STATUS OF PESTS IN HONEYBEE *(A. Mellifera* L.*)* AND THEIR CONTROL MEASURES APPLIED IN CHITWAN AND NAWALPARASI DISTRICTS OF NEPAL

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Submitted to

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DECLARATION

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

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This is to recommend that the thesis entitled "Status of pests in honeybee (*Apis mellifera* L.) and their control measures applied in Chitwan and Nawalparasi districts of Nepal" has been carried out by Mr. Jagat Prakash Chaudhary for the partial fulfilment of Master's Degree of Science in Zoology with special paper Entomology. This is his original work and has been carried out under my supervision. To the best of my knowledge, this work has not been submitted for any other degree.

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LIST OF ABBREVIATIONS

Abbreviated form	Details of abbreviations
APP	Agricultural Perspective Plan
APROSC	Agriculture Projects Services Centre
BDS	Bee Development Section
CBD	Cotton Development Board
CDZ	Central Department of Zoology
DADO	District Agriculture Development Office
DFTQC	Department of Food Technology and Quality Control
FAO	Food and Agricultural Organization
FBC	Federation of Beekeeper Chitwan
HMG	His Majesty Government
ICIMOD	International Center for Integrated Mountain Development.
INGOs	International Non-governmental Organizations
IPM	Integrated Pest Management
JMA	Japan Meteorological Agency
MoAC	Ministry of Agriculture and Cooperatives
MoAD	Ministry of Agriculture Development
NARC	National Agriculture Research Council
NEPCIL	Nepal Pesticides and Chemical Industries Pvt. Ltd.
NGOs	Non-governmental Organizations
PMRD	Pesticide Management and Registration Division
POPs	Persistent Organic Pollutants
PPSN	Plant Protection Society Nepal
VDC	Village Development Committee

ABSTRACT

This research was done in the pocket area of Jutpani, Padampur and Pithuwa VDCs of Chitwan district and Pragatinagar, Mukundapur and Gaindakot VDCs of Nawalparasi district of Nepal during spring (15 March - 27 April) and rainy (17 July - 28 September) seasons in 2010.

Altogether, 139 honeybee pests were collected including three families, two orders and three species. Two species of mites were *Tropilaelaps clareae* and *Varroa jacobsoni* and one species of Wax moth *Galleria mellonella* (Greater wax moth) were observed that causes damage in the beekeeping industry. Mites belonged to the family Tarsonemidae and Varroidae while Greater wax moth belonged to the family Pyralididae. The family Tarsonemidae was the major pests during spring season while the family Pyralididae was the major pests during rainy season.

The species diversity of pests during spring season was found to be 0.99 in Chitwan and 1.03 in Nawalparasi district while during rainy season was found to be 1.07 in both the districts.

Among the 42 flowering plants studied, 22 were nectar and pollen yielding bee plants, five were pollen yielding bee plants and 15 were nectar yielding bee plants during the study period in both the study sites of the apiaries.

Most beekeepers used apistan, formic acid, few used Sulphur, some used domestic herbal pesticides (*Centella asiatica*, *Azadirachta indica, Adhatoda vesica*) and IPM methods were seen rarely being practiced for the control of mites and management of the pests that occurred in beekeeping. For the control of Greater wax moth, beekeepers used fumigation of aluminium phosphide, Para-dicholobenzene and few used net.

The problems of beekeepers were ecological, socio-economical and management in the study sites. The ecological problems were 95.8% in Chitwan and 87.5% in Nawalparasi district. The mean percentage of socio-economical problems was 69.8% in Chitwan and 50.5% in Nawalparasi district. The mean percentage of management related problems was 63.2% in Chitwan and 60.4% in Nawalparasi district.

1. INTRODUCTION

1.1 General background

Beekeeping is the management of honeybee colonies by human beings to harvest maximum products such as honey, bee wax, propolis and also to utilize the colonies for crop pollination. It is a non-land based activity and does not compete with other resources. It is becoming an important component for sustainable management of mountain agriculture and integrated rural development programs in Nepal (Thapa, 2012). The role of beekeeping in providing food, nutritional, economical and ecological security to rural communities, cannot be overlooked as it has always been linked with the cultural and natural heritage of rural communities. At micro level, beekeeping is an additional income-generating activity and at macro-level, investment may be quite high but there is greater use of temporal and spatial diversity of natural resources such as pollen and nectar that otherwise go unutilized (Verma, 1990).

Honeybees of the Order Hymenoptera are one of the most beneficial insects to human beings. In the beginning, they were kept primarily for honey production. Honey is beneficial to human being in different aspects such as for food and medicines. Besides honey, other products like pollens, propolis, royal jelly, bee venom etc. are utilized by mankind for household, religious, cultural, medicinal and commercial purposes since prehistoric times (MoAD, 2008). But later it was realized that the greatest value of honeybees is in their service as pollinator for all kinds of plants. There is constant link between the honeybees and floral kingdom. It is impossible to imagine the floral kingdom without honeybees so it is also called “Pearls of nature” (Bista, 1997).

Nepal is predominantly a mountainous country comprising about 68% hilly region, 17% Terai region and 15% Himalayan region. The vegetation of Nepal exhibits remarkable diversity in different elevation and climate. The wide floral diversity has made Nepal a suitable place for scientific honeybee farming activities (MoAC, 2005 b). Among total population, about 66% people depend on agriculture (MoAD, 2011 a). Most of the hilly people are tenant farmers, landless and farm labourers living at or below subsistence level. For these farmers, beekeeping activities may be a beneficial trade. For beekeeping, they do not need their own agriculture land and need not have to invest a big amount as in other agricultural or industrial sector (MoAC, 2005 b).

Nepal is rich in honeybee diversity. Five species of honeybee viz. the world's largest cliff honeybee (*Apis laboriosa* Smith), Tropical giant honeybee (*Apis dorsata* Fab.), Asian hive honeybee (*Apis cerana* Fab.), Dwarf honeybee (*Apis florae* Fab.) and European honeybee (*Apis mellifera* L.) are established in Nepal (MoAD, 2008). Distribution of indigenous honeybee is strictly governed by the topography of the Himalayan kingdom (Thapa and Wongsiri, 2003). Honey hunting from wild bees *Apis laboriosa* and *Apis dorsata* has been practiced for hundreds of years which is very popular in eco-tourism development in high Himalayan mountain region (Thapa, 1999).

1.2 Honeybee Pests

The organisms which are ectoparasites or endoparasites can create havoc in the honeybee colonies by damaging beekeeping industry (Crane, 1990). The common pests of honeybee colonies are mites, wax moth, death's head moth and bee lice in Nepal (Bista and Shivakoti 2001, Thapa et al., 2000).

1.3 Development and Uses of Pesticides

The international code of conduct on the distribution and use of pesticides defines pesticides as "any substance or mixture of substances intended for preventing, destroying or controlling any pest including vector of humans or animals causing harm during or otherwise interfering with, the production, processing, storage, transport or marketing of foods, agricultural commodities, wood and wood products or animal feed stuffs or which may be administered to animal for the control of insects, arachnids or pests in or on their bodies" (FAO, 1994).

Pesticides have been used since immemorial time. Arsenate, Paris green and Lead were used in the form of pesticides in 200 B.C. These were inorganic and botanical pesticides (Nicotine and Pyrethrum) which were less effective. These pesticides were commonly used at the end of 1940 A.D. and named as the "first generation pesticides" (MoAD, 2011 c). Various synthetic chemical pesticides like Organochlorine, Organophosphate, Carbamates and Synthetic pyrethroids were invented after DDT and used from 1950 to 1970 A.D. These pesticides are termed "Second generation Pesticides" (MoAD, 2011 c). The concept of IPM started in 1970 A.D. Microbial pesticides were developed and used. These groups of pesticides are called "Third generation pesticides" (MoAD, 2011 c). Simultaneously, the use of hormones came into practice on pest control programme since

1980s. These compounds are considered as "Fourth generation pesticides". In this way, development and use of pesticides are in progress of ascending order (MoAD, 2011 c).

Rana (2001) reported that the chemical pesticides such as Paris green, gammaxene and nicotine sulphate were first introduced in Nepal in 1950 from USA for Malaria control by Gandaki hydro power project (Manandhar, 2006). NEPCIL was the first pesticide production factory established in 1977 at Bahadurganj, Kapilbastu to produce some major pesticides gammaxene, methyl parathion and zinc phosphide. The Indian representative such as Crop Health Production Ltd., Excel Industries Ltd., Cyanamid India Ltd. and Bharat Pulverizing Mills Ltd. were the main suppliers of pesticides in Nepal. Organizations like the CDB and Nepal Malaria Eradication Programmes were also authorized to purchase pesticides from foreign distributors. Presently, Indian Pesticide dealers cross the open border freely, selling pesticides in the Terai region and in major towns of Nepal (Palikhe, 2001).

There are around 71 common pesticides under 306 trade names in which 210 insecticides, 64 fungicides, 18 herbicides, 9 rodenticides, 1 miticide and 4 others are available in the market while several available pesticides are possibly carcinogenic to humans (MoAC, 2005a).

Table 1: Pesticides import in Nepal

Fiscal Year	Pesticides Import (kg)
2005/06	131270.43
2006/07	131284.55
2007/08	347494.56
2008/09	356345.64
2009/010	211079.34
2010/011	335673.52

(Source: MoAD, 2011 b)

1.4 Honey production in Nepal

The People's Republic of China is the world's largest producer of honey, followed by USA, Argentina, Turkey and Mexico. Nepal also exports honey to different overseas markets since the last few years, but the volume and the value of export is not optimal. Until 2001/2002, Norway used to be the largest buyer of Nepalese honey. But due to pesticides residue related problems in the honey, honey from Nepal is banned to enter into any European country including Norway in the recent years (MoAD, 2008). At present, the major countries

importing honey from Nepal are Japan and South Korea. However, for the last few years, countries like UAE, Thailand and Bangladesh are also emerging as the new markets.

Nepal is regarded as one of the most potential country to produce high quality honey due to its diverse climatic conditions and bio-diversity. The major beekeeping districts of Nepal are Chitwan, Nawalparasi, Rupandehi, Kapilbastu, Dang, Sarlahi, Sunsari, Mahotari, Makwanpur, Banke, Bardia, Arghakhachi and Kanchanpur. Most of the honey produced in Nepal is sold in the domestic market and only a very small quantity is exported. The major use of honey in Nepal is its consumption as food item and use in Ayurvedic medicine.

Table 2: Number of honeybee colonies and honey production

Fiscal Year	No. of Colonies	Honey Production(MT.)
2005/06	125100	650
2006/07	124500	650
2007/08	124500	1000
2008/09	124500	650
2009/010	140000	1100
2010/011	140850	1365

Source: Statistical Information on Nepalese Agriculture (2010/2011 MoAD).

1.5 Statement of the Problems

The use of pesticides in the honeybee colony is increasing with the increase in pest attacks on honeybee. The pests cause wide spread destruction to honeybee colonies. To cope with the pest problem, there is need of extensive study on pest types as well on their biological control. Once identified, the pests can be controlled by biological or physical methods. This may lead again to export of pesticide residue free honey. The present study was carried out in the pocket area of Chitwan district, VDCs such as Padampur, Jutpani and Pithuwa and also in Nawalparasi district VDCs Pragatinagar, Mukundapur and Gaindakot to identify the major pest problems and pesticides used in the honeybee colonies.

