. Growing coffee under the shade reduces the pest problem due to existence of sustainable ecosystem in the farm. Farmers are also resorting organic pesticides to combat the pests as these pesticides can be produced locally. This has ensured quality coffee for the consumer and profitable farming for coffee growers.

The Central Coffee Research Institute (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 paste 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 biopesticide treatments were effective against the mealy bug by causing direct mortality and to some extent also by acting as repellents and the parasitoid was relatively safe from its effect. The treatments

included extracts of Tulsi (*Ocimun sanctum*), Bilwa (*Aegle marmelos*), Milky weed *(Calotropis gigantea)* -Marigold (*Tagetes erecta).* Hence, these bio-pesticides could be used under situations where coffee is organically 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 (*Azedirechta indica)*, banmara (*Eupatorium odoratum*), bakaino (*Melia azadirach*), dungri phool (*Lantana sp.)*, tobacco (*Nicotiana tabaccum*), gandhejhar *(Ageratum sp.*) are some of the examples which could be used in the control of insects.

Neem is known to contain over hundred biologically active constituents that can be used in various agricultural formulations like insecticide, bactericides, antiviral compound. Research data suggests that more than 300 species of insect 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).

Many plant derived preparation comprises and array of plant chemicals which act upon both behavioral and physiological processes. Some may possess insecticidal properties while other repel pest or discourage feeding or egg laying activities.

3. STUDY AREA

3.1 Background

The study area, Madanpokhara is one of 65 Village Development Committee (VDC) of Palpa district. It is a potential coffee pocket of the district. It is just 10 km far away from Tansen Municipality. It has good transportation facility as it is situated along Siddhartha Highway.

The total population of this VDC is 6222 and total household is 1235. The average household size is 5. Of the total population 2430 are children (between 0-14 years age group) forming economically inactive group, 3276 are economically active group (between 15-59) and 534 are aged category (above 60 years). The literacy rate of the VDC is 60% out of which 31% are male and 29% are female constituents (District Demographic Profile of Nepal 2002).

3.2 Location

Topographically Madanpokhara lies in 83^0 32' 53.24" East (E) - 83^0.34' 9.78" E and 27^0 47' 37.54" North (N) - 27 50' 8.32 N.

3.3 Soil and topography

The soil constituent of Madanpokhara consists higher percentage of sand which differ in physical structure and degree of fertility. The altitude of Madanpokhara ranges between 700m to 1200m the mean sea level.

3.4 Land use

It covers an area of 18.14 square kilometer (sq km) with cultivated land area of 0.9 sq km, open wood forest of 7.39 sq km, scrub of 1.12 sq km settlement area of 8.73 sq km.

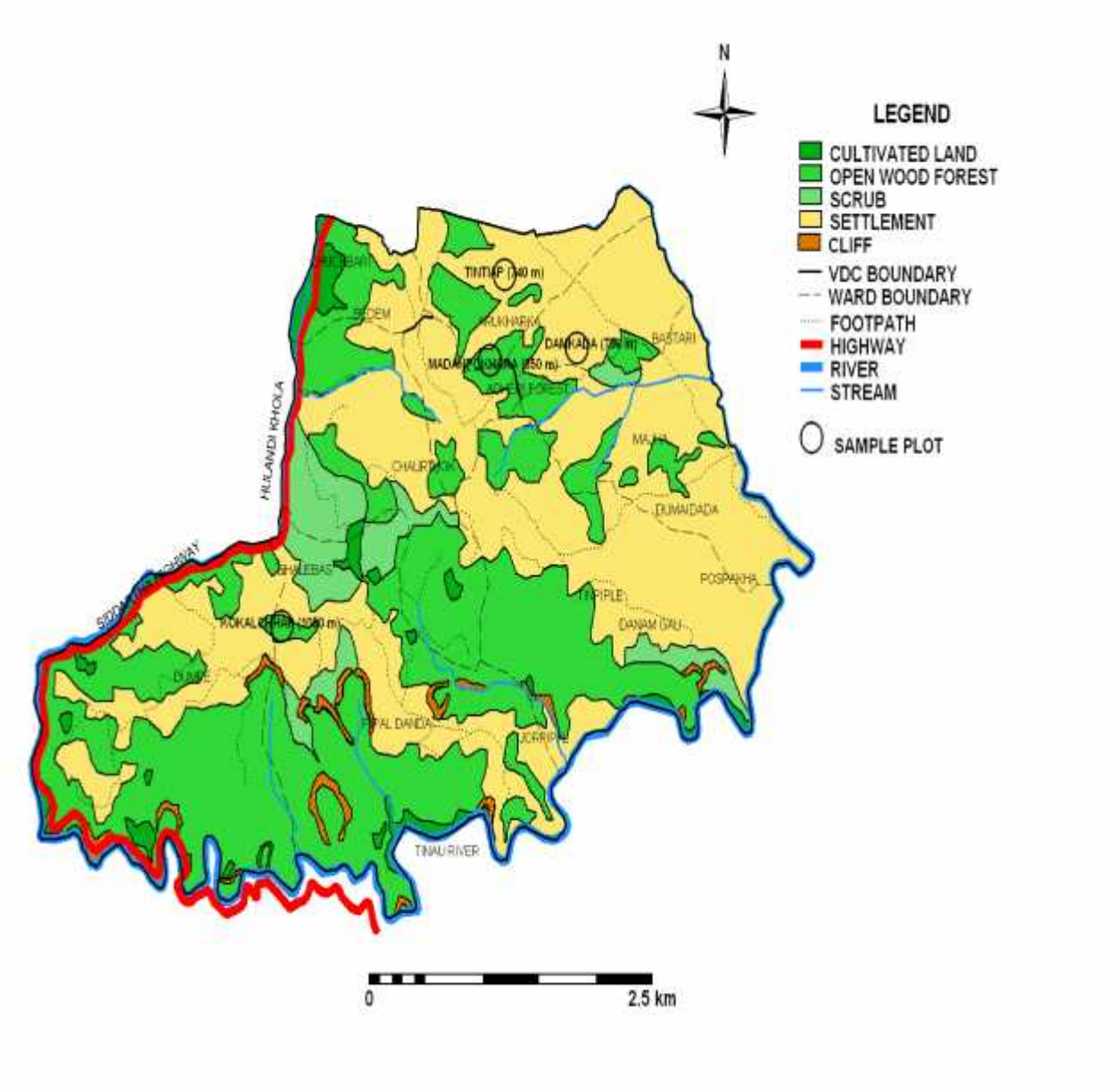

Figure 1: Map of Madanpokhara VDC, Palpa

3.5 Climate

As the climatic data of Madanpokhara was not available so the climatic record of the nearest meteorological station, Tansen (27^0 52' N-83^0 32' E, elevation 1067 m) was used. The climate of Madanpokhara is sub-tropical type.

