I
INTRODUCTION

1.1 GENERAL BACKGROUND:

Rodents (Order Rodentia) are a diverse group of small mammals that have a cosmopolitan distribution. They are a key mammalian group and are highly successful in adapting to many environments throughout the world. There are more than 1700 species of rodents identified in the world (RatZooMan, 2006). In Nepal 50 species of rodents have been recognized (Baral and Shah, 2008). Rodents make up the largest order of mammals, with over 40 percent of mammalian species. They occupy all the available habitat types and have evolved to a variety of life styles, including burrowing, tree climbing, climbing and swimming. All the rodents have four sharp, chisel-shaped, continuously growing incisor teeth for gnawing behind which is a gap, or diastema, before the grinding or chewing cheek teeth (usually three or four in each jaw). The incisors are kept sharp because the hard enamel surface at the front wears less rapidly than the soft dentine behind. Nearly all species are small, although a few, such as the beaver, agouti and capybara, reach medium size. They have two incisors in the upper and lower jaw which grow continually and must be kept short by gnawing.

Rodents are known to transmit diseases and act as reservoir host for many zoonotic pathogens including parasites that pose a health risk to humans (Walsh *et al*., 1993; Singleton *et al*., 2003). Endo-parasites of rodents play an important role in the zoonotic cycles of many diseases, e.g. schistosomiasis and angiostrongyliosis. Several studies on endoparasites of commensal and forest rodents have been carried out in Malaysia (Singh and Cheong, 1971; Leong *et al.*, 1979; Yap *et al*., 1977; Krishnasamy *et al*., 1980; Ambu *et al*., 1996).

Rats and mice play a significant role in public health, chiefly due to their role as carriers or reservoirs for microorganisms associated with infections and diseases that can be transmitted to humans. These diseases include plague, salmonellosis, leptospirosis, murine typhus, rickettsial pox, lymphocytic choriomeningitis, rat-bite fever, hanta virus haemorrhagic pulmonary syndrome, haemorrhagic fever, Venezuelan equine encephalitis *(Alphavirus),* powassan encephalitis (*Flavivirus*), rabies, Rocky Mountain spotted fever and tularemia as well as parasitism such as trichinosis, eosinophilic meningitis, taeniasis, cryptosporidia (Singleton *et al*., 2003) and *Trypanosoma lewisi* (Linardi and Botelho, 2002).

Transmission of these infections to humans occurs by indirect contact. Some are transmitted through contact with infected rodent urine or faeces, others through fleas and lice, and still others through mosquito bites (Ruiz, 2004). According to Battersby *et al*. (2002), rural wild brown rats on farm serve as vectors of zoonotic and many other diseases and may represent a serious risk to the health of human and domestic animals. Rats are found to be infected with a number of zoonotic parasites including cryptosporidium, pasturella, listeria, yersinia and Hantavirus, and represent a potential risk to the health of humans and domestic animals. The brown rats *(Rattus norvagicus)* from Doha, Qatar have been reported to be infested by *Hymenolopis diminuta* (Abu-Madi *et al.*, 2001). Salmonella in faecal pellets of wild brown rats *(Rattus norvagicus)* in the west Midlands is sufficient to present a potential risk to public health (Hilton *et al*., 2002).

Rodents are hosts to a number of ectoparasites such as lice, fleas, mites and ticks that can transmit viral, bacterial and protozoan parasites to man and animals (Linardi *et al.*, 1985; Durden and Page, 1991; Soliman *et al.*, 2001). In addition, they can harbor many different protozoan and helminthic endoparasites (Nickel and Buchwald, 1979; Davoust *et al.*, 1997; Mafiana *et al.*, 1997; Namue and Wongsawad, 1997; Mahida, 2003). Other than the tremendous economic losses to agriculture owing to their pestiferous nature, rats survive and proliferate in close association with humans in households, agricultural and commercial places (Benigno and Marges, 1978), thus making them interesting subjects for research. Although there are several reports on rat parasites in other parts of the world, documented studies in our country are wanting.

Human infection occurs by the consumption of food or water contaminated with embryonated eggs passed with rodent droppings. Some parasites are transmitted through contact with infected rodent urine or faeces, others through arthropods (Beg *et al*., 1983). *Rattus rattus*, *Rattus norvegicus* and *Mus musculus* can serve as vectors of zoonotics and many other diseases and may represent a serious risk to the human and domestic animals health (Webster and MacDonald, 1995).

1.2 STATUS OF RODENTS IN NEPAL:

The biological diversity of Nepal is of international importance due to its richness in fauna and flora owing to diverse topography to a wide altitudinal range and climatic zone. Globally about 5000 species of mammals are found of which 208 different species have been recorded from Nepal, which makes about 5% of the global population of mammals (Baral and Shah, 2008). Geographically these mammals are distributed from the range of 63 m. in terai to 5500 m. in the mountainous region. Such a huge mammalian diversity is due to the diversed land topography, climatic variation and floral diversity.

Mammals of Nepal are included in 12 orders and 33 families, among which order Rodentia comprises of 3 families viz: Sciuridae, Muridae and Hystricidae consisting of 50 species. Among these 3 families of Rodentia, family Muridae is most diverse. It includes 5 sub-families viz: Cricetinae, Arvicolinae, Gerbilinae, Murinae and Rhizomyinae.

In Nepal 50 species of rodents have been recognized (Baral and Shah, 2008). Rodents make up the largest order of mammals, with over 40 percent of mammalian species. They have two incisors in the upper and lower jaw which grow continually and must be keep short by gnawing. Rodents are represented by many families of which family Muridae embraces all the small rodents known as rats, mice and rat-like rodents. Rodents are regarded as the major pest in fields and farm houses in Nepal, causing 15-20% damage to crops and stored grain annually.

1.3 JUSTIFICATION OF THE STUDY:

Rodents (Rodentia: Muridae) specially rats and mice are found in huge number in Kirtipur. They are commonly found in local houses, departmental stores, grocery, garbage dumping sites, agricultural fields etc. Apart from their various devastating activities to man, the major concern is the spread of rodent-reservoir zoonoses. They are known to transmit diseases and act as reservoir host for many zoonotic pathogens including parasites that pose a health risk to humans (Walsh *et al*., 1993). Ecto as well as endo-parasites of rodents play an important role in the zoonotic cycles of many diseases, e.g. plague, schistosomiasis, hymenolepiasis etc. Increased rodent population in an area can be directly related to the increased zoonotic diseases in human population (Bradshaw, 1999). Human infection occurs by the consumption of food or water contaminated with embryonated eggs, previously released from rat liver through cannibalism, predation or decomposition of carcasses. In addition, rodents can cause disease by contaminating food, drink and eating utensils with urine or droppings.

However, little has been documented on this aspect. The scarcity of scientific documentation as well as the underlying threat of rodent-reservoir zoonoses emphasizes the necessity of this study. This study will provide some baseline information about the parasites of rodents which may have zoonotic importance relating to public health.

1.4 LIMITATION OF THE STUDY:

Research studies face many problems, so obviously have limitations to the study. The present study no doubt, bears the following limitations.

- This academic study has been carried out for the partial fulfillment of the requirements for the Master's Degree in Zoology at Tribhuvan University, Kathmandu, Nepal.
- The time for this study was also limited and carried out within two seasons only.
- Due to the lack of sophisticated instruments the identification of parasites was done up to genus level only.
- The research has limitations regarding finance and time constrains.

II
LITERATURE REVIEW

Rodents are known to transmit diseases and act as reservoir host for many zoonotic pathogens including parasites that pose a health risk to humans (Walsh *et al*., 1993). Ecto as well as endo-parasites of rodents play an important role in the zoonotic cycles of many diseases, e.g. plague, schistosomiasis, hymenolepiasis etc. Increased rodent population in an area can be directly related to the increased zoonotic diseases in human population (Bradshaw, 1999). Human infection occurs by the consumption of food or water contaminated with embryonated eggs passed with droppings.