In the recent years, honey is regarded as the agri-product that has given opportunity for rural employment to farmers by selling in the market. But Nepalese agri-products have faced some problem in export market due to the contamination of pesticides and other chemicals. Nepal has enough export potential for agriculture and processed products in

the international market. As Nepal has already become a member of WTO, this opportunity can be best utilized.

Pesticide use or disuse in the production and distribution of products has become an important public policy issue. Although, average consumption of pesticides in Nepal is far lower than many other developed countries, the problems of pesticide remain very high in Nepal. Pesticide surveillance report revealed that the presence of pesticides in different food commodities is high in the country.

1.6 Objectives of the Study

The general objective was to study the status of pests and pesticides applied in the honeybee colonies in the pocket regions of Chitwan and Nawalparasi districts in species of *Apis mellifera* colonies.

The specific objectives of this study were:

i. To collect and identify pests of honeybee.
ii. To study the species diversity of pests with seasonal variation.
iii. To identify chemicals used in the control of pests
iv. To identify problems (Socio-economical, Managemental, ecological aspects) of beekeepers living in the above mentioned VDCs.

1.7 Rationale of the study

Honey is a traditional Nepalese product and in the former old report, it had been mentioned that Nepal produce more than 10,000 MT /Year (Statistical Information on Nepalese Agriculture (2010/11, MoAD). The export market of these products is expected to rise in future. But in recent years, Nepalese agri-products have faced some problems in export markets due to pests, diseases and pesticides & other chemicals present in the honey as residue.

This study will generate data on current status of pests & pesticides used in honeybee colonies in Chitwan and Nawalparasi districts. This data will help to design laboratory analysis programmes, formulate appropriate education programs to help food control agency and implement food safety program in the country effectively. This will ultimately help to boost up export to international markets of these potential agri-products.

2. LITERATURE REVIEW

The literatures reviewed and pertained to the present investigation are discussed below:- In past, the honey used by human was directly derived from the wild stock and gradually men started beekeeping for the honey. At present man has developed various modern techniques for beekeeping and are producing most of honey by themselves rather than being dependent on wild stock (Gautam, 1984). Bhatt (2005) reported that Saligram (1997) has mentioned eight species of honeybees in ayurvedic and its medicinal importance which are Makshika, Ksudra, Chhatra, Bhramara, Pouttica, Audalak Ardhya and Dala.

2.1 Honeybees

Honeybees are the most familiar insects of the order Hymenoptera and classified as four species, grouped in the subfamily Apinae of the family Apidae, all within the genus *Apis* (Hopla et al., 1994). They are characterized by the presence of two pairs of membranous wings, chewing and lapping types of mouthparts. Their body is divisible into head, thorax and abdomen. Stinging organ is present in the female honeybees (Michael, 1999).

They are social and colonial insects found all over the world, highly organized and developed. Their colonies live in the nests exhibiting a remarkable polymorphism i.e. caste system and division of labour (Abrol, 1997). They feed on pollen and nectar of flowers for manufacture of honey and bee wax. Due to highly specialized structure and function, they communicate with each other through a sign language and mating occurs in nuptial flight after which the males die. Development includes complete metamorphosis i.e. egg, larva, pupa and adult (Anne and Michael, 2005).

2.2 Global distribution

The genetic diversity of *Apis mellfera* has been organized into 24 sub-species having varied economic usefulness. These sub-species are adapted to a wide range of ecological conditions at latitude ranging from 0° at equator to latitude as high as 50°N and 30°S (Ruttner, 1987).

Similarly, Verma (1990) have described two hive bee species and three wild honeybee species found in the Hindu-Kush Himalayan region viz. *Apis cerana, Apis florea, Apis dorsata, Apis laboriosa*. Of them, only the *Apis mellifera* is the exotic bee species introduced in Nepal.

In China, out of more than 8.5 million colonies of honeybees kept in modem hives, 70 % are *Apis mellifera* and only 30% are native *Apis cerana* (Zhen-ming et al., 1992). Similarly in south Korea, only 16% beekeeping is with native *Apis cerana* and the remaining has been replaced by exotic *Apis mellifera* (Choi, 1984).

The south and south-east Asian region is rich in honeybee species and genetic diversity. Amongst the different honeybee species, *Apis cerana* (Asian hive honeybee) is equivalent to the *Apis mellifera* (European honeybee) because both can be domesticated and can build parallel combs. Great strides in modernizing beekeeping with the native and exotic honeybee species are being made in different eco-geographic zones (temperate, sub-temperate and sub-tropical) of the region (Verma, 1990).

Taxonomy of *Apis mellifera*

Order	-	Hymenoptera.
Family	-	Apidae
Genus	-	*Apis*
Species	-	*mellifera*
Common name	-	European honeybee

Altogether, there are four sub-species of *A. mellifera* honeybee that are *A. m. lingustica, A. m. carnica, A. m. caucasia* and *A. m. mellifera*. Among which *lingustica, carnica* sub-species are being imported by progressive beekeepers in Nepal but most common sub-species is *linguistica* (HMG/N, 2002). It is clear that beekeeping with *A. mellifera* in the Terai is potential enterprise for higher income compared to crop production (Pokhrel, 2009).

2.3 Honeybees in Nepal

Beekeeping is one of the oldest traditional household activities in rural areas of Nepal. It is an agricultural practice which includes rearing of honeybees on commercial scale for the production of honey as well as wax, propolis and bee venom as by-products. Beekeeping is the oldest agricultural art practiced by man that occurred mostly in wild

state in large area inhabiting hollow trees and caves (MoAC, 2005). But modern beekeeping has been done in factory made hives by their natural behaviour of colony organization increasing honey yield (Neupane, 2010).

The climatic conditions in different parts of Nepal, especially in tropical and sub-tropical region are favourable for *Apis mellifera* species of honeybees (K.C. and Shrestha, 2000).

In Nepal, the Lost Wax method to make ornate metal figures date back to the 13th century which shows the history of beekeeping (Thapa, 1999). Modern beekeeping started with *A. cerana* in 1923 AD after a visit of late PM Judha Shamser Rana to Europe and established as a cottage industry. HMG provided basic beekeeping training in remote areas in 1969. The beekeeping development project started with *A. cerana* in 1970 (Saubolle and Bachmann, 1979). In 1975, 250 modern hives were distributed to farmers by HMG and non-government organizations (Neupane, 2010). HMG established BDS for training and research purposes as a separate unit in Kathmandu in 1986. HMG received financial support for beekeeping training and development of beekeeping industry from the Government of the Netherlands in 1988 (Neupane, 2010). Since then beekeeping has been in practice and currently it is spread in 13 districts of Nepal (Neupane, 2010). Though a beneficial and important agricultural practice, its production is being hindered by attack of predators, pests and different diseases (Abrol, 1993).

Entomology Division (1999) and Thapa and Pokhrel (2001) reported that the beekeeping with improved and imported crossbreed honeybee *A. mellifera* L. started since 1993-1995 (Bhusal and Thapa, 2005). According to BDS the average annual honey yield in Nepal is only 4.15/colony (HMG/N, 2002). The commercial beekeepers migrate their colonies between mid-hills and Terai regions according to floral cycles. Depending on the effectiveness of the beekeeper in management of the colonies, the honey yield capacity of mellifera species is about 80-100 Kg/colony/year but 20-30 Kg/colony/year now in Nepal (Neupane, 2010). *Apis mellifera* beekeeping demands large financial investment and intensive techniques which make it unsuitable to poor rural farmers (Thapa et al., 2000) in mid-land regions, inner Terai and Terai regions below 1500 MSL. This Melliferous beekeeping is becoming more popular than Cerana beekeeping. Hence, Terai and Mahabharat range of hilly regions are the most favourable for Mellifera beekeeping.

There are 8490 colonies of Mellifera in Chitwan district and 1100 colonies in Nawalparasi district. From Chitwan district about 196725 Kg/year and from Nawalparasi

district 20000Kg/year honey production is reported (GoN, 2010). The highest number of Mellifera colonies recorded was 9000 colonies in Dang. From this place about 2,34,000 Kg/year honey production has been reported (GoN, 2010).

2.4 Pests of *Apis mellifera*

Two decades ago, there were no serious pests, predators and diseases of honeybees in Nepal but introduction of *Apis mellifera* that has been spreading dramatically all over the country is becoming a major threat for beekeeping in Nepal (Thapa et al., 2000). Thai Sac brood disease (1981) spread so fast all over the country that within four years it covered almost the entire parts of the country and reached to peak in western border areas within three years. By 1984, the disease started to subside and the bees started to regain normal condition. Thapa (2006) is of the opinion that the Asian mite, *Varroa jacobsoni* is associated with *A. cerana* and *A. dorsata* bees but causes no serious problem to them, but it is fatal to *A. mellifera* colonies.

The various species of ecto and endoparasitic mites are the major pests of honeybee colonies (Abrol, 1997). The following pests have been recognized in *A. mellifera* colonies.

2.4.1 Mites

Mites create serious problems in honeybee colonies (Abrol, 1997). Sammataro et al., (2000) have reviewed the subject and listed 19 mesostigmatid mites parasitizing bees (Baker, 2010). The mites found on Bumble bees (*Bombus* sp.) are quite different to those found on honeybees (*Apis* sp.) and have been described by Chmielewski and Baker (2008). The following six species of mites have established parasitic relationships with *A. mellifera* (Hopla et al., 1994).

2.4.1.1 Endoparasitic mite

They are of the following types.

***Acarapis* sp. (family Tarsonemidae)**

Rennie and White (1865-1928) described first about this mite. Two persons were investigating the cause of Isle of Wight disease (Hopla et al., 1994). This mite is also named as *Acarapis woodi* Rennie, being first reported (Rennie, 1921).

Despite the early controversy regarding the potential impact of the tracheal mite on beekeeping in Europe, it is now clear that this mite can inflict serious damage. The presence of these mites in the Asian bees and destruction created by this mite is not verified in Nepal (Neupane, 2005).

2.4.1.2 Ectoparasitic mite

It is of the following species.

***Euvarroa* sp.**

Delfinado and Baker (1974) recorded this species living in association with *A. florea* colonies in India. Kapil and Aggarwal (1987) reported that it has also been found in the hive debris of *A. mellifera* (Abrol, 1997).

***Varroa* sp. (family Varroidae)**

The varroa mite was first reported living in association with *A. mellifera*, in 1962. *Varroa jacobsoni* was first described by Oudemans (1963) collected from *A. mellifera* colonies in Philippines (Abrol, 1997).

The primary causes of failure of Melliferous beekeeping are due to *V. jacobsoni* and *Tropilaelaps clareae* pests in Asia and more than 1000 colonies of *A. mellifera* were lost due to *Varroa* attack in Philippines (De Jong and Morse, 1979). *Varroa* mites attack, weakens and dwindles the colonies. Ball (1983) and Shabnov (1984) reported that it also increases the honeybee pathogens such as bacteria and viruses indirectly (Abrol, 1997). De Jong et al. (1982); Griffiths and Bowman (1981) reported that *Varroa jacobsoni* infests both *A. mellifera* and *A. cerana* colonies resulting annihilation of entire honeybee stocks (Abrol, 1997). Akratanakul and Burgett (1975) reported that *V. jacobsoni* is present almost all over the countries of both south and south-east Asia (Abrol, 1997).