The mean monthly temperature ranged from 6.82^0 C in January to 30.6^0 in June.

December, January and February were the coldest months while June, July were the hottest month. Similarly the average monthly relative humidity ranged from 60.32 in April to 89.44% in July. The most humid months were July, August, September and October. The average annual rainfall ranged from 3.2 mm to 398.12 mm. June, July and August was precipitous months (Source: Dept. of Meteorology and Hydrology, 2007).

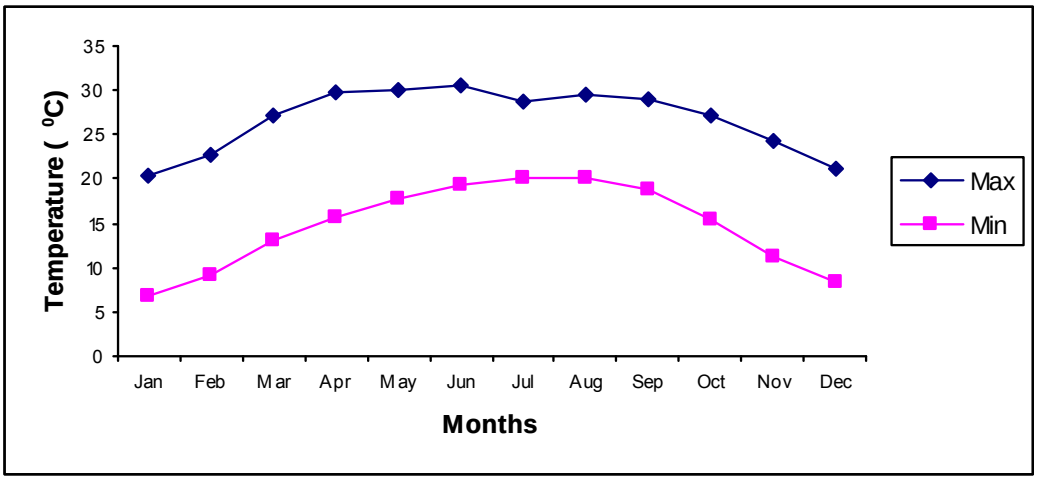

Figure 2: Monthly Average (Five yearly, 2002-2006) Maximum and Minimum Temperature for Tansen.

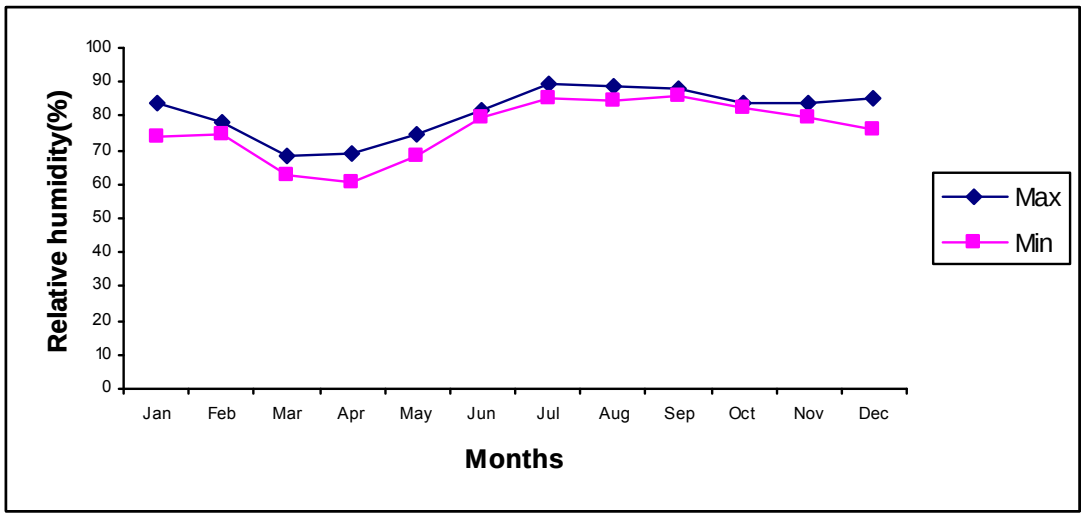

Figure 3: Monthly Average (Five yearly, 2002-2006) Maximum and Minimum Relative Humidity for Tansen

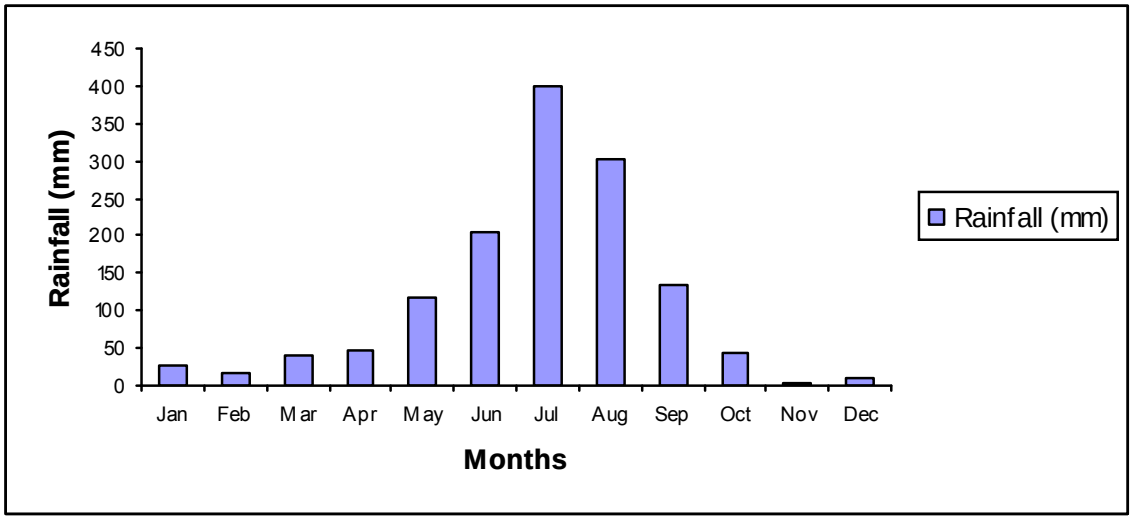

Figure 4: Monthly Average (Five yearly, 2002-2006) Maximum and Minimum Rainfall for Tansen.