Some parasites are transmitted through contact with infected rodent urine or faeces, others through arthropods (Beg *et al*., 1983). *Rattus rattus*, *Rattus norvegicus* and *Mus musculus* can serve as vectors of zoonotics and many other diseases and may represent a serious risk to the human and domestic animals health (Webster and MacDonald, 1995). The development of control methods against zoonotic parasites is dependent on knowledge of their life cycles and transmission pattern in each zoogeographical condition.

2.1 GLOBAL CONTEXT:

In a study carried in Korea, 1995, three species of helminthes viz: *Capillaria hepatica; Hymenolepis diminuta* and *Taenia taeniaformis* were reported from liver and intestine of *Rattus norvegicus* (Seong *et al.*, 1995).

Similarly, in an examination of different tissues of 90 rodents of species *Mus musculus; R. rattus* and *R. norvegicus* conducted in South-West Iran, 2000, a total of four helminthes and one protozoa was reported (Kia *et al., 2000*).

In Phillipines, in *Rattus* spp. caught in wet markets of different places reported two ectoparasites viz: *Echinolaelapus echidnius* (mite) and *Polypax spinulosa* (louse) and 8 species of endoparasites. Despite of heavy infection with intestinal parasites (100% with *T.*

taeniaeformes) and marked hepatic tissue damage (100% with *C. hepatica*) owing to severe capillaries and strobilocercus larval infection, all rats appeared healthy and agile (Claveria *et al.*, 2005).

The common zoonoparasites found in rodents of three species viz:- *R. rattus; Mus musculus* and *Bandicota* sp. in Kandy district of Sri Lanka were *Xenopsylla cheopis; H. diminuta; Moniliformes moniliformes; Cysticercus fasciolaris* and *Raillietina* spp. (Sumangali *et al.*, 2007).

In a study conducted in Egypt, 2008, on commensal rodents from different areas near garbage, canal edges, farm animals and likes, a number of zoonotic helminthes (10 trematodes, 4 cestodes and 10 nematodes) were found in 135 rodents sample of 4 species viz: *R. norvegicus; R. r. frugivorous; R. r. alexandrines* and *Mus musculus* (Kady *et al.*, 2009).

Similarly, in a study carried out in Taiwan in 2009, the infection rates of *R. norvegicus; R. rattus* and *Suncus marinus* with cestodes, nematodes and protozoans were found to be highly significant (Tung *et al.*, 2009).

A cross sectional survey conducted in Egypt in 2009 to compare the prevalence of helminthes in rodents, a total of 24 species of helminthes were identified among 271 rodents (Elshazly *et al.*, 2009). Similarly, in a study on rodents from five wet markets in Kualalampur, 2006, a total of 17 species of parasites were found in 97 samples of rats of 3 species. Among these 17 species of parasites 11 were found to be zoonotic (Pramasvaran *et al*., 2009).

In a comparative study carried out in Pakistan, 2009, among human stool sample and different species of rodents, a relation between presence of helminthes in rodents and human beings was found; indicating the zoonotic value of commensal rodents (Rafique *et al.*, 2009).

Recently in Thailand, Chaisiri *et al*. (2010) revealed that the rodents were infected with 11 species (2 cestodes, 8 nematodes and 1 acanthocephalan) of parasites. The prevalence of infection was 66.2% (45 out of 68 rats infected). Of the GI helminthes, the dominant parasites were Trichostrongylidae (33.8%) followed by *Raillietina* sp. (20.6%), *Syphacia muris* (14.7%) and *H. diminuta* (11.8%).

2.2 IN CONTEXT OF NEPAL:

Though the study on the ecology and biology of different rodent species in Nepal has been carried out by different workers, no such literature regarding the study of parasite of rodents was found in context to our country. Some of the related literatures to this study have been mentioned as under.

Outbreaks of plague have occurred in Nepal in the past. From 1960 to 1962 a total of 150 cases were reported in Rupandehi and Mahottari districts. As the programme to eliminate malaria also controlled the flea population, the incidence of plague declined sharply (Joshi, 1985)

Joshi (1985) has mentioned that after the earthquake hit in 1966 there was an out break of bubonic plague in the Nawara village of Bajhang district of the Seti zone of Far West Nepal. About 28 people died out of 47 persons infected. It was spread from the flea of wild and domestic rats as well as dog flea. It is suspected that in this second epidemic, the infection was first contracted from wild rodents or their fleas and subsequently went on to cause an outbreak of pneumonic plague (Bahmanvar, 1985). These reports show the potentiality of rodents to the zoonotic diseases.

Abe (1977) has carried out a survey of small mammals at 22 localities of Central Nepal. Taxonomic problems, ecological distributions, habits, reproductions and food habits have also been studied. From August 1966 to August 1970, Nepal Ectoparasitic Program conducted an extensive survey of the mammals and ectoparasitic fauna of Nepal. More than 4000 mammalian specimens representing 130 species were collected.

Frantz (1973-74) carried out a rodent research project, especially with reference to rodent ecology, behavior and control in the Kathmandu Valley with comparative studies in Terai and Himalayan region. Frantz (1973-74) studied the biology, taxonomy and population, ecology, economic and health threat to man, factors responsible for support of rat population and some experimentation with environmental population (Majpuria and Majpuria, 1998).

Majpuria (1978, 79) did a survey of rodents of Kathmandu Valley and studied their biology, taxonomy and control measures in greater detail (Majpuria and Majpuria, 1998).

Shrestha (1998) conducted studies on the reproductive biology of the field rat, *Bandicota bengalensis*, rearing methods and age composition of wild populations. He has also been involved in ecological studies and the development of effective control for rodents in agriculture and establishing a sampling method. He has done study on the ecology and biology of Roof Rat, *Rattus rattus*, in Kathmandu valley, Nepal.

III

OBJECTIVES

3.1 GENERAL OBJECTIVE:

The aim of this study is to identify different ecto and endo-parasitic species found in rodents as well as to investigate their zoonotic importance.

3.2 SPECIFIC OBJECTIVES:

- To identify different parasitic species found in trapped rodents.
- To compare the prevalence of parasitic fauna found in rodents of different sites.
- To compare the prevalence of parasitic fauna found in different rodent species.