***Tropilaelaps* sp. (family Laelapidae)**

Delfinado and Baker (1961) first discovered *Tropilaelaps clareae* in *A. mellifera* colonies (Baker, 2010). In 1963, these mites infested *A. mellifera* colonies that were imported into the Philippine Islands. Hopla et al. (1994) opined that *Tropilaelap clareae* was found living in association with *A. mellifera* colonies in the Philippines, Java, Malaysia, Hong Kong, Vietnam, India and Thailand. Woo and Lee (1997) reported that the degree of damage depends on the number of mites infesting each larva (Mahammad et al., 2012).

Tropilaelaps koenigerum

Anderson & Morgan (2007) described two new species of this mite. They are (i) *T. mercedesae* parasitizing on *Apis dorsata*, *A. laboriosa* and in the introduced *A. mellifera* colonies and (ii) *T. thaii*. The distribution of these two species was recorded from India (Kashmir), Nepal and Sri Lanka (Baker, 2010).

2.4.2 Wax moth

Wax moths only cause considerable damage in the apiaries of the weak colonies. It may also be implicated in the spread of contagious diseases, especially foulbrood, by consuming contaminated combs. Two types of wax moth have been recognized: Lesser wax moth and Greater wax moth.

2.4.2.1 Lesser wax moth

It is very common in most parts of the world except colder region and mostly found in higher altitude. They are suspected to inhabit most of Africa (including Madagascar), Australia, Europe (particularly in Greece) and North America as well as parts of the Neotropics (at least Columbia, Jamaica, Puerto Rico and Trinida), the Bangal region, Sri Lanka, Japan and the Marquesas Islands and Tahiti in French Polynes **(**Lesser wax moth. http://www.en.wikipedia.org/wiki/lesser_wax_moth.html**)**. Larval forms feed and destroy the comb above economic thresh hold value (Sharma et al., 2011).

2.4.2.2 Greater wax moth

Eckert (1951), Smith (1960) and Singh (1962) reported that Greater wax moth is the most important pest for beekeeper because of the serious losses it can inflict (Insects: Lepidoptera (moths). http://www.ars.usda.gov). The greater wax moth is cosmopolitan. Its distribution is mostly in the plains and lower altitude but rarely in higher altitude (Pests and diseases of honeybees. http://www.agritech.tnau). Nielsen (1971) had mentioned that adult wax moth can live from 3 days up to over 1 month, but most of the fertilized females die after 7 days when they are in the environment of about 30-32°C while at lower temperatures longevity increases (19 days at 20°). Larvae feed on honey, nectar or pollen, if available, or alternatively, wax. Thakur (1991) reported the wax moth populations start to increase from March, reaching its peak in August (99-100%) in India (Gulati et al., 2004). Varshney et al. (2008) reported that infestation of greater wax moth started from July and peak in September.

2.5 Pesticides used to control the pests/Pesticides residues.

Beekeepers of India and Nepal use Formic acid and Sulphur powder to control ecto and endoparasitic mites like *Acarapis* sp., *Varroa jacobsoni* and *T. clareae* (Shivakoti and Bista, 2000).

Wilson (1965), Williams (1980) and Owayss & Abd-Elgayed (2007) reported that chemical methods used to control wax moths includes substances that are considered friendly to environment like methyl salicylate, clove oil, formic acid, sulphur , acetic acid, basil oil (Owayss A. Ayman et al., 2007). Besides this 1, 2-dibromo-ethane (DBE), 1, 4-dichloro-benzene (p-DCB), naphthalene has also been used in some countries. These compounds are dangerous for bee brood and human health, while they require repeated application and may react and destroy the metal parts of the combs, (Owayss A. Ayman et al., 2007).

Such application of pesticides for the control of wax moths and mites (ecto and endoparasites) causes significant contamination on bee products. (Owayss A. Ayman et al., 2007).

Gulati et al. (2004) reported that the uses of bio-chemical agents like *Bacillus thuringiensis, Galleria* nuclear polyhedrosis virus (GNPV), oviposition attractants, genetic manipulation etc. provide to check against wax moths population. Ahmad et al. (1983), Tawfic et al. (1985) and Verma et al. (1999) reported that larval form of *Apanteles galleriae* is effective against wax moths' population (Gulati et al., 2004).

Ariana et al. (2002) reported that the use of several plant oils like thyme (Thymus), savory (Satureja) and spearmint (Mentha) have acaricidal properties against Varroa mites (Muhammad et al., 2012).

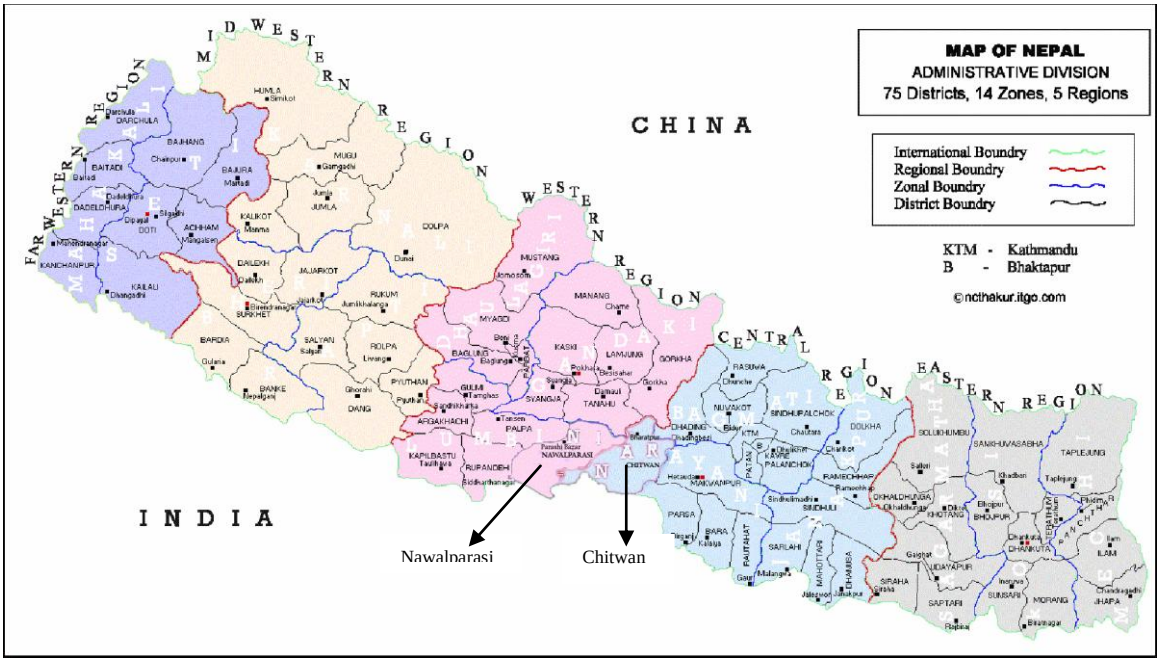
The national pesticides surveillance data of Nepal (1995-2005) revealed that 12.1% of the food samples were detected with residues of pesticides including malathion (3.9%), BHC (3.1%), Methyl parathion (2.8%), DDT (1.8%) and parathion (0.3%). Koirala et al., (2009) stated that detection of pesticide residues in the commodity-wise food analysis showed the highest level of residues in root vegetables (11.9%) followed by leaf vegetables (10.9%).

Pesticides are toxic in nature and do not differentiate between targeted and non-targeted species and hence should essentially be subject to safe and judicious use. Due to injudicious and indiscriminate use of pesticides, many accidents have occurred in different parts of Nepal and presence of pesticides in food, honey, fruits, vegetables and even in mother's milk is a matter of grave concern (Koirala et al., 2009).

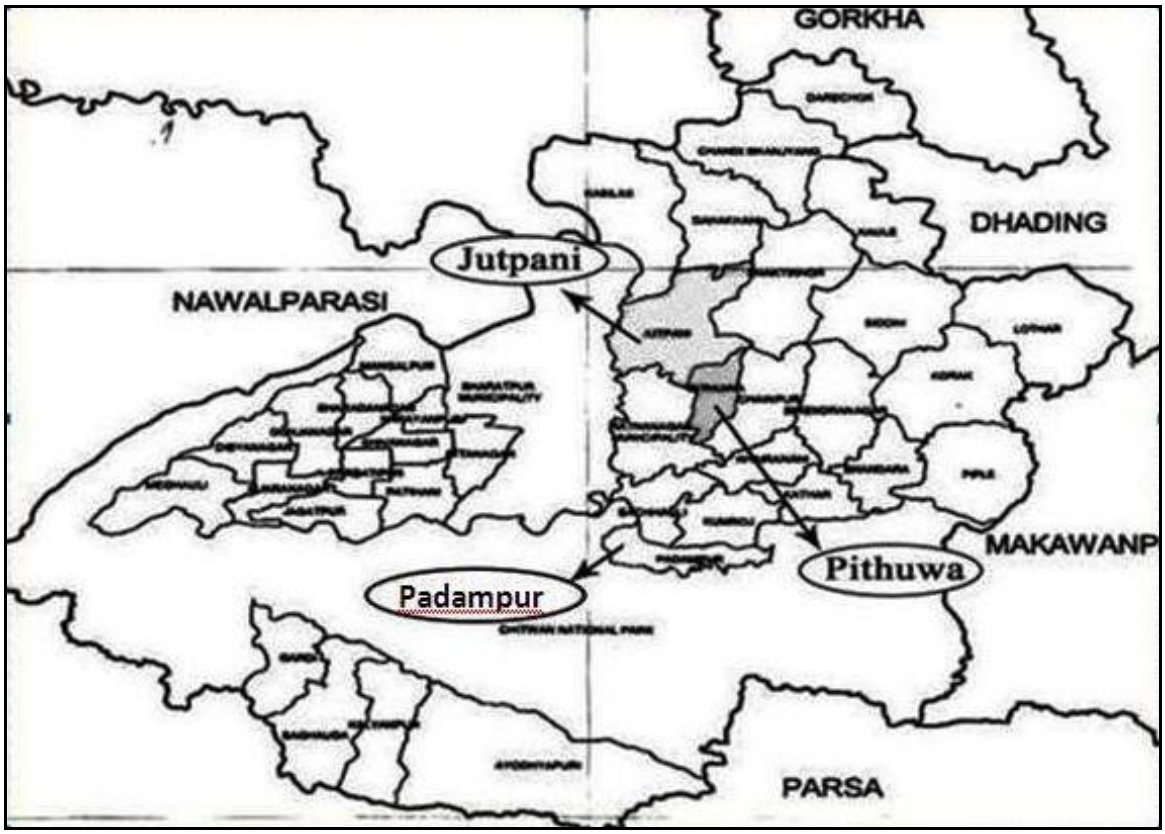
3. MATERIALS AND METHODS

3.1 Study site, time and duration

The study sites were selected in the Chitwan and Nawalparasi districts. Chitwan district lies in the inner terai region of central Nepal and Nawalparasi district lies in the terai region of western Nepal. Three VDCs were selected in the Chitwan and Nawalparasi districts on the criteria of honey production. These sites were in the apiaries of VDC Padampur-1,2,6 and 8; Jutpani-1,2,6 and 8; Pithuwa-3,4,7 and 8 which were situated North East to Bharatpur and about 4 km. North to Mahendra highway in the Chitwan district. Similarly, VDC Mukundapur-1,2,6 and 8; Pragatinagar-1,3,4 and 6; Gaindakot-3,5,6 and 8 in the bank of Narayani river of Nawalparasi district. The present investigation was carried out during spring (March-April) 15 March- 27 April and Rainy season (July-September) 17 July-28 September 2010 in the apiaries of the selected VDCs in both the above mentioned districts.