3.6 Coffee history in Madanpokhara VDC

Coffee cultivation in Palpa district started in 1978 A.D. Madanpokhara VDC of Palpa holds the history of commercial coffee cultivation within the district. The seedlings of coffee were provided by government nursery till 1981 A. D. The farmers started using their own plant material after the establishment of private nursery. The cultivation was also favored by the establishment of Tinau Watershade Management Project and

was on the peak till 1989 A.D. But lack of proper marketing facility, high infestation of borer and lack of pest management knowledge, overshadowed the charm of coffee cultivation. To overcome these problems farmers of Madanpokhara established an institutional body, Nepal Coffee Producers Association (NCPA) in 1990 A.D. consisting of number of coffee producers group. This institutional body is working since then. It became member of Central Federation in 1997 A.D. and was registered in June 2000 A.D. NCPA is working to standardize coffee farming practices among farmers and providing marketing support to farmers group. District Coffee Producers Association (DCPA) is the body of NCPA in coffee producing districts is in close contact with the farmers.

4. METHODOLOGY

4.1 Data collection

The study was based on primary as well as secondary data collection. The secondary data had been collected from different sources like related publications, websites, government and non-government institutions.

The primary data had been collected by visiting the study sites. Madanpokhara, the study site was visited twice covering pre-monsoon June 6^{th}-12^{th}, 2006 and post monsoon seasons October 31^{st}- November 6^{th}, 2006.

Key Informant Survey (KIS) and Focus Group Discussions (FGD) were done to explore overall situation of coffee cultivation. The list of participants of KIS and FGD and the set of question asked during FGD are given in appendix 5 and 6 respectively. Within the VDC few representative sites were selected for survey on the basis of three altitude category utilized for coffee cultivation. The altitudinal categories were noted as site A (below 800m), site B (between 800m-1000m) and sites C (above 1000m).

4.2 Pest collection

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

Soft specimens which occurred in cluster were collected by using soft brush and put in the preservative. Beating process as well as use of aspirator was also applied for the collection of small insects.

Each specimen was then labeled including date of collection condition of host plant and location. The collected specimens were then brought to the laboratory of Central Department of Zoology, Tribhuvan University for their identification.

4.3 Photography

The specimens were then photographed by Sony Cyber shot 5.1 digital camera. The photography of nursery plants and infestations of pest in natural state were also done.

4.4 Identification

The identification of the pests was done by taking guidance from research supervisor.

4.5 Two-Way-ANOVA (Analysis of Variance)

Seasonal variations in total number of insects collected in three different sites (A, B and C) and in two seasons (pre-monsoon and post-monsoon) 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 and two different seasons were tested.

4.6 Geographical Information Survey (GIS)

GIS was applied for the map of Madanpokhara VDC of Palpa, Nepal.

5. RESULT

5.1 Result of KIS and FGD

There were five producer groups in Madanpokhara with about 97 members all together. Farmers associated with coffee producer groups must plant at least 50 plants in their orchards. Associated members had the highest of 700 plants. Average plants per member of the group were 90.

However the number of coffee planted in orchard varied according to farmer purpose of cultivating coffee. Within the VDC farmers with 4-5 plants were also noticed who planted coffee in their kitchen garden. Some had planted coffee in the garden just to test their adaptability whereas few had planted just for ornamental purpose.

It was found that coffee was grown in low land, upland and sloppy upland. Coffee in upland was grown with partial irrigation while in lowland it was grown with good irrigation facility and in sloppy upland with no irrigation facility.

5.1.1 Cropping pattern

The main cropping pattern adopted by farmers was found as given below.

1. Intensive multi-cropping pattern
2. Coffee mixed with fruit and fodder
3. Coffee under forest
4. Coffee in kitchen garden
5. Solo coffee with shade
6. Coffee in edge of upland

Among these patterns the intensive multi-cropping pattern was found dominant which consist of three layers of plant with coffee in the middle layer fruit trees in the upper layer and supplementary crop in the lower layers. Legume, vegetables, spices and cereals were the supplementary crops. Coffee mixed with fruit and fodder pattern was mainly observed in the upland and sloppy upland where the primary interest was production of food for market sale. The production of fodder was another interest in the farm with large number of livestock.

5.1.2 Shade management in coffee orchard

Coffee cultivation requires good shade in order to get good production and also for protection from pests and diseases but shade was not found properly managed in the orchards. The farmers were well aware of the consequence of poor shade management still there was no good practice on it. Both heavy and medium shade were essential in the orchard with respect to small and big coffee plants

Majority of shade was provided by tree fruits and fodder. Banana, Litchi, Guava, Pear were the most used fruit plants in the orchard. The farmer responded the best option for heavy shade management was Jack Fruit. Heavy shade is essential for small plants during the winter as the misty condition make them susceptible to different diseases.

Both indigenous and imported plants were found in the orchard however farmers seemed to be anxious about the effectiveness of the shade plants used. A number of respondents did complain about *Ipil ipil* plant not good enough to use in their orchard because of the fly, which hampered them all year round. A list of shade plant used in the orchard is given in Annex 1.

5.1.3 Weeds in coffee orchard

The weeds in coffee orchard 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 and Goat weed were much abundant. Goat weed, being an odorous plant was also used to make the bio-pesticide by the locals which might be a reason why it was not considered as a problem in the orchard

These weeds were controlled by hand weeding. The list of weeds in coffee orchards is given in the table below.

Table 3: List of common weeds in coffee orchard.

S.No	Local name	Common name	Scientific name	Family name
1	Siru ghans	Cogon grass	*Imperata cylindrica*	Gramineae
2	Gandhe jhar	Goat weed	*Ageratum conyzoides*	Asteraceae
3	Banmara	Siam weed	*Eupatorium adoratum*	Asteraceae
4	Dudhe jhar	Snake weed	*Euphorbia hirta*	Euphorbiaceae
5	Kalikuro		*Bidens spp*	Asteraceae
6	Dubo	Bermuda grass	*Cynodon dactylon*	Gramineae
7	Chariamilo		*Oxalis latifolia*	Asteraceae

5.1.4 Incidence of insect pest in coffee plant

As per farmer, the trend of incidence of insect pest was increasing day by day. It was found that farmers in the group in the lowland were interested in diversification due to heavy loss cost by insect as their income was not proportional to their effort in growing coffee. The major insect problem as perceived by farmers, their time of attack on plant stage and basis of identification and protection major are given below.

Table 4: List of insect problem as perceived by farmers their time of attack on plant stage and basis of identification.