IV

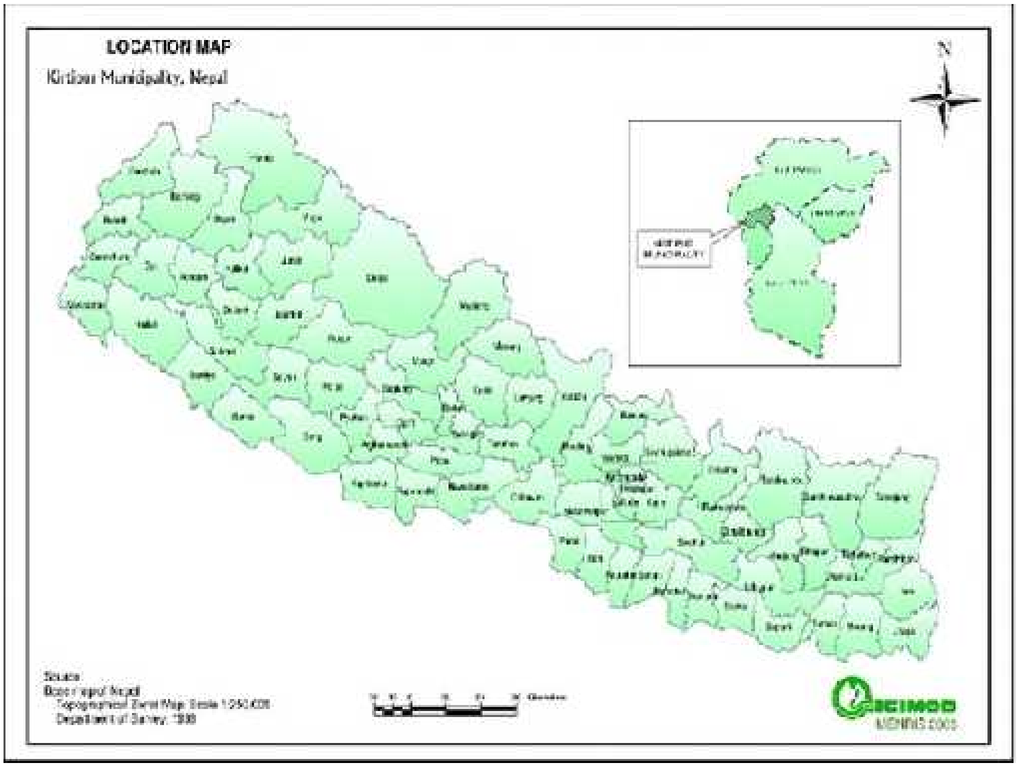
MATERIALS AND METHODS

4.1 STUDY AREA:

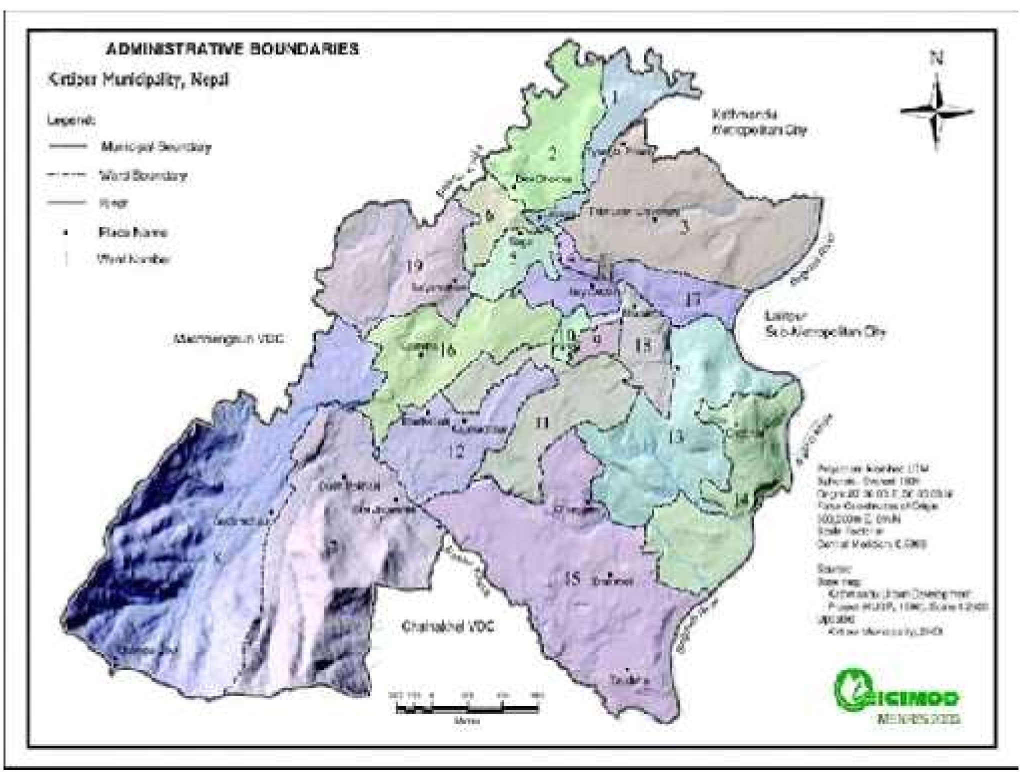
Nepal is one of the richest countries in terms of biodiversity, due to its unique geographical position and latitudinal variation. Geographically, it is 80º 4'' to 88º 12'' East longitude and 26º 22'' to 30º 27'' North latitude. It is an independent, sovereign and landlocked country bordered by China to the North and India to the East South and West. It is approximately 885 km in length and its mean width is 193 km width a total land area of 1, 47,181 Sq. km.

The proposed study area for the research is Kirtipur Municipality of the Kathmandu district. Kirtipur is one of the recently urbanized city of Kathmandu valley located to South-west of the central Kathmandu. It is declared as municipality in 2053 BS and is divided into 19 wards. It extends from 27º41'36'' – 27º38'37'' N to 85º18'00'' – 85º14'64'' E. It has 1300 to 1402 meter of altitudinal range from sea level. It is surrounded by the Bagmati River in the east, Tinthana and Machchhegaon VDC in the west, ward no. 14 of the Kathmandu Metropolitan in the north and Chalnakhel VDC and Shesnarayan VDC in the south. The shape of the municipality resembles almost a square, the area being 14.76 sq.km and the study area covers an over all area of the municipality.

Map 1: Kirtipur municipality indicating the sampling sites.



Map 2: Nepal showing the location of Kirtipur.



Map 3: Kirtipur showing administrative boundaries.

4.2 MATERIALS USED:

Since the study was based under laboratory examination, the materials used during the work have been listed below:

4.2.1 *Laboratory tools:*

i. Plastic bags	ii. Gloves	iii. Petri-dish
iv. Cavity-block	v. Cover-slips	vi. Slides
vii. Glass-rod	viii. Dropper	ix. Scissor
x. Forceps	xi. Needle	xii. Vials
xiii. Beaker	xiv. Conical flask	xv. Cello-tape
xvi. Test-tube	xvii. Dissecting tray	xviii. Rubber-band
xix. Test-tube stand	xx. Binocular-Microscope	xxi. Photographic-Microscope

4.2.2 *Chemicals used:*

i. Alcohol series (30%-100%)	ii. Xylene
iii. DPX mounts	iv. 10 % Formalin
v. AFA solution	vi. Lacto phenol
vii. Glycerin	viii. Nail-polish
ix. Gowar’s stain	x. Methyl-salicylate
xi. 5 % Potassium dichromate ($K_2Cr_2O_7$)	xii. Sodium chloride solution
xiii. Zinc chloride solution	

4.3 SAMPLE COLLECTION AND SAMPLING TECHNIQUE:

Rodents were trapped from different sites of Kirtipur, Kathmandu district from July 2010 to April 2011 using single-catch rat traps. Fruits, coconut, dried fish and potato and tomatoes were used as baits. Five different structures *i.e.* local houses, vegetable market, departmental stores, agricultural fields and garbage disposal sites were sampled for commensal rats and mice in Kirtipur city. The sampling was done randomly by using the live traps in different sites. The sites were randomly sampled for six months. Total of 32 specimens were trapped till the end of this work. They were *Rattus rattus* (6), *Rattus turkestanicus* (12), *Rattus nitidus* (6), *Bandicota indica* (1), *Bandicota bengalensis* (3), *Niviventer fulvescens* (3) and *Mus cervicolar* (1).

4.4 COLLECTION OF ECTO-PARASITES:

The trapped rodents (rats and mice) were collected each morning and brought to the laboratory. Rodents were anesthetized by plugging cotton balls dipped in chloroform in the snout. Then the rodents were tagged and photos were taken for identification. Ecto-parasites were collected immediately after anaesthetizing, boiled in 10% KOH (aq), dehydrated through alcohol series and then mounted in DPX.

4.5 COLLECTION OF ENDO-PARASITES:

The rodents were dissected venrally and helminths were recovered from various organs (liver, stomach, small intestine and large intestine) of the animal. The helminths were fixed, counted and preserved in 70% glycerine alcohol for identification. Nematodes were cleared in lactophenol and mounted using glycerene and nail-polish for examination under a microscope. Cestodes and trematodes were pressed in-between the slides and kept in AFA solution for 3 days and washed under open tap then stained in Gowar’s stain (whole night) or Semi-conc stain, dehydrated in ethanol, cleared in methyl salicylate and mounted.