Chitwan District



Nawalparasi District

Fig. 1 : Map of selected sites of Chitwan and Nawalparasi districts.

3.2 Beekeeper's interview

A questionnaire was developed and used for collecting required information from the beekeepers of 48 households of which 2 households of each wards and 24 households in each district to picture out the present status of beekeeping. The information was mainly focused on the status of pests and pesticides which were used to control the pests, problems of beekeepers (Socio-economical, Managerial and Ecological aspects) and pasture management in the apiaries of Chitwan and Nawalparasi districts.

The information regarding honeybee's pests condition, pesticides used and problems encountered by the beekeepers were collected by taking interviews with the beekeepers, Federation of Beekeeper, Chitwan, Sagar beekeeping, Nawalparasi, Agro-vet dealers, Government agencies and related associations.

3.3 Data analysis

3.3.1 Species diversity

Species diversity includes both species richness and evenness. The community which contains large number of species is called richness while rare and common species is called evenness. It was calculated by following the index methods of Shannon-Weiner (1948) for measuring species diversity of communities.

$$\overline{H} = -\sum pi \ln pi$$

Where,

$\overline{H}$ = Shannon diversity index.

pi = the proportion of individuals of species i = n_i/N

ln = $\log_e$ = Natural logarithms(base e)

3.4 Mites sampling

Twenty-four colonies of *A. mellifera* in different apiaries were selected randomly from each district. They were then observed to find the pest status during the study period. The adults and broods of honeybees were examined by collecting hive debris from the floor of the bee hives. The adult deformed bees with distorted abdomens, missing legs, damaged wings and crawling rather than flying adult bees together with dying bee larvae were collected from the bee colony. All the collected samples were then washed with

Methylated Spirit. Tracheae of adult bees were dissected for investigating any presence of tracheal mites.

3.5 Identification

The collected specimens were identified by comparing the existing specimens kept at the Museum of Entomology Division NARC and BDS Godavari.

3.6 Specimen preparation/Photography

The minute insect pests were preserved in the alcohol. They were then mounted on the permanent slides by undergoing usual process of dehydration in the alcohol series and staining. The bigger insects were pinned up, dried and then placed in the insect collecting box. Photographs of the preserved specimens were taken by using binocular microscope while bigger insects and infested hives in natural state by Nikon 8.0 digital camera.

3.7 Vegetation

The bee plants growing in the vicinities of the selected apiaries in the VDCs of the Chitwan and Nawalparasi districts were observed during spring (Mar.-April) and rainy (July-Sept.) season, 2010. The observation of the bee plants was done giving special attention on nectar and pollen yielding plants.

3.8 Meteorological data

The meteorological data of Padampur, Jutpani and Pithuwa VDCs of Chitwan district was collected from the meteorological station at Bharatpur, while that of Pragatinagar, Mukundapur and Gaindakot VDCs of Nawalparasi district was collected from the meteorological station at Simari.

4. RESULTS

The season of abundance of the pest's population in honeybee colonies and pesticides used for the control measure and problems related to bee farming occupation were observed and studied. The two visits (spring and rainy season) were targeted so as to collect required informations. Random questionnaire survey was conducted mainly with the beekeepers of the above mentioned VDCs, Federation of Beekeeper, Chitwan, Sagar Beekeeping, Nawalparasi, Agro-vet dealers, Government agencies and related associations.

4.1 Pest status

During the investigation period it was found that fifty-seven *Tropilaelaps clareae* and thirty *Varroa jacobsoni* mites were the major pests during both spring and rainy season. Fifty-two *Galleria mellonella* (Greater wax moth) was found as minor pests during spring and major pests during rainy seasons (Appendix: 3 & 4).

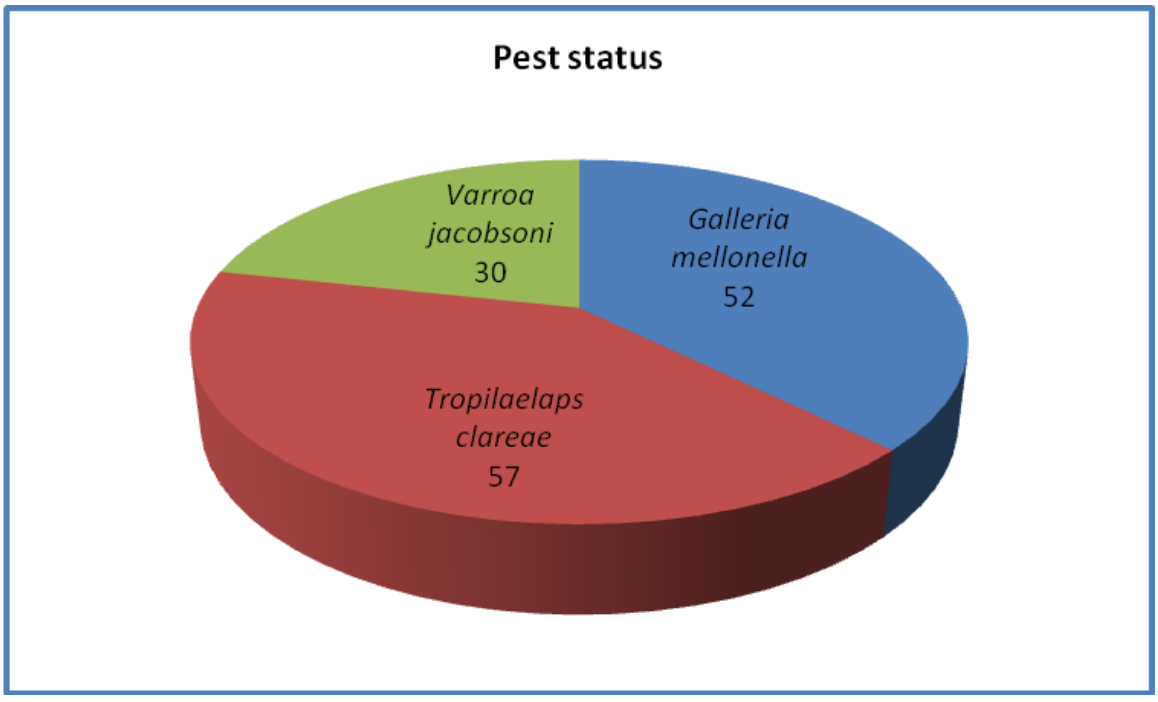


Fig. 2 : Status of pests at spring and rainy season of the selected sites.

Table 3 : Collected pests, Time of collection, Nature of damage and their status in the study sites.

Pest	Time of Collection	Nature of damage	Status
Varroa jacobsoni	Mar.-Apr./July-Sept.	Larva, Pupae & adult	Major/Major
Tropilaelap clareae	Mar.-Apr./July-Sept.	Larva & Pupae	Major/Major
Galleria mellonella (*Achroia grisella*)	Mar.-Apr./July-Sept.	honey comb & honey	Minor/Major

Table 4 : Total number of honeybee samples collected from different areas.

Selected VDCs of Chitwan district			
Season / Sites	Spring	Rainy	Total
Padampur	16	16	32
Jutpani	16	16	32
Pithuwa	16	16	32
Total	48	48	96
Selected VDCs of Nawalparasi district			
Pragatinagar	16	16	32
Mukundapur	16	16	32
Gaindakot	16	16	32
Total	48	48	96

Three different species of pests were recorded from the studied samples of honeybee colonies. The total numbers observed were 41 mites and 24 Greater wax moth pests in which 14 *Varroa jacobsoni* and 27 *Tropilaelaps clareae* from Chitwan (Appendix: 3) while 46 mites and 28 Greater wax moth pests in which 16 *Varroa jacobsoni* and 30 *Tropilaps clareae* from the Nawalparasi district of the selected sites (Appendix: 4). The maximum numbers of collected specimens were of the family Tarsonemidae.

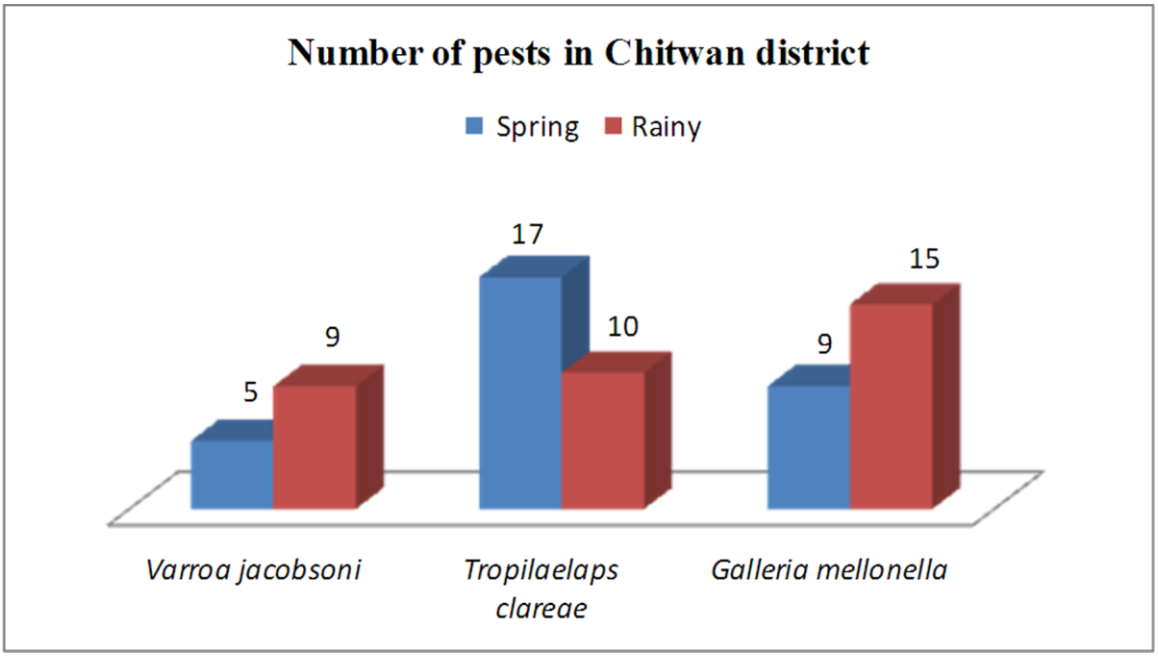


Fig. 3 : Number of honeybee pests in spring and rainy season of Chitwan district.