Insect pests	Time of attack	Plant stage	Basis of identification
Soil insect pest			
Field cricket	Year round	All stages	Visible
Foliage pests			
Scale	Summer/Autumn	Old plants	Incrust foliage
Aphids	Year round	Young leaves	Visible
Hairy Caterpillar	Autumn/Winter	Young leaves	Larva with hairs
Fruit pests			
Scales	October-December	Unripe fruit	Incrust fruit
Mealy Bug	,,	,,	Visible
Black ant	October-January	Ripe fruit	Visible
Stem pest			
White stem borer	Year round	Old plant	White bodied black headed larva
Red stem borer	September-November	Young stem and branch of old plant	Red bodies and black headed larva
Nursery pests			
Loopers		Young leaves	Visible

Apart from the above listed insect pests farmers mentioned about non-insect pest of nursery and ripe fruits. Snails were prominent in the nursery infesting seedling thus causing damage in the nursery and rodents like rats and squirrels were troublesome during fruit ripening stage. However no any pests were mentioned as storage pests.

Among the listed pest the stem borers were the most harmful causing economical damage. The white stem borers in two sites A and site B were found causing economical loss. It was not complained from the site C.

Farmers were not much worried about the foliage pest. They were found aware of damage done by mealy bug and had noticed the incidence of ants on the fruits and leaves incrust by them.

5.1.5 Loss due to insect pest

The approximate loss by insect pest in the three different sites A, B and C were given as 60%, 30% and 20% respectively which was very much high in the site A.

The loss incurred due to insect pest was mainly determined by counting number of plants dead. The loss was also analyzed by comparing the yield per plant and also by comparing the last year's production.

5.1.6 Pest management practices by farmers

As the farmers were intended to grow coffee organically, use of chemical pesticide was not found in practice. For the control of insect pests a locally prepared organic pesticide called as “Jaibik Bikshadi” was found in practice. Locally available “Neem tel” was also used as pesticide for the control of insects like aphids, scales and mealy bugs.

The organic pesticide was prepared by mixing the crushed leaves of locally available odorous plants and cattle urine in a drum and allowed to ferment for about 45 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 orchard annually after pruning.

The farmers gave the following local plants being used as raw materials to prepare pesticide.

Table 5: List of plants used to prepare pesticide

S.no	Local name	Common name	Scientific name	Family name
1	Lasoon	Garlic	*Allium sativum*	Amaryllidaceae
2	Bakaino	China berry	*Melia azadirach*	Maliaceae
3	Neem	Neem	*Azedirechata indica*	Maliaceae
4	Khursan	Hot pepper	*Capsicum annum*	Solanaceae
5	Surti	Tobacco	*Nicotiana tobacum*	Solanaceae
6	Sisnoo	Stinking nettle	*Utrica dioca*	Utricaceae
7	Pudina	Mint	*Mentha arvensis*	Labiateae
8	Sayapatri	Marigold	*Tagetus spp*	Asteraceae
9	Gandhe jhar	Goat weed	*Ageratum conyzoides*	Asteraceae
10	Titepati	Mug wart	*Artemesia vulgaris*	Compositae
11	Timmur	Prickly ash	*Xanthoxylum armatum*	Rutaceae
12	Aduwa	Ginger	*Gingiber officinalis*	Zingiberaceae

Similarly Neem tel was diluted with water in the ratio of 2ml per liter. This formulation was used at least once a year.

For the borer the following local cultural practices were done.

1. Red stem borer - Training and pruning of infested branches.
2. White stem borer - Scrubbing with jute sack and other coarse materials on the rough bark of the plant.
   - Plastering the mixture of red mud and cattle urine in 1:1 ratio on the infested part.

Farmers responded that prevention was better method for the stem borers. Regular inspection of coffee plant and smoothening of stem by scrubbing with jute sack and other coarse materials prevent the egg laying by the adult beetle on the rough bark of the plant.

Apart from all these practices farmers were found to use Bordeaux mixture to protect plant from diseases. The mixtures used were Copper Sulphate and Calcium Oxide in 1:1 ratio. Then 1% solution was made ready to be used in coffee plant.

5.1.7 Tools used for application of pesticide

The use of hand sprayer was made for the application of Bordeaux mixture whereas broom, brushes were used for the application of other botanical pesticide.

5.1.8 Time of application

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

5.2 Field Observation

Two field visits were done in order to explore the insect pest incidence, infestation level, and damage pattern and samples collection for identification. The first visit was pre-monsoon visit from June 6th-12th, 2006 .It was the flowering stage of the coffee plant. The second visit was post-monsoon visit from October 31st to 6th November, which was early fruiting period.

Various insects were found associated with coffee crop. A total of 640 specimens were collected belonging to 6 orders of class Insecta. The specimens collected from the representative coffee orchards of Madanpokhara VDC are given in Annex 2. The infestation level was calculated for each type of insect by its percentage presence. The insect with their identification status and common name is shown in Annex 3.

5.2.1 Constituent of insect associated with coffee

Order Orthoptera constituted three species: *Catantops sp*, field cricket and longhorn grasshopper.

Order Hemiptera constitited 7 species: *Megymenum* sp, *Eusarcocoris sp*, *Acanthocoris sp*, *Leptocorisa sp*, Spittle bug, *Ernestinus sp* and *Bothrogonia sp.*

Order Homoptera included 3 species: *Toxoptera sp*, Mealy bug and Brown Scale.

Order Lepidoptera consist four species: Bagworm, Looper, Red Stem Borer and hairy caterpillar.

Order Coleoptera constituted 10 species: *Coccinella sp*, *Diapromorpha sp*, *Aulacophora sp*, *Podagrica sp*, *Calasposoma sp*, *Ophrida sp*, *Aspidomorpha sp*, *Diapromorpha sp*, white stem borer, weevil and *Gonocephalum sp*.

Order Hymenoptera included two species: Red ant and Black ant.