Salt (NaCl(aq)) flotation technique was followed to extract parasitic eggs and larvae from the gut contents. The size of the eggs was measured using an oculo-micrometer. Overall and the prevalence of parasites in each host species were calculated as a percentage of infected individuals and the total number of individuals examined. Zoonotic parasites were identified comparing with literature.

The parasites obtained from the rodents were identified using several references (Chandler, 1961; Faust *et al.*, 1970; Schmidt and Roberts, 1989; Roberts and Janovy, 1996; Bush *et al.*, 2001) and also identified by comparing with the images downloaded from internet.

4.6 DATA COLLECTION:

Since the study was based on laboratory work, the rodents trapped and collected from different sites were brought to the laboratory of department and the ecto as well as endo-parasites were collected from each specimen and the number and species of parasites thus collected were recorded. This gives the primary data to the study.

4.7 STATISTICAL ANALYSIS:

The data obtained from the study was analyzed through Chi-square test with Yate's correction to evaluate the relations between prevalence of infection among host sex.

The analysis was also investigated by Two-way ANOVA to evaluate the relation between the prevalence of infection among five different sites along with the prevalence of infection by different species of parasites. The relation between the prevalence of infection between different rodent species and the prevalence of infection by different species of parasite was also analyzed by Two-way ANOVA. The critical probability was set at $p = 0.05$.

Analysis was also done by representing with the table, bar diagram, line diagram and pie chart.

V
RESULTS

The result of this study has been mentioned under following sub headings:

5.1 TRAPPED RODENT SPECIES:

A total of 32 rodents comprising of 12 *Rattus turkestanicus*, 6 *Rattus nitidus*, 6 *Rattus rattus*, 3 *Niviventer fulvescens*, 3 *Bandicota bengalensis*, 1 *Bandicota indica* and 1 *Mus cervicolar* were collected and examined.

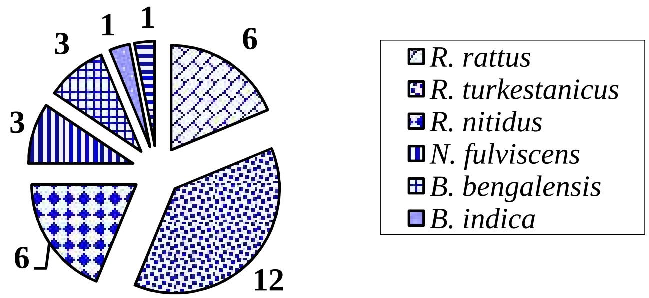


Figure 1: Species and numbers of trapped Rodent: Muridae.

5.2 SEX-WISE INFECTION IN RODENTS:

Out of 32 rodents captured, 16 were males (50%) and 16 were females (50%). Almost all rodents were found to be in infected by at least one type of ecto-parasite. Among which 15 male rodents (46.87%) were infected with endo-parasites and all female rodents (50%) were found to be infected with endo-parasite. Thus making an over all infection of 96.87%. No significant difference in the prevalence of parasites was found between male and female rodents.

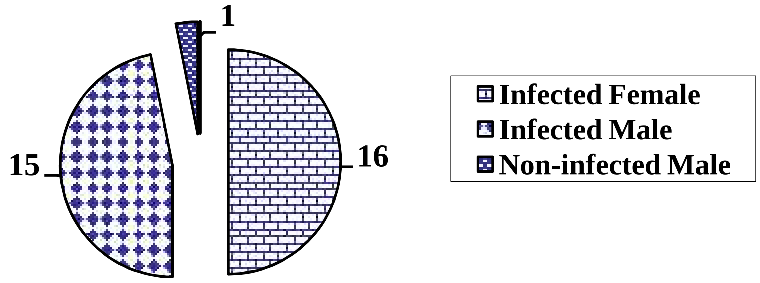


Figure 2: Sexwise infected rodent.

5.3 PREVALENCE OF ECTO-PARASITES:

All rodents were found to be infected with ecto-parasites. Alltogether four types of ecto-parasites were found. The ecto-parasites identified were *Polyplax spinulosa* (Rat Louse), *Xenopsylla cheopis* (Rat Flea), *Ornithonyssus bacoti* (Tropical Rat Mite) and *Laelaps echidnina* (Spiny Rat Mite). The most prevalent ectoparasite was *Polyplax spinulosa* (87.5%) followed by *Laelaps echidnina* (78.125%), *Xenopsylla cheopis* (59.375%) and *Ornithonyssus bacoti* (28.125%).

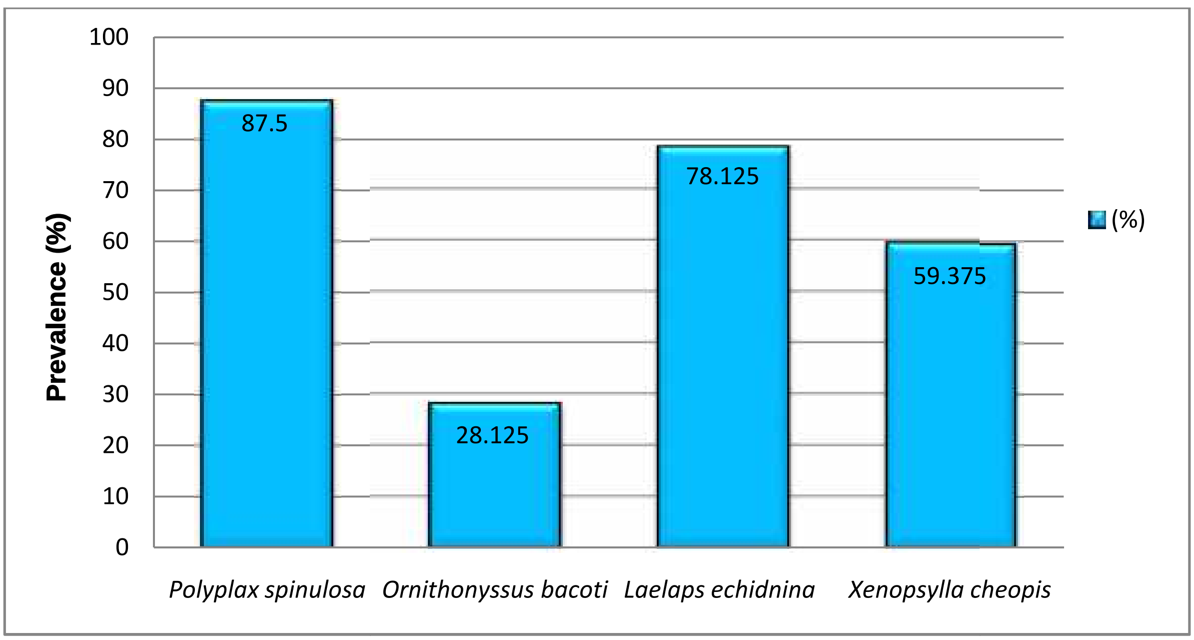


Figure 3: Prevalence of ecto-parasites in rodents.

5.3.1 *Polyplax spinulosa* (Burmeister, 1839)

Classification:

Phylum:	Arthropoda
Class:	Insecta
Order:	Anoplura
Family:	Polyplacidae
Genus:	*Polyplax*
Species:	*P. spinulosa* (Burmeister, 1839)
Common name:	Rat Louse

(Photograph No. : 1)

Discussion:

Polyplax spinulosa is a sucking louse (Anoplura) from the genus *Polyplax*. It occurs worldwide and commonly infects its type host, the brown rat (*Rattus norvegicus*), and related species like the black rat (*Rattus rattus*), *Rattus pyctoris*, *Rattus nitidus*, *Rattus argentiventer*, *Rattus tanezumi*, *Rattus exulans*, and *Bandicota indica*. (Durden and Musser, 1994). It is also occasionally found in other rodents, such as the marsh rice rat (*Oryzomys palustris*) in North America (Durden, 1988).