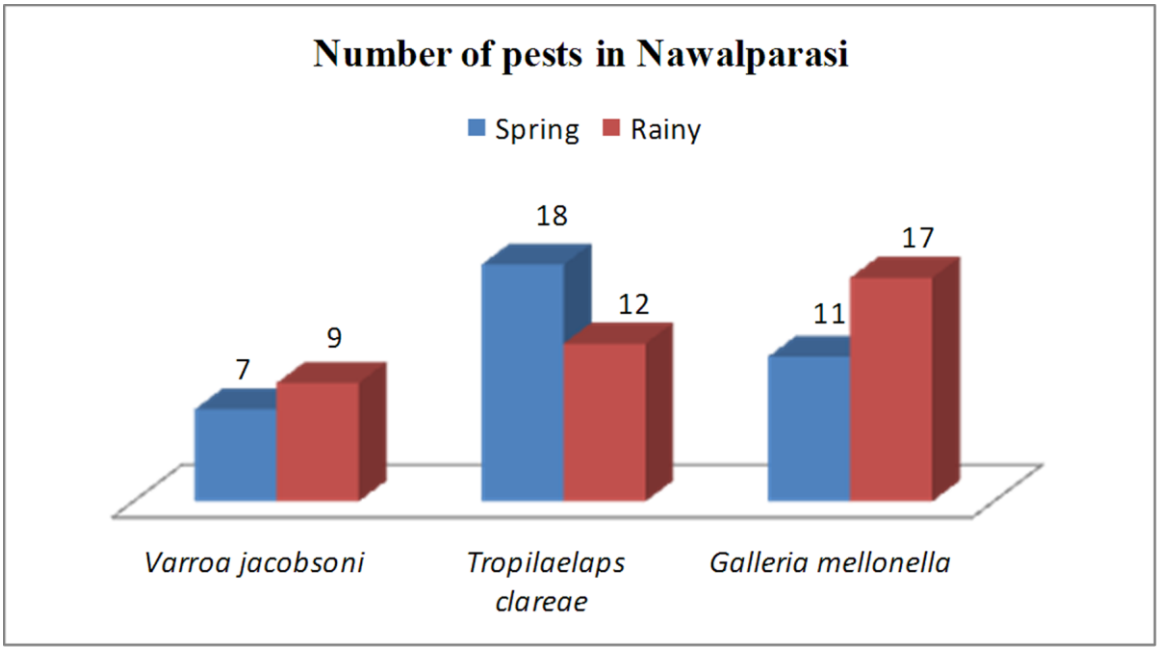


Fig. 4 : Number of honeybee pests in spring and rainy season of Nawalparasi district.

4.1.1 *Varroa jacobsoni*

The size of the *varroa* mite was found to be 1 mm. long and 1.5 mm. wide. The mites were mostly found in the region of head and thorax and in between thorax and abdomen of the adult honeybees. The *varroa* mites were observed in the apiaries of both the Chitwan and Nawalparasi districts.

4.1.2 *Tropilaelaps clareae*

The mites were red brown in colour and measured 1 mm. long and 0.5 mm. wide in size. During observation *Tropilaelaps* crawled freely and rapidly on combs of the nest and in the cells of the brood.

It was observed that these mites damaged the brood combs especially of drone cells in irregular patterns and made the honeybee colony very weak by making adult bees stunted with deformed wings and shrunken abdomens.

4.1.3 *Galleria mellonella* (Greater wax moth)

The greater wax moth measured 13 mm. long and 29 mm. wings expanded. The body of *Galleria mellonella* looked brownish grey in colour.

4.2 Species diversity

The species recorded during the present study were *Varroa*, *Tropilaelaps* and *Galleria mellonella*, the lesser wax moth. The species diversity of pests was (H_1=0.99) during spring and (H_2=1.07) during rainy season in the Chitwan district (Appendix: 3) while (H_3=1.03) during spring and (H_4=1.07) during rainy season in Nawalparasi district (Appendix: 4).

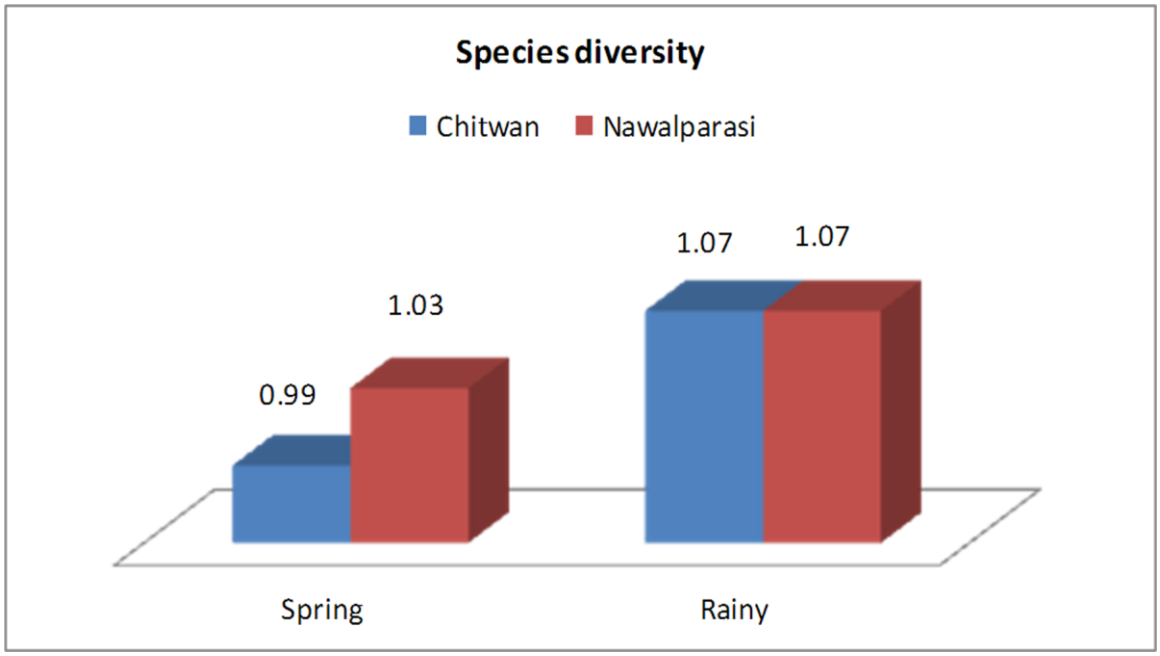


Fig. 5: Species diversity of honeybee pests in Chitwan and Nawalparasi.

4.3 Pesticides used to control pests

During the study it was observed that most beekeepers use Apistan, but some beekeepers use sulphur dust, formic acid, oxalic acid and domestic herbals like *Centella asiatica* (Titepate), *Azadirachta indica* (Neem), *Adhatoda vesica* (Asuro), *Allium sativum* (Garlic), Tobacco smoke and ashes for controlling mites in the honeybee colonies in both the above mentioned districts. It was also found that very few experienced beekeepers adopted biological control by controlling queen bee for laying eggs for 21 days to manage the mite problems. Net was also used for controlling the wax moths from entering in the bee hives. The net was placed by covering the hives at night.

Table 5 : Control schedule management adopted for honeybee pests at Chitwan and Nawalparasi districts.

Pest	**Management adopted by the beekeepers**
Mite	Applying formic acid, oxalic acid, apistan, sulphur dust, methyl bromide, tobacco smoke, domestic herbals and other biological methods etc.
Wax moth	Applying fumigants like para-dichlorobenzene and aluminium phosphide. Some beekeepers adopt IPM method.

4.4 Climate

According to the meteorological data 2010 collected from Bharatpur, the mean of monthly maximum temperature ranged from 21ºC during January and 37.6ºC during April and minimum temperature ranged from 9.2ºC during December and 25.5ºC during July in Chitwan district respectively. Similarly, according to the meteorological data 2010 collected from Simari, the mean of monthly maximum temperature ranged from 19.6ºC during January and 42 ºC during June and minimum temperature 6 ºC during December to 25.4ºC during August in Nawalparasi district. The monthly maximum rainfall ranged from 5 mm. during January and 704.3 mm. during July and minimum rainfall ranged from 4.5 mm. during January and 165.0 mm. during August in Chitwan district. Similarly, the monthly maximum rainfall ranged from 46.0 mm. during April and 1259.5 mm. during August and minimum rainfall ranged from 38.0 mm. during June and 315.0 mm. during August in Nawalparasi district.

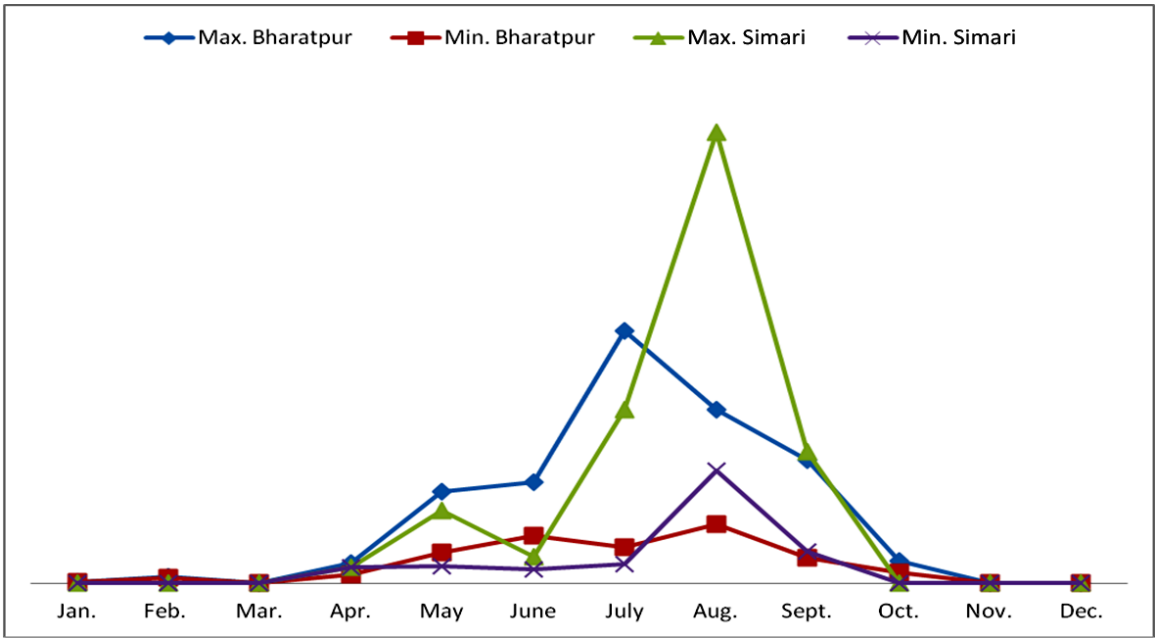


Fig. 6 : Graph of monthly maximum and minimum rainfall in Bharatpur & Simari.

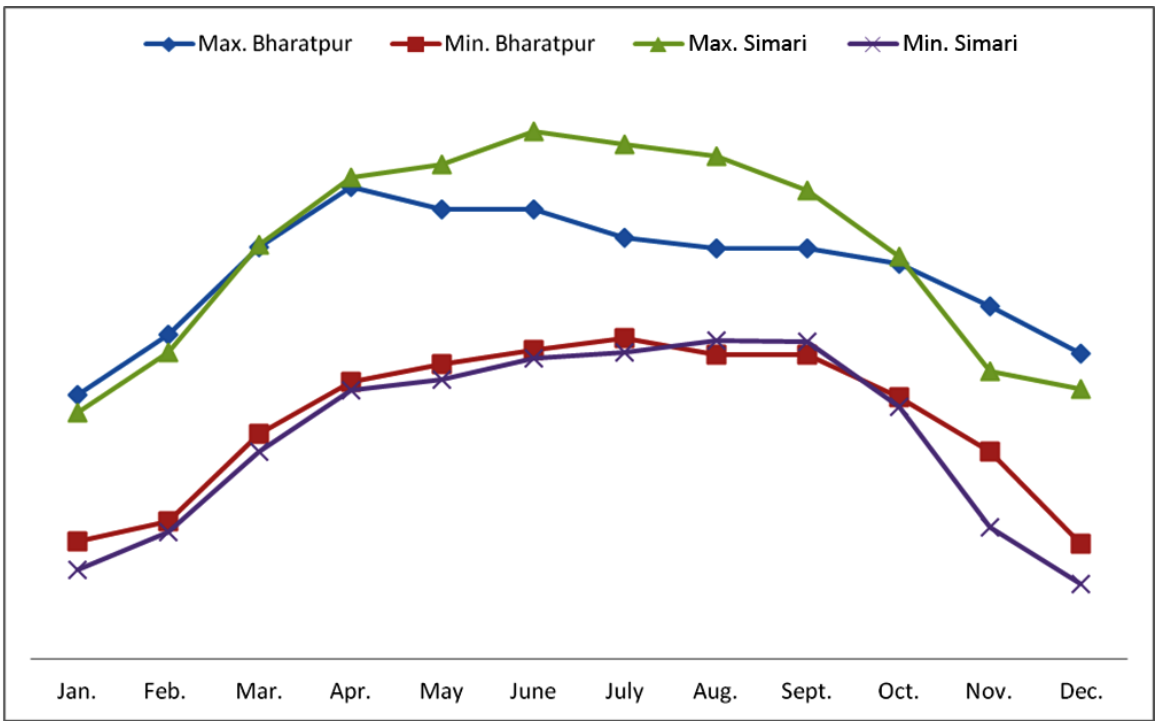


Fig. 7 : Graph of maximum and minimum temperature of Bharatpur and Simari.