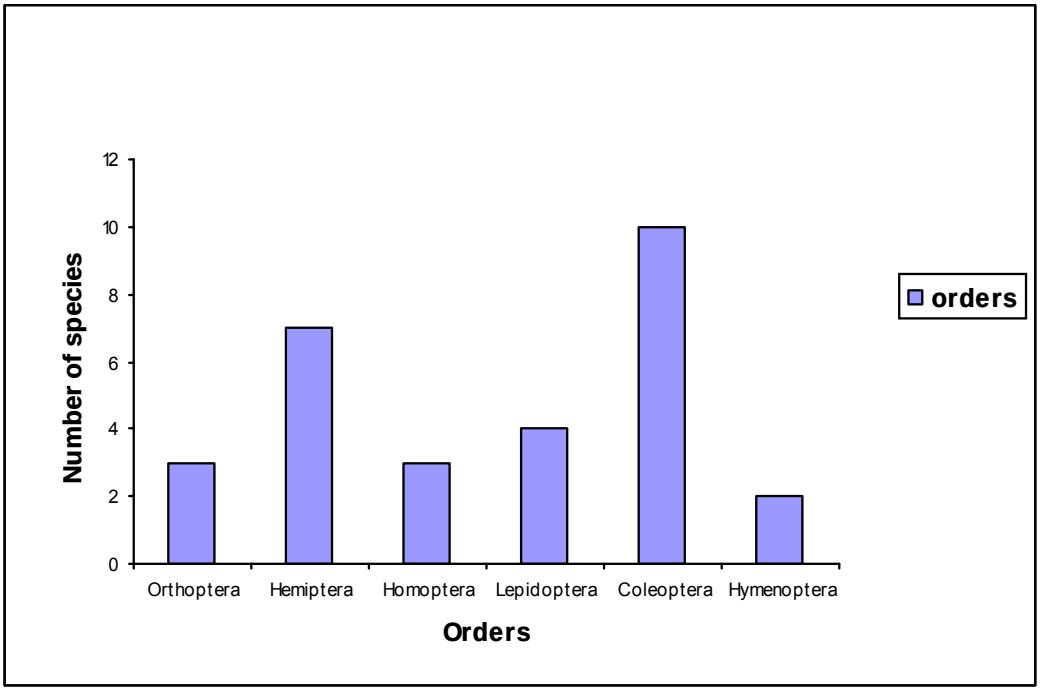

Figure 5: Number of species belonging to different orders.

5.2.2 Number of species found in different sites and in different seasons

Number of species found in different sites and season was variable. It showed that site A constituted the least no. of species with a total of 15, 8 species in first and only 7 in the second whereas site B constituted the highest number of species with a total of 28 out of which 18 species were found in first visit and 10 species were found in the second visit. Similarly site C was with 11 species in first visit and 10 species in the second visit.

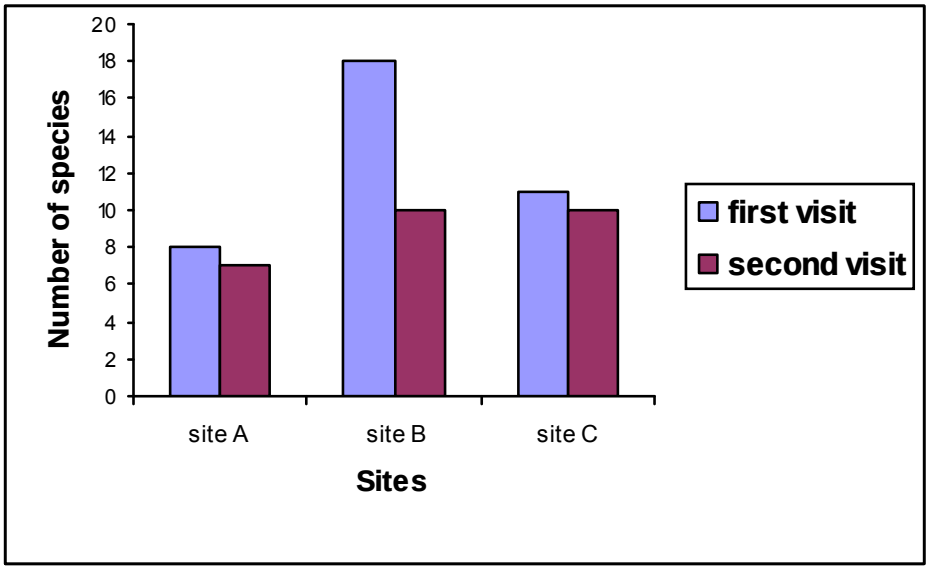

Figure 6: Number of species found in different sites and in different seasons

In site A, 4 species *Catantops sp, Coccinella sp,* Mealy bug and white stem borer were common in both the seasons. Long horn grasshopper, Weevil, *Calasposoma sp* and *Megymenum sp* were only found during the first visit whereas red ant, black ant and red stem borrer were found during the second visit.

In site B, 5 species were common in both the seasons. They were *Catantops sp,* Long horn grasshopper, *Coccinella sp, Toxoptera aurantii sp* and Mealy bug. 13 species were found only in first visit. They were Weevil, *Aulacophora sp, Calasposoma sp, Ophrida sp, Aspidomorpha sp, Gonocephalum sp, Eusarcocoris sp,* Black ant, Looper, Hairy Caterpillar, Bag worm and white stem borer. The 5 species found only in the second visit of this site were field cricket, *Leptocorisa sp,* Spittle bug, *Bothrogonia sp* and Red ant.

Similarly in site C, 3 speices were common in both the seasons. They were *Catantops sp,* Long horm grasshopper and Mealy bug. *Diapromorpha sp, Aulacophora sp, Podagrica sp, Eusarcocoris sp, Acanthocoris sp,* Looper, Hairy caterpillar and Bag worm were the 8 species found only during the first visit. *Coccinella sp, Leptocorisa sp, Ophrida sp, Toxoptera sp, Ernestinus sp,* Red ant and black ant were the 7 species found only in the second visit.

5.2.3 Two way ANOVA

The two way ANOVA showed no significant difference in total no. of species found in different site and in the two seasons. Fc(2, 2)=3.74 and Fr(1, 2)=3.56 which is lesser than the tabulated value.

5.2.4 Distribution of total number of specimens in different sites and in different seasons

The distribution of total no. of specimens was the highest in site B with a total of 293 whereas the lowest in site A with the total of 147. In the first visit site C was with the lowest no. of insects whereas in second visit it was site A having the lowest no. of 65 only. The distribution of total no. of specimens is shown in the following table.

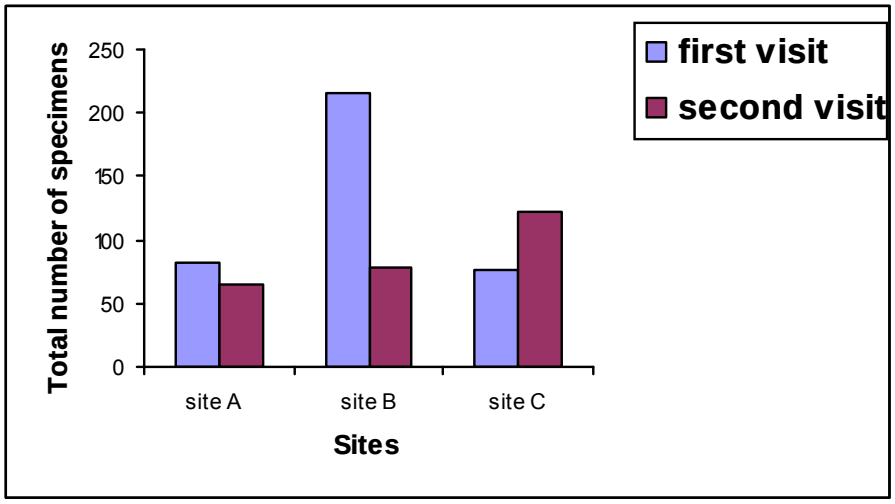

Figure 7: Distribution of total number of specimens in different sites and in different seasons.