In context to the ecto-parasites of rodents, only few studies have been found. In the study of Philippines 67% infection with *Echinolaelaps echidnius* and 42% infection with *Polyplax spinulosa* was found by Claveria *et al*. (2005).

This species has not been reported yet from Nepal in any host.

5.3.2 *Xenopsylla cheopis* (Rothschild, 1903)

Classification:

Phylum:	Arhropoda
Class:	Insecta
Subclass:	Pterygota
Order:	Siphonaptera
Family:	Pulicidae
Sub Fam:	Pulicinae
Genus:	*Xenopsylla*
Species:	*X. cheopis* (Rothschild, 1903)
Common name:	Rat Flea

(Photograph No.: 3 and 4)

Discussion:

The rat flea was one of the major causes of the Black Death (Plague). It was collected in Egypt by N. C. Rothschild along with Karl Jordan and described in 1903 (Manuscript, Drawing and Photograph Collection of Nathaniel Charles Rothschild (1877–1923)). He named it *cheopis* after the Cheops pyramids.

In context to the ecto-parasites of rodents, only few studies have been found. Only one species of ecto-parasite i.e. *Xenopsylla cheopis* with 4.76% infection was reported from Sri Lanka (Sumangali *et al*., 2007).

In the present study *Xenopsylla cheopis* reported from rodents is for the first time from Nepal.

Table 1: Classification of ecto-parasites.

5.3.3 *Ornithonyssus bacoti* (Hirst, 1913)		5.3.4 *Laelaps echidnina* (Koch, 1836)	
Classification:		**Classification:**	
Phylum:	Arthropoda	Phylum:	Arthropoda
Class:	Arachnida	Class:	Arachnida
Subclass:	Acari	Subclass:	Acari
Order:	Mesostigmata	Order:	Mesostigmata
Family:	Macronyssidae	Family:	Laelapidae
Genus:	*Ornithonyssus*	Genus:	*Laelaps*
Species:	*O. bacoti* (Hirst, 1913)	Species:	*L. echidnina* (Koch, 1836)
Common Name:	Tropical Rat Mite	Common name:	Spiny Rat Mite
(Photograph No.: 2 and 5)		(Photograph No.: 2 and 6)	

Discussion:

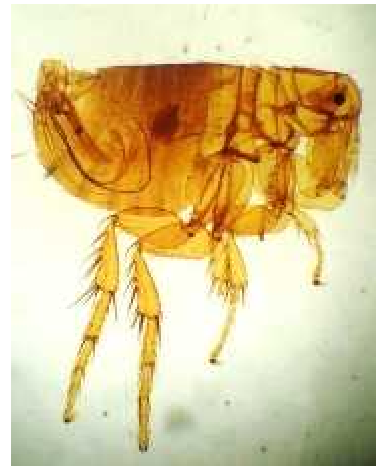
No such literature has been found regarding the ecto-parasites: *Ornithonyssus bacoti* and *Laelaps echidnina* of rodents in global and national context.

In the present study *Ornithonyssus bacoti* and *Laelaps echidnina* have been reported from rodents for the first time from Nepal.

PLATE I

PN. 1: *Polyplax spinulosa* (1 mm)

PN. 2: *Laelaps echidnina* (L)
Ornythonyssus bacoti (O)



PN. 3: *Xenopsylla cheopis* (Male, 1.8 mm)

PN. 4: *X. cheopis* (Female, 2.6 mm)

PN. 5: *O. bacoti* (0.5X0.7 mm)

PN. 6: *L. echidnina* (0.7X1.2 mm)

PN. 7: Collecting ecto-parasites.

PN. 8: Dissecting rat.

PN. 9: Observing parasite under microscope.

5.4 PREVALANCE OF ENDO-PARASITES:

A total of 31 rodents (15 males and 16 females) infected with endoparasites was found thus giving an overall infection rate of 96.875%. Ten species of endoparasites were identified (1 Trematoda, 2 Cestoda, 6 Nematoda and 1 Acanthocephala). The identified trematodes were: *Schistosoma* sp.; nematodes: *Syphacia* sp., *Nippostrongylus* sp., *Capillaria hepatica*, *Heterakis* sp., *Physaloptera* sp. and *Aspiculuris* sp.; cestodes: *Hymenolepis diminuta*, strobilocercus larvae of *Taenia taeniaeformis* and acanthocephalan: *Moliniformis dubius.* The most prevalent endoparasite was the cestode *Taenia taeniaeformis* (strobilocercus larva) (62.5%), followed by nematode *Syphacia* sp. (53.125%) and cestode *Hymenolepis diminuta* (12.5%). Infected liver by the eggs of *Capillaria* sp. (43.75%) was also found.

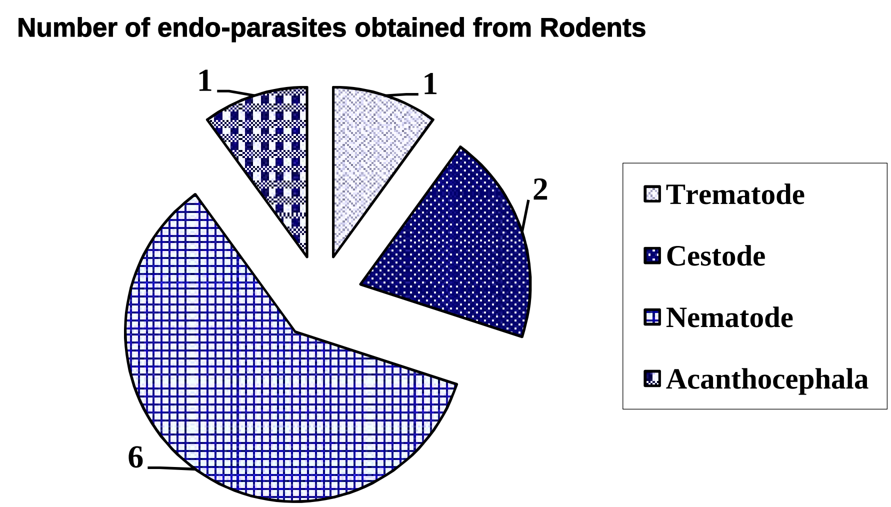


Figure 4: Number of endo-parasites obtained from Rodents.

Among the ten species of helminthes identified, six species (60%) have been incriminated as zoonotic. The following parasites *Schistosoma* sp., *Syphacia* sp., *Capillaria hepatica*, *Hymenolepis diminuta*, *Taenia taeniaeformis*, and *Moliniformis dubius* are considered as zoonotic and are of medical importance.