4.5 Vegetation

During the study period, the bee plants found in the localities of Chitwan and Nawalparasi districts were observed and studied. The major and minor honey flow period were drawn out from the nectar and pollen availability period.

4.6 Questionnaire Survey

4.6.1 Socio-economic problems

The beekeepers of Chitwan district faced different socio-economic problems. The major problems faced by them were lack of cash (91.7%), theft (16.7%), proper honey market availability (66.7%), lack of co-ordination among beekeepers of that localities (70.8%), lack of proper organizational development (70.8%), frequent conflict among the migratory beekeepers for bee foraging pasture land (66.7%), traffic problems during honeybee migration (79.2%) and lack of national policy/programme (95.8%). The mean percentage of socio-economic problems drawn out from above mentioned data come to be 69.8%. Similarly different socio-economic problems faced by the beekeepers of Nawalparasi district were lack of cash (58.3%), theft (12.5%), proper honey market availability (66.7%), lack of co-ordination among beekeepers of that localities (33.3%), lack of organizational development (37.5%), frequent conflict among the migratory beekeepers for bee foraging pasture land (79.2%), traffic problems during migration (54.2%), lack of national policy/programme (62.5%). The mean percentage of socio-economic problems drawn out from the above described data had come to be 50.5%. The patterns of socio-economic problems of both the studied area are graphically shown below.

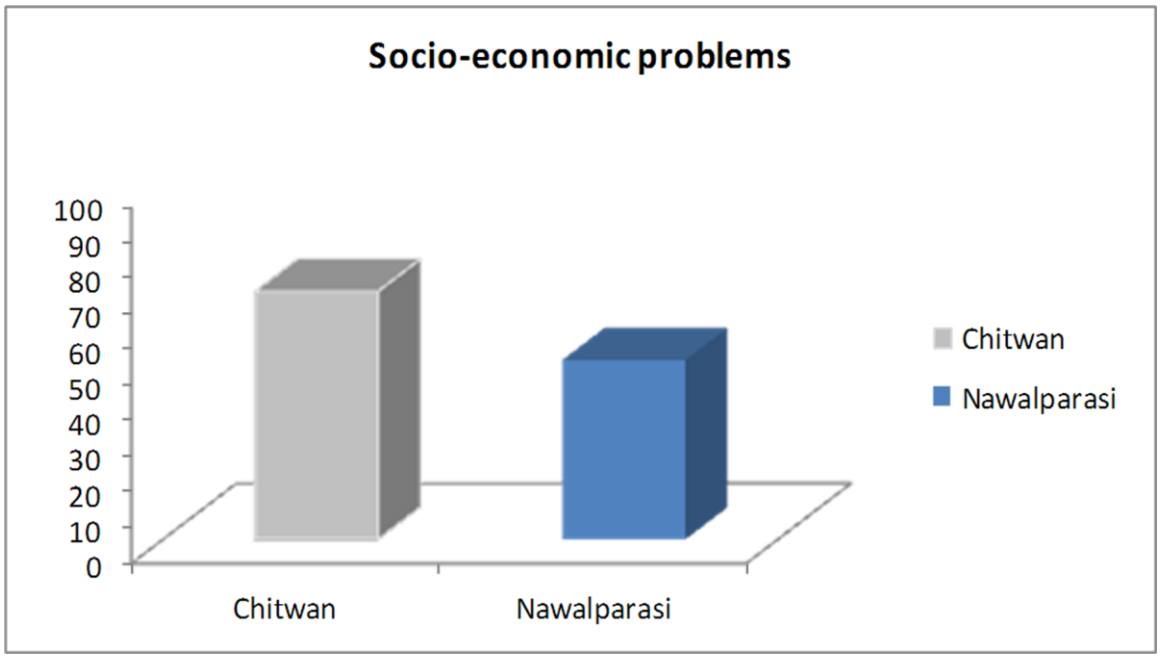


Fig. 8 : Socio-economic problems in Chitwan and Nawalparasi districts.

4.6.2 Ecological problems

The reduction of bee foraging pasture land is due to deforestation, soil erosion and land slide. The mean percentage of ecological problems in Chitwan is 95.8%. While the mean percentage of ecological problems in Nawalparasi district is 87.5%. This is graphically is shown below.

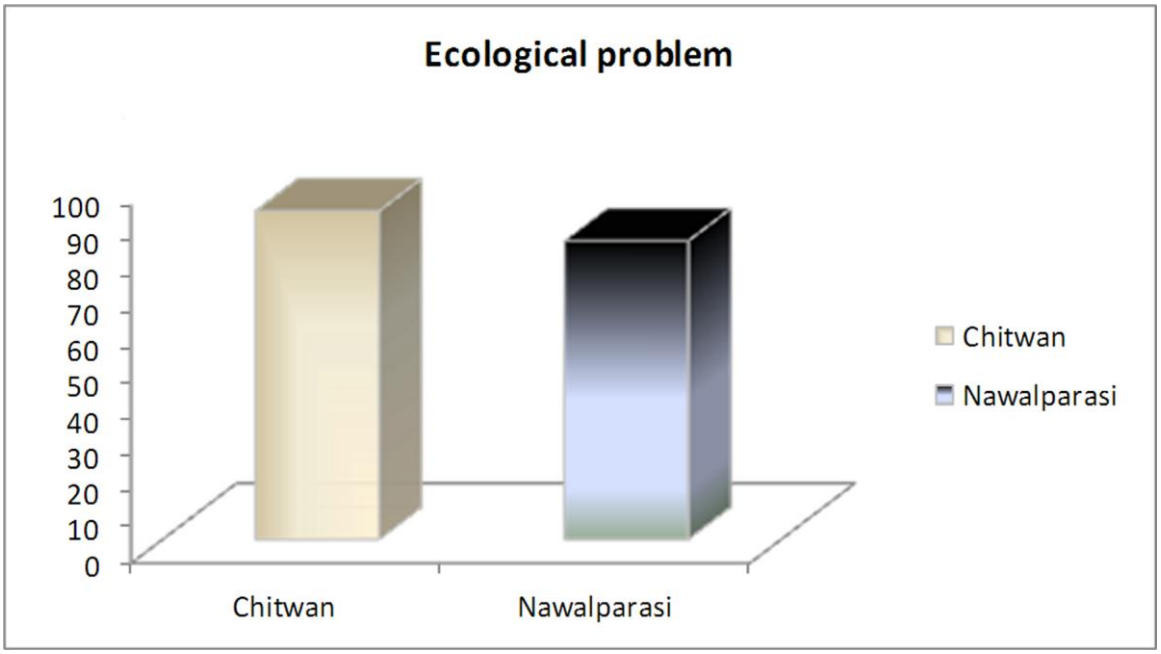


Fig. 9 : Ecological problems of the beekeepers in Chitwan and Nawalparasi districts.

4.6.3 Management related problems

Lack of skill in colony management (33.3%), lack of nearby proper honeybee diagnosis centre (91.7%), poor feeding management (41.7%), use of unsterilized old hives (62.5%), unavailability of proper bee medicine nearby (62.5%) and application of hazardious pesticides in the agricultural crop yard is (87.5%) in Chitwan. The mean percentage of managemental problems found in Chitwan is 63.2%. While lack of skill in colony management (45.8%), lack of nearby proper honeybee diagnosis centre (58.3%), poor feeding management (54.2%), use of unsterilized old hives (70.8%), unavailability of proper bee medicine nearby (54.2%) and use of hazardious pesticides in the agricultural crop field is (79.2%) in Nawalparasi. The mean percentage of management problems is found to be 60.4% in Nawalparasi.

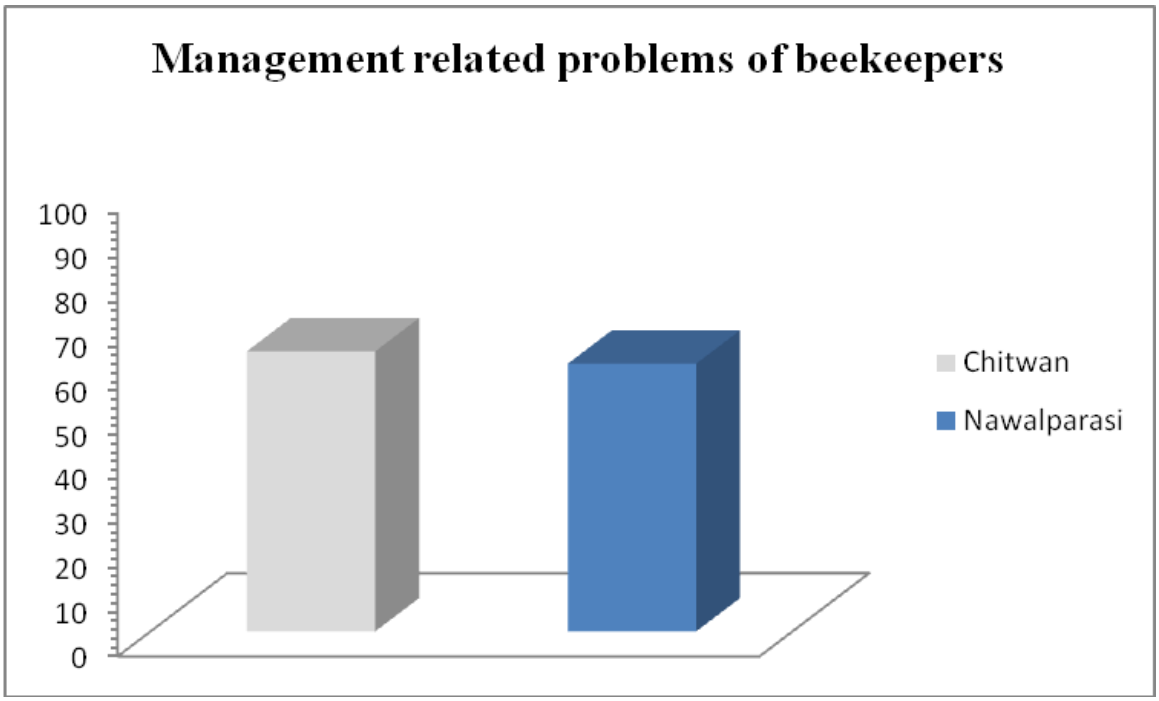


Fig. 10 : Management related problems in Chitwan and Nawalparasi districts.