5.2.5 Two way ANOVA

The two way ANOVA showed no significant difference in total no. of insects in different sites and in different seasons. Fc(2, 2)=0.126 and Fr(1, 2)=0.045 which is less than the tabulated value.

5.2.6 Infestation, infestation level and damage

During the field visits many insects were found damaging the coffee plant. The direct damaging insects included the group of sapsuckers, leaf damagers and stem borer. The list of damage pattern, the species and the infestation level is given in Annex 4.

The highest infestation was found by the brown scale (16.406%) among the sapsuckers which was followed by *Toxoptera sp.* (10.75%), Mealy bug (6.25%), *Leptocorisa sp.* (1.718%), Spittle bug and *Ernestinus sp.* (1.25% each), *Eusarcocoris sp.* (0.781%) and *Megymenum sp.* (0.156%).

The Brown scale was found from a single orchard of site B during the first visit. It was found in cluster in leaves and adjacent petioles of the coffee plant (Plate I: 1 & 2).

The black aphid (*Toxoptera aurantii*) was prevalent in the both the seasons in site B whereas in second visit only in site C. It was collected from the young shoot of coffee plant (Plate I: 3).

The Mealy bug was found on the stalk, berries and the soft part of the branches. A crust of mould was also found with the berries incrusted by the Mealy bugs (Plate I: 4). The infestation was seen in all the 3 sites and in the both seasons. However, the incidence was seen high during the second visit.

The other sapsuckers were not found as economical as the Mealy bug, brown scale and *Toxoptera aurantii*. So, there were no common practices for the sapsuckers. But the botanical pesticides prepared by the local people were used in order to protect the plant from the high sap sucking pests.

The defoliator infesting coffee were *Catantops sp.* (11.5%), *Ophrida sp.* (6.562), *Calasposoma sp.* (5.937%), Long horn grasshopper (3.281%), Weevil and Looper (3.125 each), *Aulacophora sp., Podagrica sp.* and bag worm (0.625% each), Hairy caterpillar (0.468%) and *Aspidomorpha sp.* and *Diapromorpha sp.* (0.312 each).

Infestation of *Catantops sp* was seen high in those orchards where weeds were not properly managed (Plate I: 5). Its infestation was high in site C than in any other sites. Noticeable wholes were visible in the leaves of the coffee plant (Plate I: 6). Loopers

(Plate II: 1) and Hairy caterpillar (Plate II: 2) were the main defoliators of nursery (Plate II-2) plants which were managed by hand picking method. During the field visit a very interesting damage pattern of Weevil was seen which cut the edge of the leaf characteristically in a semi circular manner.

The defoliators despite of their high infestation level were not considered of economic importance by the farmers and no any particular practices were applicable for them. Bio-pesticide as foliar spray seemed enough for their control.

Among the Stem borers, White stem borer (Plate II: 3) was of great economic importance than Red stem borer as its infestation stopped the productivity of the plant. The incidence of white stem borer was the highest in site A, higher during the first visit than the second one, but its incidence was found during first visit only in site B. The incidence of the pest was not found in site C.

Infestation of larva of White stem borer was marked by yellowing of the leaves of the plant, holes (Plate II: 4) in the stem and easy breaking of the stem). On splitting the part of the stem fine tunnel was made by the borer which was packed by its frass (Plate II: 5). A total of 51 larvae were collected from the field. A single stem was with four such larvae of different sizes. However, no adult could be collected.

Infestation of Red stem borer was found only in second visit of site A. Adult borer could not be collected. It was found in a branch which showed wilting of its upper part. The recognition of borer infested plants was made possible by the help of farmers. *Gonocephalum sp*. was collected (Plate III: 1). A field cricket was found which was known to attack various plant roots.

Black ant and Red ants were mainly found during the second visit of all 3 sites. They were mainly collected from the fruiting branches. Red ants were found associated with the berries infested with Mealy bug. The red ant and black ant were the main problem during harvesting of the ripe berries as per farmer. They were considered as the secondary pests.

PLATE I

1. Brown scale on a twig

2. Wilting of twig due to brown scale

3. *Toxoptera aurantii* and *Aulacophora sp*

4. Mealy bug and Ant association

5. *Catantops sp*

6. Damage done by *Catantops sp*

PLATE II

1. Looper

2. Hairy caterpillar

3. Nursery

4. Larva of white stem borer

5. Location of borer in twig

6. Stem showing hole of emergence and frass

PLATE III

1. *Gonocephalum sp*

2. *Calasposoma sp*

3. Coffee in mixed cropping

4.. Researcher sorting insects

5. Researcher with members of coffee producer group

6. Researcher with farmers

5. DISCUSSION

From the study it was found that coffee orchards in Madanpokhara were under threat of white stem borer causing considerable loss. The attack of stem borer was high in low altitude below 800m from the sea level than between 800-1000m from the sea level where as infestation above 1000m was not found during the study period. This might be because stem borer are more severe at lower altitude and high temperature (Walker et. al., 2007).

In 2004, Nepal Agricultural Research Council (NARC) had reported two species of stem borer i.e. *Xylotrechus smei* and *Chlorophus annulatus* from the coffee orchards of Syangja. During observation larvae, pupa and adult were collected from a single plant which indicated the longer emergence period of the borer.

Despite of having higher infestation of sap suckers no any particular method of control was taken. The crop loss due to sap suckers had not been estimated till the study period and was taken as below the economic threshold level. The main sap suckers were Brown scale, *Toxoptera aurantii* and Mealy bug.

It was found that Mealy bugs are known to be vector of Banana Streak virus that causes Banana Steak Disease. Banana being the commonest fruit planted to provide shade for coffee, infestation of Mealy bug has developed the possibility of transmitting this virus in the orchards.

Toxoptera aurantii has been reported to be a vector of Citrus Tristeza virus (CTV) that infects the tender bud of citrus (Rai, 2004). It is a minor pest of coffee. Since this aphid transmit disease in citrus. It is also possible that they may transmit disease in coffee plant.