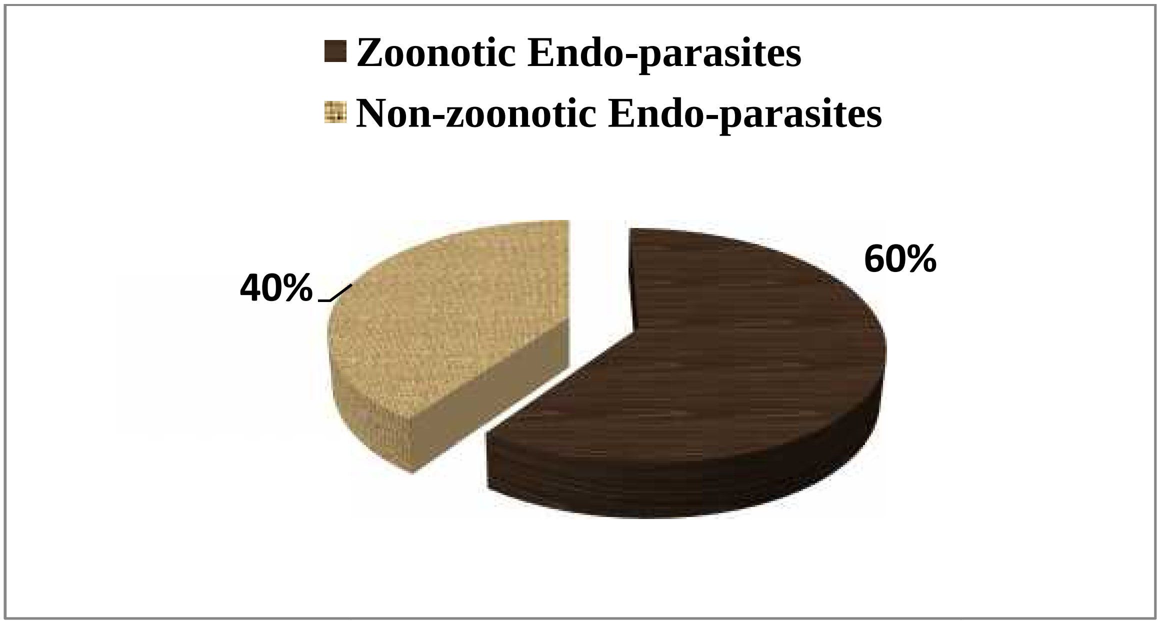


Figure 5: Prevalance (%) of Zoonotic endo-parasites.

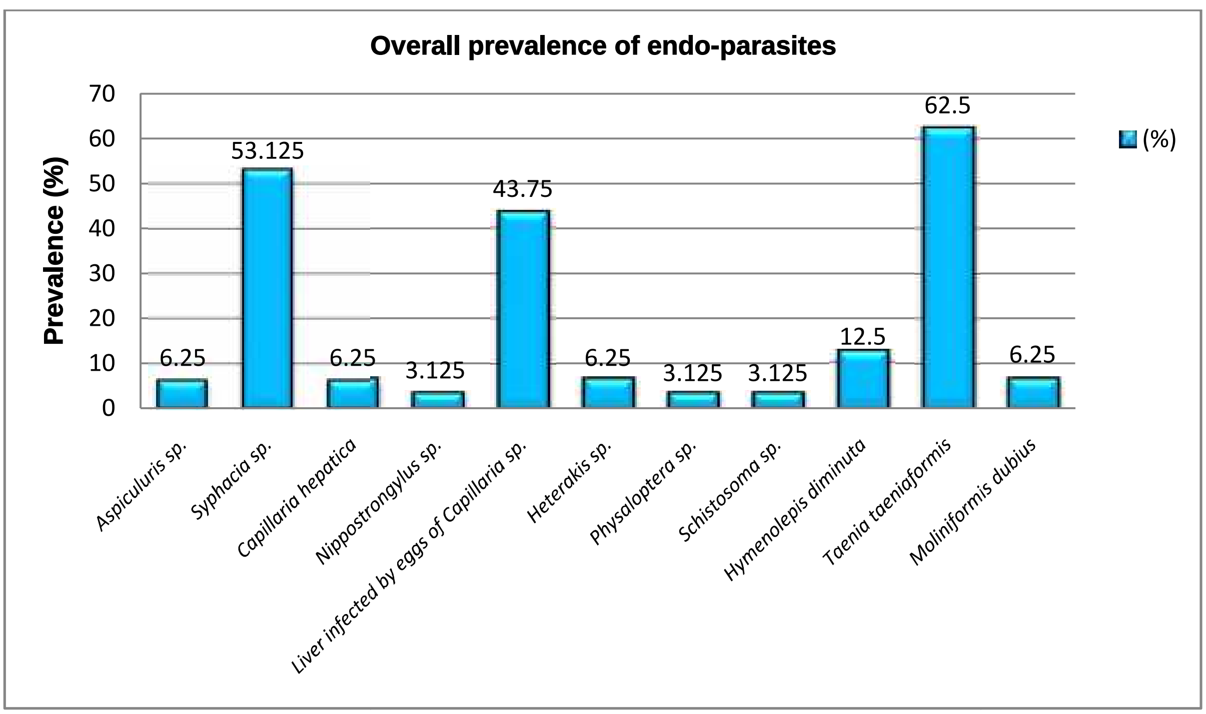


Figure 6: Prevalence of endo-parasite in rodent.

5.4.3.1 *Schistosoma* sp. (Weinland, 1858)

Classification:

Class:	Trematoda	(Rudolphi, 1808)
Order:	Digenea	(van Beneden, 1858)
Sub-Order:	Prosostomata	(Odhner, 1905)
Family:	Schistosomatidae	(Poche, 1907)
Sub-Fam:	Schistosomatinae	(Stiles et Hassall, 1898)
Genus:	*Schistosoma* sp.	(Weinland, 1858)
Common name:	Blood Fluke	

(Photograph No.: 16)

(Source: Yamaguti, S. 1958. Systema Helminthum. The Digenetic Trematodes of Vertebrates. Volume I. Part I and Part II)

Discussion:

Adult worms parasitize mesenteric blood vessels. They are unique among trematodes or any other flatworms in that they are dioecious with distinct sexual dimorphism between male and female. Eggs are passed through urine or feces to fresh water, where larva must pass though an intermediate snail host, before a different larval stage of the parasite emerges that can infect a new mammalian host by directly penetrating the skin.

No such literature was found regarding the presence of trematode: *Schistosoma* sp. in rodents with which the present study could be compared, but in this present study, *Schistosoma* sp. (3.125%) infecting *R. turkestanicus* of the departmental store has been found. As this species is one of the zoonotic species it has a public health importance relating to the study area.

In the present study *Schistosoma* sp. is recorded from the rodents for the first time in Nepal.

5.4.3.2 *Syphacia* sp. (Seurat, 1916)

Classification:

Class:	Nematoda	(Rudolphi, 1808)
Order:	Oxyuridea	(Weinland, 1858)
Family:	Oxyuridae	(Cobbold, 1864)
Sub-Fam:	Syphaciinae	(Railliet, 1916)
Genus:	*Syphacia* sp.	(Seurat, 1916)
Common name:	Rat Pin-worm	

(Photograph No.: 17)

(Source: Yamaguti, S. 1961. Systema Helminthum. The Nematodes of Vertebrates. Volume III. Part I and Part II)

Discussion:

Syphacia oryzomyos is a nematode that infects the marsh rice rat (*Oryzomys palustris*) in Florida (Kinsella, 1988). A similar species of *Syphacia* has been recorded from the rice rats *Oligoryzomys fulvescens* and *Handleyomys melanotis* in San Luis Potosí, but because only females were found, this worm could not be identified to species (Underwood *et al*., 1986).

In contrast to the report by Chaisiri *et al*. (2010) in Thailand, as reported 14.7% infection of *Syphacia muris*, the present study shows 53.125% infection of *Syphacia* sp. which shows high prevalence with 15.625% infection in household area. Paramavaran *et al*. (2009) reported low infection (3.09%) of *S. muris* from Kuala Lampur, Malaysia.

Syphacia sp. is also considered to be the zoonotic species which was found to be more prevalent in the household areas in present study.

This is the first time *Syphacia* sp. is reported from rodents in Nepal.

5.4.3.3 *Capillaria hepatica* (Bancroft, 1893)

Classification:

Class:	Nematoda	(Rudolphi, 1808)
Order:	Trichinelloidea	(Hall, 1916)
Family:	Trichuridae	(Railliet, 1915)
Sub-Fam:	Capillariinae	(Railliet, 1915)
Genus:	*Capillaria*	(Zeder, 1800)
Species:	*C. hepatica*	(Bancroft, 1893)

(Photograph No.: 18)

(Source: Yamaguti, S. 1961. Systema Helminthum. The Nematodes of Vertebrates. Volume III. Part I and Part II)

Discussion:

This species was first described in 1893, from specimens found in the liver of *Rattus norvegicus*, and named *Trichocephalus hepaticus* (Bancroft, 1893). Various authors have subsequently renamed it *Trichosoma hepaticum*, *Capillaria hepatica*, *Hepaticola hepatica* and *Calodium hepaticum*.(Hall, 1916 and Moravec, 1982) Currently it is usually referred to as either *Capillaria hepatica* or, less often,*Calodium hepaticum*. The first reported human infection of *Capillaria hepatica* was in a soldier from India (Sinniah *et al*., 1979).