5. DISCUSSION

Fourteen *Varroa jacobsoni*, twenty seven *Tropilaelaps clareae* and twenty-four *Galleria mellonella* (Greater wax moths) were observed and identified in the honeybee colonies from apiary sites of Chitwan. Similarly sixteen *Varroa jacobsoni*, thirty *Tropilaelaps clareae* and twenty-eight *Galleria mellonella* (Greater wax moths) were also observed and identified in the honeybee colonies from the apiary sites of Nawalparasi district.

The introduction of exotic honeybee species causes pests, predators, diseases and pesticides residue problems in Nepal (Bista and Shivakoti, 2001). The various problems occurred due to pests in beekeeping have not yet well been in control and their management practices have not become fully effective. The mites that are mostly found in the nest of honeybee colonies in Nepal are *V. jacobsoni, Tropilaelaps clareae and Neocypholaelaps indica* (PPSN, 2005).

Species diversity of different pest species is high which visit the apiaries and feed on honeybees. Higher the frequency of honeybee pests more the chances there will be loss in beekeeping trade. During the investigation, two species of mites and one species of wax moth were observed in the hives. These mites are *Varroa jacosoni* of the family Varroidae and *Tropilaelaps clareae* of the family Tarsonemidae of the order Acari while wax moths of the family Pyralidae of the order Lepidoptera. Species diversity of honeybee pests found in the apiaries varied with seasonal variation. The species diversity is 0.99 in spring season and 1.07 in rainy season at Chitwan and 1.03 in spring season and 1.07 in rainy season at Nawalparasi district of the study area. This varified that *Galleria mellonella* is more in both the districts during rainy season and less during spring season while mites were found more during spring season in both the districts which is also supported by (www. agritech. tnau) and Varshney et al. (2008). In Asian countries like, China, Pakistan and India, weakening and ultimately dwindling of *A. mellifera* colonies is caused by two mite species which were *Tropilaelaps clareae* and *Varroa jacobsoni*. This investigation is also supported by Ahmad et al. (1983), Tawfic et al. (1985) and Verma et al.(1999). According to Woo and Lee (1997) approximately, 30-70% reduction in honey yield was observed due to infestation of *T. clareae* (Muhammad et al., 2012)**.** The stress created by the mites and wax moth in the honeybee colonies are the basic cause which made the colony unproductive both for honey production and in using them for pollination purposes in agricultural farm land.

Formic acid, oxalic acid, apistan, sulphur dust, domestic herbals and biological methods are the main pesticides that were used by the beekeepers to control mite pests in the honeybee colonies. Food security is not possible without income security (Koirala and Thapa, 1997). The government Agricultural Development Office is promoting broad-spectrum of insecticides in Nepal. These include highly toxic pesticides (metacid and nuvan) which are hazardous to honeybees and beneficial pollinators of the ecosystem. This is also supported by Manandhar (2006).

During the investigation, the beekeepers of Chitwan locality (95.8%) and Nawalparasi locality (87.5%) mentioned that the bee foraging land was also not enough for bee farming during spring and rainy seasons.

A total number of forty-two different plant species were identified (Appendix: 2) as honeybee plants at the experimental sites during the study period. Based on flowering duration and abundance of *Brassica compestris* lin., *Zea mays***,** *Fagopyrum esculentum*, *Sesamum indicum***,** *Pogostemon spp.*, *Chenopodium album Litchi chinensis* and *Cajanus cajan* lin. were identified as extremely important honeybee plants in both the study sites of the apiaries. This gives the information that the spring season is honey flow period in both these districts. Thapa (2006) reported that seventeen honeybee plants were observed at IAAS Chitwan and its vicinity of which fourteen plants are visited by *A. mellifera*. He also listed 180 plants in which 142 plants are visited by the different species of bees which coincides with my findings of the bee flora in the investigation apiaries of Chitwan district.

The mean percentages of socio-economic problems as mentioned above are found to be 69.8% and management problems 63.2% in Chitwan while 50.5% and 60.4% in Nawalparasi. The socio-economic problem is due to lack of proper honey market. Hence all the honey is consumed in domestic markets only. The beekeepers have no channel to export their honey abroad due to pesticide residues contained in the honey. Due to these problems European countries, Japan and China have banned to import honey from Nepal.

Honey production through beekeeping could be a useful avenue for improving rural economy (Baptist and Punchihewa, 1983). APP has recognized beekeeping as high value income generating enterprise (APROSC and JMA, 1995). Poor, marginal and even landless farmers can benefit from beekeeping to support their livelihoods as it can be started even with limited resources (ICIMOD, 1999).

The improved beekeeping technology is not well adopted by the beekeepers in the investigated apiary sites of the Chitwan and Nawalparasi districts which coincides very much with Shrestha (2000). Improved beekeeping technology transfer is crucial for the successful promotion of beekeeping (Saville, 2000 ; Pant, 1983).

Promotion and development of beekeeping with necessary apiary management is most important for better harvests of bee products, pollination ecology and conservation aspects.

6. CONCLUSION AND RECOMMENDATION

The experimental results of the present investigation are summarized under the following conclusions.

(a) Two species of mites belonging to the order Acari viz.; *Varroa jacobsoni* and *Tropilaelaps clareae* were identified as pests of honeybee.

(b) These mites created serious damage to honeybee (*A. mellifera*) colonies at both sites.

(c) Similarly, other pests of honeybee belonging to order Lepidoptera viz.; *Galleria mellonella* was also recorded as major pest of honeybee in both the sites of the apiary.

(d) Forty-two Species of bee plants were recorded in both the study area during the study period. Their blooming period was also observed.

(e) The major honey flow period was observed to be spring season in the Chitwan district.

(f) The maximum species diversity of pests was recorded 1.07 in both the Chitwan and Nawalparasi districts in the rainy season.

(g) The incidence of mites was highest during the spring season in the apiary sites of Nawalparasi district. Similarly, the incidence of Greater wax moth was highest during the rainy season in Nawalparasi district. Regarding Chitwan district, the incidence of mites and Greater wax moth was not found highest.

(h) For the control of pests; organic pesticides, chemical pesticides, herbicides and antibiotics were used by the beekeepers.

Recommendation

1. Research on identification and control of pests should be carried out for promotion and development of beekeeping. Surveillance of these threats should be made throughout the country in socio-economic, management and ecological problems. There must be well equipped research centre for identification and management of the pests.
2. From the investigation, beekeepers should give due attention on the biology of these pests to save the colonies from mites and wax moth during spring and rainy seasons.

Use formic acid to control the mites. Hence, in the beekeeping technology transfer programme, the knowledge about biology of pests should also be included.

3. IPM methods and biological control methods to control pests should be applied to reduce pesticide residues in honeybee products. Then only its products can take international markets and solve the socio-economic problems of the beekeepers.
4. Protection from cutting of *Dalbergia sisoo Rob.* (Sisoo) and *Pogostemon glaber Benth.* (Rudilo) tree from the Churiya range seriously damage the habitat of the important bee flora which are important source of nectar.
5. Insecticides should be applied in their crop fields in the afternoon.
6. Beekeepers should be informed of the day and time of spraying insecticides on the crop fields so that they can close up their hives by managing food supply inside the hive and thus preventing their bees from foraging over the insecticides sprayed crop field.
7. Pesticides should be of moderate strength and should have lower residue in honey and no use of POPs.
8. Commercialization of *A. mellifera* beekeeping in Terai needs advanced agriculture research and extension mechanism including crop pollination and beekeeping training with a secured honey market for clear-cut beekeeping policy and guideline should be developed and implemented by the GoN.
9. The quarantine policies need to be revised for regulating the export and import of honeybee and its products.
10. The Amendment in the Plant Quarantine Act should be done to check the entry of new diseases and pests while exporting and importing honeybees.
11. For the control of mites, *Centella asiatica* (Titepate), *Azadirachta indica* (Neem), *Adhatoda vesica* (Asuro), Ashes and Tobacco smoke should be used and for Greater wax moth *Bacillus thrungensis* should be used.

7. REFERENCES

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PHOTOGRAPHS

Plate 1: Colonies of *Apis mellifera.*

Plate 2 : Colonies in foraging area.

Plate 3: Author observing hives of *Apis mellifera.*

Plate 4: Hive of *Apis mellifera*.

Plate 5: Collected specimens of *Galleria mellonella*.

Plate 6: *Galleria mellonella* (Greater wax moth).

Plate 7: Colony infected with mites.

Plate 8: Mites attacking on larvae.

Plate 9: Samples identifying in laboratory.

Plate 10: *Varroa jacobsoni.*

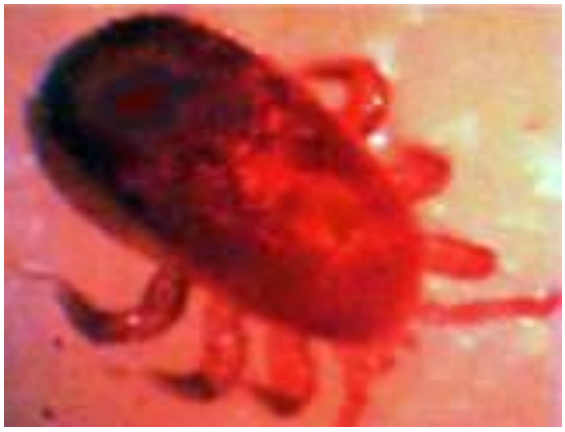

Plate 11: *Tropilaelaps clareae*.

APPENDICES

Appendix 1 : Maximum and minimum temperature and rainfall record at meteorological station of Bharatpur in Chitwan and Simari in Nawalparasi districts during study period in 2010.

	Chitwan district				Nawalparasi district			
Months	**Max. temp.**	**Min. temp.**	**Max. Rainfall**	**Min. rainfall**	**Max. temp.**	**Min. temp.**	**Max. Rainfall**	**Min. rainfall**
January	21.0°C	9.4°C	5 mm	4.5 mm	19.6°C	7.1°C	0.0 mm	0.0 mm
February	25.8°C	11.0°C	18 mm	15.5 mm	24.4°C	10.1°C	0.0 mm	0.0 mm
March	32.8°C	17.9°C	0.0 mm	0.0 mm	33.0°C	16.5°C	0.0 mm	0.0 mm
April	37.6°C	22.1°C	55.9 mm	25.5 mm	38.3°C	21.4°C	46.0 mm	46.0 mm
May	35.8°C	23.5°C	254.7 mm	85.5 mm	39.4°C	22.3°C	203.0 mm	47.0 mm
June	35.8°C	24.6°C	282.6 mm	132.0 mm	42.0°C	23.9°C	73.0 mm	38.0 mm
July	33.5°C	25.5°C	704.3 mm	100.1 mm	41.0°C	24.4°C	486.0 mm	53.0 mm
August	32.7°C	24.2°C	484.0 mm	165.0 mm	40.0°C	25.4°C	1259.5 mm	315.0 mm
September	32.7°C	24.2°C	342.5 mm	71.5 mm	37.3°C	25.3°C	368.0 mm	89.0 mm
October	31.5°C	20.8°C	63.1 mm	30.1 mm	32.0°C	20.1°C	0.0 mm	0.0 mm
November	28.1°C	16.5°C	0.0 mm	0.0 mm	22.9°C	10.5°C	0.0 mm	0.0 mm
December	24.3°C	9.2°C	0.0 mm	0.0 mm	21.5°C	6.0°C	0.0 mm	0.0 mm

Appendix 2 : List of honeybee flora observed blooming around observation sites of apiaries at Chitwan and Nawalparasi districts in 2010.