The scales despite of high population in the coffee plant was not consider to be troublesome. This may be because of the considerable population presence of the *Coccinella sp.* which has been receiving a wide attention for a long time as a predator of the Scales, Mealy bug and Aphids. A species of Lady Bird Beetle (*Coccinella inequalis*, Fabricus) was used as a natural enemy in Hawaii to control aphid

population(Mau, et al.,1992). Similarly biological control of Mealy bug by Lady Bird Beetle (*Cryptolaemus montrouzieri*) was found very effective (Diez, 2007).

Other sap sucking pests found in coffee plant during the visits were of less economic importance Thus, it could be said that there was a state of equilibrium between the populations of sap suckers in the intensive multi-cropping system.

A number of defoliators were found during the study period of which *Catantops sp., Calasposoma sp.*, and *Ophrida sp.* were found with considerable infestation level. Weevil, Loopers were also among the species that damage the leaf .It was found that coffee was not the threat of the defoliators in Madanpokhara. Most of the defoliator pest species were polyphagous which harbour in many plants in order to get the food. Coffee in multi-storey coffee pattern, pest of intercrop might have moved onto coffee when its food supply was exhausted.

The defoliator *Catantops sp.* as having the highest infestation level could prove troublesome. *Catantops melanosticus* is mainly the pest of pulse (Bohlen, 1978). *Catantops spissus spissus* is a vector or cowpea mosaic virus (CPMV) (Anonymous, 1972). Thus clean cultivation is recommended in the orchards at higher elevation of Madanpokhara.

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

Since most of the pests found associated in the 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 the total species found in three different sites in two seasons. This is possible because coffee is grown in integration with different fruit 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 are co-cultivated influence activity within the system. Integration of tree with crops or vice versa may affect colonization of plants by insect pest.

As coffee farming in Madanpokhara was done organically use of botanicals was in practice to control of pests. Botanical pesticide played significant role in the control of insects like thirps, mite, leafhoppers, and beetles. Most of the pesticides in the past were plant derivatives. Rotenone which is a contact poison is found in the root of derris plant; *Chrysanthemum* is known from hundreds of year 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 & Davidson et al.,1979)

Coffee and Conservation, 2007 has also recommended botanicals like tobacco, neem and derris plant for the control of various insects including Antestia bug, green scale and white borer

Davidson et al., 1979 has mentioned Bordeaux mixture very effective repellent to potato flea beetle, leaf hoppers, and psyllids. Thus its use in the mixed cropping farm seemed feasible.

Coffee, being a small holder undertaking it is of considerable importance to small holders in majority of cases. So, owing to the high cost of chemical fertilizers and pesticides and their residual effect, coffee was grown organically here. Use of botanical pesticides by the farmers was significant alternative to suppress the residual and faulty use of hazardous chemicals.

6. CONCLUSION AND RECOMMENDATION

6.1 Conclusion

The study showed that white stem borer was major threat of the coffee plant in Madanpokhara VDC. The crop loss per year due to this pest was high in coffee orchards below 800m but no infestation was found above 1000m.

There were pests like red stem borer, scales, mealy bug, and aphids, but they had not been able to establish their population as a major pest. The most probable reason was the presence of natural enemies and control measures taken against them prior to their outbreak.

Other insects like *Megymenum sp., Eusarcocoris sp., Acanthocoris sp., Leptocorisa sp.,* Spittle bug, *Ernestinus sp.,* Long horn grasshopper, *Aulacophora sp.,* Weevil, Bagworm, Hairy caterpillar were regarded as a minor pest of coffee and could be said as visitors on coffee plant.

There was 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 number of species in three different sites and in two different seasons.

As coffee was grown organically use of inorganic fertilizers and chemical pesticides are not in practice. Plant nutrients were supplied mainly by compost manure. For the control of pests, botanical pesticides were applied. Except Bordeaux mixture, no other chemical pesticides were used. The botanical pesticides were made by farmers themselves from locally available plants having pesticidal properties. The plants that are used for the preparation of pesticides consists neem (*Azedirechta indica*), china berry (*Melia azadirach*), siam weed (*Eupatorium odoratum*), mint (*Mentha arvensis*), marigold (*Tagetus sp.*), Mug wart (*Atremesia vulgaris*), tobacco (*Nicotiana tabacum).*

6.2 Recommendation

As the farmers grew coffee organically chemical pesticide for the controls of borer were not in practice however, integrated and preventive methods are recommended to

reduce pest incidence below economic level. As coffee pest attack mainly plant under stress, following activities are recommended as preventive measures.

- Proper monitoring of pest for tracing of infested plant and destroying the infested plant part by white stem borer. If the infestation has reached up to the root then farmers are strictly recommended not to greed for cherry from that plant and immediately uproot and burn that plant.
- Maintenance of optimum shade on coffee orchard is highly recommended as the shade tree is more effective remedy to control the borer, create favorable micro climate and also to protect the coffee plant from adverse condition like hailstones, storm and frost.
- Weeding should not be reduced to simple slashing. There should be 6-8 weeding schedules per year.
- Pruning is of paramount importance for sustained high yielding. So, timely pruning should be done.
- Use of vermicompost as an organic manure could increase the fertility of the soil.
- Farmers should discuss their field problems with one another.
- Most important of all, both the coffee planter and the businessman must be willing to work hard, believe and practice scientific farming and operate in business like manner.

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ANNEX 1

List of shade plants commonly used in the orchard

S.N.	Local name	Common name	Scientific name
1	Litchi	Litchi	*Litchi chinensis*
2	Mausam	Mausam	*Citrus reticulata*
3	Suntala	Orange	*Citrus auranitum*
4	Kera	Banana	*Musa paradiciaca*
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 heterophyllum*
10	Anar	Pomogranate	*Punica granetum*
11	Katus	Chest nut	*Castaropsi triboloids*
12	Dalchini	Cinnamon	*Cinnamomum verum*
13	Aaru	Peach	*Prunus persica*
14	Rahari	Pigeon pea	*Cajanus cajon*
15	Lapsi	-	*Choerospondias axillaries*
16	Ipil ipil	-	*Leucaena leucocephala*
17	khaniyu	Fig	*Ficus semichordata*
18	Avocado	Avocado	*Avocado sp.*

(-) not known

ANNEX 2

List of insects infesting coffee in three different sites and in two seasons.