In case of *Capillaria* sp. manifesting heavy parasitie egg burden, the present study shows 43.75% infection, which shows close similarity to the result of Seong *et al*. (1995) showing 25.58% infection. Surprisingly 100% infection was found in the study in Philippines (Claveria *et al.*, 2005). Beside *Capillaria* sp. manifesting heavy parasitie egg burden in liver only two of the rodents were found with the adult worms of *Capillaria hepatica* with 6.25%

infection limited to household and garbage sites, where as Paramasvarana *et al*. (2009) in Malaysia recorded 21.65% infection by *Capillaria hepatica*.

From Nepal:

- In 1967-92, Mainali reported *Capillaria* sp. from Lulu Cattle.
- In 1982, ADPCD reported *Capillaria* sp. in poultry from Kathmandu.
- Khanal and Gupta (2004) reported *Capillaria aerophila* from cat from Chitwan.
- Gupta and Pandey (2007) reported *Capillaria* sp. from white-rumped and slender-billed vulture from Chitwan.
- Gupta *et al*. (2007) reported *Capillaria* sp.from buffalo from Kathmandu.
- Malla *et al*. (2007) reported *Capillaria* sp. from Rhesus monkey (*Macaca mulatta*) from Kathmandu.
- In 2007, Dhoubhadel reported *Capillaria* sp. from Rhesus monkey of Swoyambhu and Nilbarahai area.

This is the first time *Capillaria hepatica* has been reported in rodents from Nepal.

5.4.3.4 *Nippostrongylus* sp. (Lane, 1923)

Classification:

Class:	Nematoda	(Rudolphi, 1808)
Order:	Strongylidea	(Diesing, 1851)
Family:	Trichostrongylidae	(Leiper, 1912)
Sub-Fam:	Viannaiinae	(Neveu-Lemaire, 1934)
Genus:	*Nippostrongylus* sp.	(Lane, 1923)

(Photograph No.: 19)

(Source: Yamaguti, S. 1961. Systema Helminthum. The Nematodes of Vertebrates. Volume III. Part I and Part II)

Discussion:

Some of the endo-parasites found in this study with low prevalence are *Aspiculuris* sp. (6.25%), *Heterakis* sp. (6.25%), *Nippostrongylus* sp. (3.125%) and *Physaloptera* sp. (3.125%). In the similar study in Malaysia, Paramasvaran *et al*. (2009) also reported 7.21% infection of *Heterakis* sp. 13.4% infection of *Nippostrongylus* sp. and 3.09% infection of *Physaloptera* sp.

No literature regarding the report of *Nippostrongylus* sp. was found in national context. Thus *Nippostrongylus* sp. has been reported for the first time from rodents in Nepal.

5.4.3.5 *Aspiculuris* sp. (Schulz, 1924)

Classification:

Class:	Nematoda	(Rudolphi, 1801)
Order:	Oxyuridea	(Weinland, 1858)
Family:	Oxyuridae	(Cobbold, 1864)
Sub-Fam:	Aspiculurinae	(Skrjabin et Schikhobalova, 1950)
Genus:	*Aspiculuris* sp.	(Schulz, 1924)

(Photograph No.: 20)

(Source: Yamaguti, S. 1961. Systema Helminthum. The Nematodes of Vertebrates. Volume III. Part I and Part II)

Discussion:

Some of the endo-parasites found in this study with low prevalence are *Aspiculuris* sp. (6.25%), *Heterakis* sp. (6.25%), *Nippostrongylus* sp. (3.125%) and *Physaloptera* sp. (3.125%). In the similar study in Malaysia, Paramasvaran *et al*. (2009) also reported 7.21% infection of *Heterakis* sp. 13.4% infection of *Nippostrongylus* sp. and 3.09% infection of *Physaloptera* sp.

No literature regarding the report of *Aspiculuris* sp. was found in national context. Thus *Aspiculuris* sp. has been reported for the first time from rodents in Nepal.

5.4.3.6 *Heterakis* sp. (Duj, 1845)

Classification:

Class:	Nematoda	(Rudolphi, 1808)
Order:	Oxyuridea	(Weinland, 1858)
Family:	Heterakidae	(Railliet et Henry, 1914)
Sub-Fam:	Heterakinae	(Railliet et Henry, 1912)
Genus:	*Heterakis* sp.	(Duj, 1845)

(Photograph No.: 21)

(Source: Yamaguti, S. 1961. Systema Helminthum. The Nematodes of Vertebrates. Volume III. Part I and Part II)

Discussion:

In a study in Malaysia, Paramasvaran *et al*. (2009) reported 7.21% infection of *Heterakis* sp.

From Nepal:

- Sharma (1943) reported *H. vesicularis* (syn) from domestic fowl from Kathmandu.
- Singh (1970) reported *Heterakis gallinae* from domestic fowl from Kathmandu.
- Singh (1970) reported *Heterakis spumosa* from rat (*Rattus norvegicus*) from Kathmandu.
- ADPCD (1982) reported *H. gallinarum* (syn) from poultry form Kathmandu.

5.4.3.7 *Physaloptera* sp. (Rud, 1819)

Classification:

Class:	Nematoda	(Rudolphi, 1808)
Order:	Spiruridea	(Diesing, 1861)
Family:	Physalopteridae	(Leiper, 1908)
Genus:	*Physaloptera* sp.	(Rud, 1819)

(Photograph No.: 22)

(Source: Yamaguti, S. 1961. Systema Helminthum. The Nematodes of Vertebrates. Volume III. Part I and Part II)

Discussion:

Some of the endo-parasites found in this study with low prevalence are *Aspiculuris* sp. (6.25%), *Heterakis* sp. (6.25%), *Nippostrongylus* sp. (3.125%) and *Physaloptera* sp. (3.125%). In the similar study in Malaysia, Paramasvaran *et al*. (2009) also reported 7.21% infection of *Heterakis* sp. 13.4% infection of *Nippostrongylus* sp. and 3.09% infection of *Physaloptera* sp.

No literature regarding the report of *Physaloptera* sp. was found in national context. Thus *Physaloptera* sp. has been reported for the first time from rodents in Nepal.

5.4.3.8 *Hymenolepis diminuta* (Rudolphi, 1819)

Classification:

Class:	Eucestoda	(Southwell, 1930)
Order:	Cyclophyllidea	
Family:	Hymenolepididae	(Railliet and Henry, 1909)
Sub-Fam:	Hymenolepidinae	(Perrier, 1897)
Genus:	*Hymenolepis*	(Weinland, 1858)
Species:	*H. diminuta*	(Rudolphi, 1819)
Common name:	Rat Tape-worm	

(Photograph No.: 14 and 23)

(Source: Wardle, R.A. and McLeod, J.A. 1968. The Zoology of Tapeworms.)

Discussion:

H. diminuta is prevalent worldwide, but only a few hundred human cases have been reported (Lo *e al.*, 1989; McMillan *et al*., 1971; Mercado and Arias, 1995). Few cases have ever been reported in Australia, United States, Spain, and Italy. In countries such as Malaysia, Thailand, Jamaica, Indonesia, the prevalence is higher (Tena *et al*., 1998; Marangi *et al*., 2003; Kan *et al*., 1981). In 1989, a child from St. James Parish, Jamaica was the subject of the first documented case of *H. diminuta* occurring in Jamaica, West Indies (Cohen, 1989).

In 1989, a child from St. James Parish, Jamaica was the subject of the first documented case of *H. diminuta* occurring in Jamaica, West Indies (Cohen, 1989).