S.N.	Botanical name	Family	Common Name	Flowering period	Status
1.	*Abelmoschus esculentus*	Malvaceae	Okra	June-Sept.	N+P
2.	*Aesandra butyracea*	Sapotaceae	Chiuri	Mar.-Apr.	N
3.	*Albizia spp.*	Fabaceae	Sirises	Mar.-Apr.	N
4.	*Bombax ceiba*	Bombaceae	Simal	Mar.-Apr.	N
5.	*Brassica oleraceae*	Brassicaceae	Broccoli	Mar.-Apr.	N+P
6.	*Brassica spp.*	Cruciferae	Rape, Mustard	Mar.-Apr.	N+P
7.	*Callistemon citrinus*	Murtaceae	Bottle brush	Mar.-Oct.	N+P
8.	*Cajnus cajan*	Fabaceae	Red gram	July-Sept.	N
9	*Capsicum annum*	Solanaceae	Chilly	June-Sept.	N+P
10	*Carica papaya*	Caricaceae	Papaya	Whole year	N
11.	*Cedrela odorata*	Meliceae	Tuni	Mar.-Apr.	N
12.	*Chenopodium album*	Amaranthaceae	Bethe	Mar.-Apr.	N
13.	*Citrus spp.*	Compositae	Pomelo	Mar.-Apr.	N+P
14.	*Cocos nucifera*	Arecaceae	Coonut	Jun.- Oct.	P
15.	*Cucumis spp.*	Cucurbitaceae	Cucumber, Melon	Mar.-Apr.	N+P
16.	*Cucurbita pepo*	Cucurbitaceae	Pumpkin	Apr.-Sept.	N+P
17.	*Dalbergia sisoo*	Fabaceae	Sisoo	Mar.-Apr.	N

S.N.	Botanical name	Family	Common Name	Flowering period	Status
18.	*Diospyros kaki*	Ebenaceae	Persimmon	Jan.-June	N
19.	*Eucalyptus spp.*	Myrtaceae	Eucalyptus	Mar.-Sept.	N+P
20	*Euphorbia pulcheria*	Euphorbiaceae	Lalupate,	Mar.-June	N+P
21.	*Fagopyrum esculentum*	Polygonaceae	Buckwheat	July-Sept.	N+P
22.	*Gossypium spp.*	Malvaceae	Kapas	July-Sept.	N
23.	*Helianthus annulus*	Compositae	Sunflower	July-Sept.	N+P
24	*Hibiscus rosa-chinensis*	Malvaceae	China rose	Mar.-July	N+P
25.	*Jatropha spp.*	Euphorbiaceae	Castor	Mar.-Apr.	P
26.	*Litchi chinensis*	Spindaceae	Litchi	Mar.-Apr.	P
27.	*Lycopersicum esculentum*	Solanaceae	Tomato	Mar.-Oct.	N+P
28.	*Magnifera indica*	Anacardiaceae	Mango	Mar.-Apr.	N+P
29.	*Musa spp.*	Musaceae	Banana	Whole year	N+P
30.	*Pogostemon spp.*	Labiate	Rudilo	Mar.-Apr.	N
31.	*Prunus spp.*	Rosaceae	Apricot, Peach	March-June	N
32.	*Punica granatum*	Lythraceae	Anar	Mar.-Apr.	P
33.	*Shorea robusta*	Dipterocarpaceae	Sal	Mar.-Apr.	N+P
34.	*Syzygium spp.*	Jamuna	Myrtaceae	Mar.-Apr.	N+P
35.	*Sesamum indicum*	Pedaliaceae	Sesame	July-Sept.	N
36.	*Solanum spp.*	Solanaceae	Brinjal, Tomato	July-Sept.	P+N

S.N.	Botanical name	Family	Common Name	Flowering period	Status
37.	*Trifolium spp.*	Leguminosae	White clover	Feb.-July	N+P
38.	*Vigna unguiculata*	Fabaceae	Cowpea	July-Sept.	N
39.	*Vitis vinifera*	Vitaceae	Grape	Mar.-Apr.	N
40.	*Zea mays*	Graminae	Maize	June-Aug.	P
41.	*Zizyphus spp.*	Rhamnaceae	Jujube	Mar.-Apr.	N+P
42.	*Artocarpus lakoocha*	Moraceae	Badhar	Mar.-Apr.	N+P

N= Nectar yielding plants. P= Pollen yielding plants and N+P= Nectar and Pollen yielding plants.

Appendix 3： Seasonal distribution of honeybee pests in study sites of Chitwan district in 2010.

Order	**Family**	**Species**	**Spring (Mar.-Apr.).No. of ind. sps.**	**Pi**	**ln Pi**	**pi ln pi**
Acari	Varroidae	*Varroa jacobsoni*	n_i=5	0.16	-1.83	-0.29
	Tarsonemidae	*Tropilaelaps clareae*	n_i=17	0.52	-0.65	-0.34
Lepidoptera	Pyralididae	*Galleria mellonella*	n_i=9	0.29	-1.24	-0.36
Total			N=31		H_1=-∑pi ln pi= 0.99	
Percentage			64.58			
Order	**Family**	**Species**	**Rainy (July-Sept.) No. of ind. sps.**	**Pi**	**lnPi**	**pi ln pi**
Acari	Varroidae	*Varroa jacobsoni*	n_i=9	0.26	-1.35	-0.35
	Tarsonemidae	*Tropilaelaps clareae*	n_i=10	0.29	-1.24	-0.36
Lepidoptera	Pyralididae	*Galleria mellonella*	n_i=15	0.44	-0.82	-0.36
Total			N=34		H_2=-∑pi ln pi= 1.07	
Percentage			70.83			

Appendix 4： Seasonal distribution of honeybee pests in study sites of Nawalparasi district in 2010.

Order	Family	Species	Spring (Mar.-Apr.).No. of ind. sps.	Pi	ln pi	pi ln pi
Acari	Varroidae	*Varroa jacobsoni*	n_i=7	0.19	-1.66	-0.32
	Tarsonemidae	*Tropilaelaps clareae*	n_i=18	0.50	-0.69	-0.35
Lepidoptera	Pyralididae	*Galleria mellonella*	n_i=11	0.31	-1.17	-0.36
		Total(N)	36		H_3=-∑pi ln pi=1.03	
		Percentage	75			
Order	**Family**	**Species**	**Rainy(July-Sept.) Number of individual species**	**Pi**	**ln pi**	**pi ln pi**
Acari	Varroidae	*Varroa jacobsoni*	n_i=9	0.24	-1.43	-0.34
	Tarsonemidae	*Tropilaelaps clareae*	n_i=12	0.32	-1.14	-0.37
Lepidoptera	Pyralididae	*Galleria mellonella*	n_i=17	0.45	-0.80	-0.36
		Total(N)	38		H_4=-∑pi ln pi=1.07	
		Percentage	79.17			

Appendix 5 : Pests and pesticides use to control it in Chitwan and Nawalparasi districts in 2010.

S.N.	Honeybees	Type of pests problems	Season	Pesticides applied	Frequency of pesticides	Interval of last pesticide used and picking of product
1.	*A. Mellifera*	Parasitic Mites	Rainy & Spring	Domestic Herbal (Neem, Asuro, Titepate, Garlic, Ash and Tobacco smoke)	5-6 (times)	0-7 (days)
2.	*A. Mellifera*	Parasitic Mites	Rainy &Spring	Formic Acid	2-4	7-14 days
3.	*A. Mellifera*	Parasitic Mites	Rainy &Spring	Sulphur, Apistan, Apiguard	1-2	7-14 days
4.	*A. Mellifera*	Parasitic Mites	Rainy &Spring	Tetracycline	2-4	15 days and above

Appendix 6 : Socio-economic problems of beekeepers in Chitwan and Nawalparasi districts in 2010.

S.N.	Socio-economic problems	Respondents at selected at sites of Chitwan district			Total	%	Respondents at selected sites of Nawalparasi district			Total	%
		Padampur	Jutpani	Pithuwa			Pragatinagar	Mukundapur	Gaindakot		
1.	Lack of cash	7	8	7	22	91.7	7	2	5	14	58.3
2.	Theft	2	0	2	4	16.7	2	1	0	3	12.5
3.	Lack of honey market	4	5	7	16	66.7	6	4	6	16	66.7
4.	Lack of national policy/programme	7	8	8	23	95.8	6	5	4	15	62.5
5.	Lack of organization development	6	5	6	17	70.8	4	3	2	9	37.5
6.	Lack of co-ordination	5	7	5	17	70.8	2	4	2	8	33.3
7.	Traffic problem on migration	6	6	7	19	79.2	4	3	6	13	54.2
8	Conflict for pasture use	5	6	5	16	66.7	6	7	6	19	79.2
	Total mean percentage					69.8	Total mean percentage				50.5

Appendix 7 : Ecological problems of beekeepers in Chitwan and Nawalparasi districts in 2010.

S.N.	Ecological problems	Respondents at selected at sites of Chitwan district			Total	%	Respondents at selected sites of Nawalparasi district			Total	%
		Padampur	Jutpani	Pithuwa			Pragatinagar	Mukundapur	Gaindakot		
1.	Deforestation / Pasture lacking	8	7	8	23	95.8	7	8	6	21	87.5

Appendix 8 : Management related problems of honeybee colony in Chitwan and Nawalparasi districts in 2010.

S.N.	Management practices	Respondents at selected at sites of Chitwan district			Total	%	Respondents at selected sites of Nawalparasi district			Total	%
		Padampur	Jutpani	Pithuwa			Pragatinagar	Mukundapur	Gaindakot		
1.	Use of bad hives	4	6	5	15	62.5	6	7	4	17	70.8
2.	Poor feeding management	3	4	3	10	41.7	5	4	4	13	54.2
3.	Lack of skill	5	1	2	8	33.3	4	3	4	11	45.8
4.	Unavailability of bee medicine	4	6	5	15	62.5	3	4	6	13	54.2
5.	Lack of bee clinic	7	8	7	22	91.7	5	6	3	14	58.3
6.	Poisoning	7	6	8	21	87.5	8	5	6	19	79.2
	Total mean percentage					63.2	Total mean percentage				60.4

Appendix 9 : List of banned pesticides in Nepal

(POPs and non-POPs pesticides covered).

S.N.	Name of pesticide	Remarks
1.	Chlordane	Persistent Organic Pollutant
2.	DDT	Persistent Organic Pollutant
3.	Dieldrin	Persistent Organic Pollutant
4.	Endrin	Persistent Organic Pollutant
5.	Aldrin	Persistent Organic Pollutant
6.	Heptachlor	Persistent Organic Pollutant
7.	Toxafen	Persistent Organic Pollutant
8.	Mirex	Persistent Organic Pollutant
9.	Lindane	Persistent Organic Pollutant
10.	BHC	
11.	Phosphamidon	
12.	Organo-mercury fungicides	
13.	Methyl parathion	
14.	Monocrotophos	

(Source:-Statistical pesticide book 2068 B.S. PRMD)