S.N.	Scientific name	Common name	site A		site B		site C		total no. of species
			1st visit	2nd visit	1st visit	2nd visit	1st visit	2nd visit	
1.	*Catantops sp*	shorthorn grasshopper	5	3	8	6	30	20	72
2.	-	Field cricket	-	-	-	1	1	-	1
3.	-	long horn grasshopper	2	-	3	1	7	8	21
4.	*Coccinella sp.*	Lady bird beetle	8	12	2	8	-	2	32
5.	-	weevil	16	-	4	-	-	-	20
6.	*Diapromorpha sp.*	leaf beetle	-	-	-	-	2	-	2
7.	*Aulacophora sp.*	Pumpkin beetle	-	-	1	-	3	-	4
8.	*Podagrica sp.*	Flea beetle	-	-	-	-	4	-	4
9.	*Calasposoma sp*	Leaf beetle	13	-	25	-	-	-	38
10.	*Ophrida sp.*	Leaf beetle	-	-	12	-	-	30	42
11.	*Aspidomorpha sp.*	Tortorise beetle	-	-	2	-	-	-	2
12	*Gonocephalum sp*	Bark beetle	-	-	3	-	-	-	3
13.	*Megymenum sp*	Stink bug	1	-	-	-	-	-	1
14.	*Eusarcocosis sp*	Stink bug	-	-	4	-	1	-	5
15.	*Acanthocoris sp*		-	-	-	-	4	-	4
16.	*Leptocorisa sp*	Rice bug	-	-	-	3	-	8	11
17.	-		-	-	-	8	-	-	8
18.	*Toxoptera aurantii*	Black aphid	-	-	19	30	-	20	69
19.	-	Mealy bug	2	13	3	4	8	10	40
20.	-	Brown scale	-	-	105	-	-	-	105
21.	*Bothrogonia sp*	Leaf hopper	-	-	-	3	-	-	3
22.	*Ernestinus sp*	-	-	-	-	-	-	8	8
23.	-	Red ant	-	26	-	14	-	3	43
24.	-	Black ant	-	7	2	-	-	14	23
25.	-	Looper	-	-	4	-	16	-	20
26.	-	Hairy caterpillar	-	-	2	-	1	-	3
27.	-	Bagworm	-	-	3	-	1	-	4
28.	-	Red stem borer	-	1	-	-	-	-	1
29.	-	White stem borer	35	3	13	-	-	-	51

(-) not known

ANNEX 3

Classification of insects

	Orders	**Family**	**Genus**	**Common name**
1	Orthoptera	Acritidae	*Catantops sp*	Short horn grass hopper
		Gryllidae	-	Field cricket
		Tettigonidae	-	Long horn grasshopper
2	Coleoptera	Coccinellidae	*Coccinella sp*	Lady bird beetle
			Aulacophora sp	Pumpkin beetle
			Podagrica sp	Flea beetle
			Calasposoma sp	Leaf beetle
			Ophrida sp	,,
			Aspidomorpha sp	Tortoise beetle
			Diapromorpha sp	Beetle
		Cerambicidae	White stem borer	White stem borer
		Curculionidae	-	Weevil
		Tenebrionidae	*Gonocephalum sp*	Bark beetle
3	Hemiptera	Pentatomidae	*Megymenum sp*	Stink bug
			Eusarcocoris sp	,,
		Coriedae	*Acanthocoris sp*	Squash bug
			Leptocorisa sp	-
		Cercopidae	-	Spittle bug
		Miridae	*Ernestinus sp*	-
		Cicadellidae	*Bothrogonia sp*	Leaf hopper
4	Homoptera	Aphididae	*Toxoptera sp*	Aphid
		Pdeudococcidae	-	Mealy bug
		Coccidae	-	Brown scale
5	Lepidoptera	Psychidae	-	Bagworm
			-	Looper
			-	Red stem borer
			-	Hairy caterpillar
6	Hymenoptera	Formicidae	-	Red ant
			-	Black ant

(-) not known

ANNEX 4

Damage pattern, infestation of species and infestation level

Damage pattern	**Species**	**Infestation level in %**
Sap suckers	*Megymenum sp*	0.156
	Eusarcocoris sp	0.781
	Acanthocoris sp	0.625
	Leptocorisa sp	1.718
	Spittle bug	1.25
	Ernestinus sp	1.25
	Bothrogonia sp	0.468
	Toxoptera aurantii	10.75
	Mealy bug	6.25
	Brown scale	16.406
Defoliator	*Catantops sp*	11.25
	Long horn grasshopper	3.218
	Aulacophora sp	0.625
	Podagrica sp	0.625
	Calasposoma sp	5.937
	Ophrida sp	6.562
	Diapromorpha sp	0.312
	Aspidomorpha sp	0.312
	Weevil	3.125
	Bag worm	0.625
	Looper	3.125
	Hairy caterpillar	0.468
Stem borer	Red stem borer	0.156
	White stem borer	7.968
Fruit pest	Red ant	6.718
	Black ant	3.593
Bark feeder	*Gonocephalum sp*	0.468
Root destroyer	Field cricket	0.156
Predator	*Coccinella sp*	5

ANNEX 5

Participants of KIS and FGD

Participants of KIS

1. Kamal Khanal, Programme Co-ordinator, DCPA, Palpa
2. Kedar Basyal, Field Supervisor, DCPA, Palpa

Participants of FGD

1. Durga Bahadur Khand, Chhap- 4
2. Gita Singh Thakuri, Chhap- 4
3. Kalpana Singh Thakuri, Chhap- 4
4. Rukmini Khand, Chhap- 4
5. Kalpana Ghimire, Tintiaanp- 8
6. Shanti Devi Ghimire, Tintiaanp- 8
7. Tika Devi Bhattarai, Tintiaanp - 8
8. Krishna Maya Bhattarai, Madanpokhara- 5
9. Ram Prasad Ghimire, Madanpokhara- 5
10. Sita Devi Bhattarai, Madanpokhara- 5
11. Narayani Khanal, Madanpokhara- 9
12. Urmila Ghimire, Madanpokhara- 9

ANNEX 6

List of Questions

Name:

Address:

1. How long have you been involved in coffee cultivation?
2. Which cropping pattern have you adapted for coffee cultivation?
3. What are the plants you have grown for shade?
4. Have you noticed the pest incidence in coffee orchard?
5. What are major insects that are harmful to coffee plants?
6. List the plant parts that are affected by above mentioned insects.
7. Mention the time of attack by these insects.
8. What is the percentage loss in crop yield due to insects? How do you estimate the loss?
9. Mention the management practices you have adopted for the control of these pests.
10. Do you use chemical pesticides? If yes, which chemical pesticides are used and for what?
11. Which tool do you use to apply chemical pesticides?
12. Do you have any idea about the hazards of the use of chemical pesticides?
13. How many times do you apply pesticides?