In Korea, *H. diminuta* was found 16.0% out of 325 rats (Seo *et al*., 1964) and 6.1% out of 33 *R. norvegicus* (Seo *et al*., 1968), likewise Seong *et al*. (1995) found 32.55% prevalence of *H.*

diminuta out of 43 rats. Sumangali *et al.* (2007) reported 9.52% infection of *H. diminuta* in his study from 21 rodents in Sri Lanka

From Nepal:

- ADPCD (1982) reported *Hymenolepis* sp. from poultry from Kathmandu.
- Gupta and Gupta (1988) have reported the prevalence of *Hymenolepis nana* (2.47%) from Kirtipir area.
- Gupta (1989) reported *Hymenolepis carioca* from *Gallus domesticus* from Kathmandu.
- Parajuli (2003) showed the prevalence of *H. nana* (2.73%) and *H. diminuta* (4.37%) in mushar community of Chitwan district.

***Hymenolepis diminuta* has not been reported from rodents yet from Nepal.**

5.4.3.9 *Taenia taeniaformis*

Classification:

Class:	Eucestoda	(Southwell, 1930)
Order:	Cyclophyllidea	
Family:	Taeniidae	(Ludwig, 1886)
Genus:	*Taenia*	(Linnaeus, 1758)
Species:	*T. taeniaformis*	
Common name:	Cat Tape-worm	

(Photograph No.: 24)

(Source: Wardle, R.A. and McLeod, J.A. 1968. The Zoology of Tapeworms.

Discussion:

In Korea 65.12% infection with *Taenia taeniaformis* was found (Seong *et al*., 1995). Surprisingly 100% infection was found in the study in Philippines (Claveria *et al.*, 2005), where as 24.74% infection was found by Paramasvaran *et al*. (2009) in Malaysia.

From Nepal:

- ADPCD (1982) reported *Taenia* sp. from dog, cat and human from Kathmandu.
- Gupta and Gupta (1988) have reported the prevalence of *Taenia solium* (0.35%) from Kirtipir area.
- Joshi *et al*. (2001a, 2001b, 2003) reported the status and control of *Taenia solium* cysticercosis / Taeniosis in Nepal.
- Karki (2003) reported 8.28% prevalence of *Taenia* spp. among magar communities in Barangdi VDC, Palpa.
- Parajuli (2003) showed the prevalence of *Taenia* sp. (1.63%) in mushar community of Chitwan district.
- Prevalence of *Taenia taeniaformis* eggs (0.91%) in domestic cat is reported by Khanal (2004).
- In 2007, Dhaubhadel reported *Taenia* sp. from Rhesus monkey of Swoyambhu and Nilbarahai area.

In the present study *Taenia taeniaformis* is recorded for the first time in rodents from Nepal.

5.4.3.10 *Moniliformis dubius* (Meyer, 1932)

Classification:

Class:	Acanthocephala	(Rudolphi, 1808)
Order:	Archiacanthocephala	(Meyer, 1931)
Family:	Moniliformidae	(van Cleave, 1924)
Genus:	*Moniliformis*	(Travassos, 1915)
Species:	*M. dubius*	(Meyer, 1932)
Common name:	Spiny-headed Worm	

(Photograph No.: 13 and 25)

(Source: Yamaguti, S. 1963. Systema Helminthum. Acanthocephala. Volume V)

Discussion:

The first human infection of *M. moniliformis* infection was reported in Japan in a 14 months old baby boy. It was speculated that the infection was associated with the high infection rate of this parasite in *R. norvergicus* in the baby's locality (Miyazaki, 1991). According to the report by Skjabin (1958), infection of *M. dubius* is often found in cities or near human living places because its life cycle needs cockroach as an intermediate host to complete its life cycle (Skrjabin, 1958).

In present study, two rats of species *R. turkestanicus* and *R. nitidus* were found to be infected with *Moniliformes dubius* with a low prevalence rate of 6.25% which shows comparability with the study by Chaisiri *et al*. (2010) in Thailand. A previous study in Malaysia revealed that 9.8% of rats were positive for *M. moniliformis* (Paramasvaram *et al*., 2009).

No such literature regarding the report of *Moniliformes dubius* was found in national context. Thus this is the first report of *Moniliformes dubius* from Nepal in rodents of Kirtipur.

PLATE II

PN. 10: Dissected female rat.

PN. 11: Dissected male rat.

PN. 12: Visceral mass.

PN. 13: *M. dubius* in small intestine.

PN. 14: *H. diminuta* in small intestine.

PN. 15: Liver infected with cyst.

PN. 16: *Schistosoma* sp**.**

PN. 17: *Syphacia* sp.

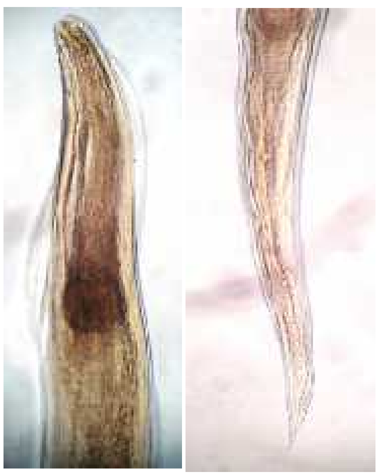
PN. 18: *Capillaria hepatica*

PLATE III

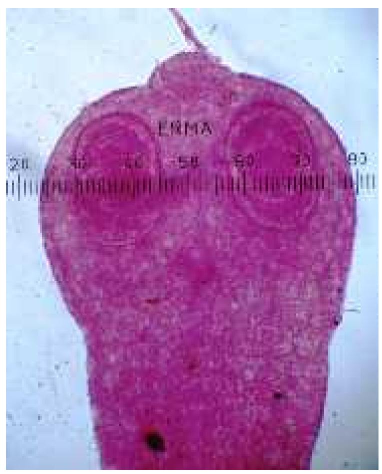
PN. 19: *Nippostrongylus* sp.

PN. 20: *Aspiculuris* sp.

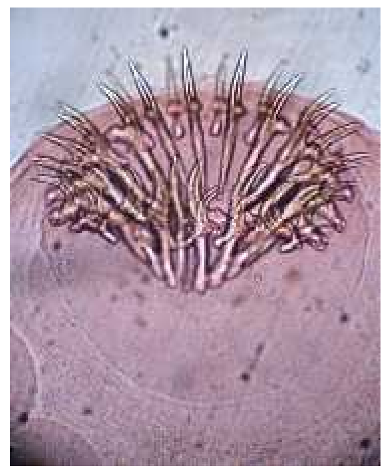
PN. 21: *Heterakis* sp.



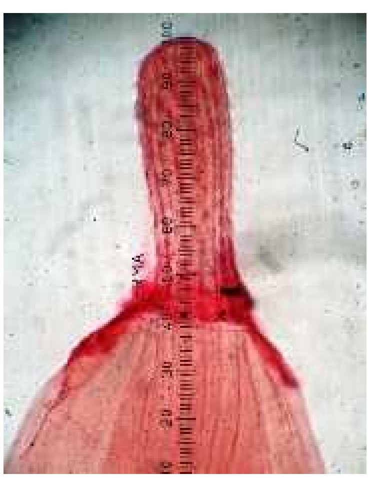
PN. 22: *Physaloptera* sp.



PN. 23: Scolex of *H. diminuta*



PN. 24: Scolex of *T. taeniaformis*



PN. 25: Head of *M. dubius*

PN. 26: Grinding stool sample for stool test.

PN. 27: Observing stool sample.

5.4.2 *Concurrent endo-parasitic infections in rodents:*

Among the 32 rodents captured only one (3.125%) was non-infected with endo-parasite, seven (21.875%) with single infection, ten (31.25%) with double infection, 13 (40.625%) with triple infection and one (3.125%) was infected with four endoparasite.

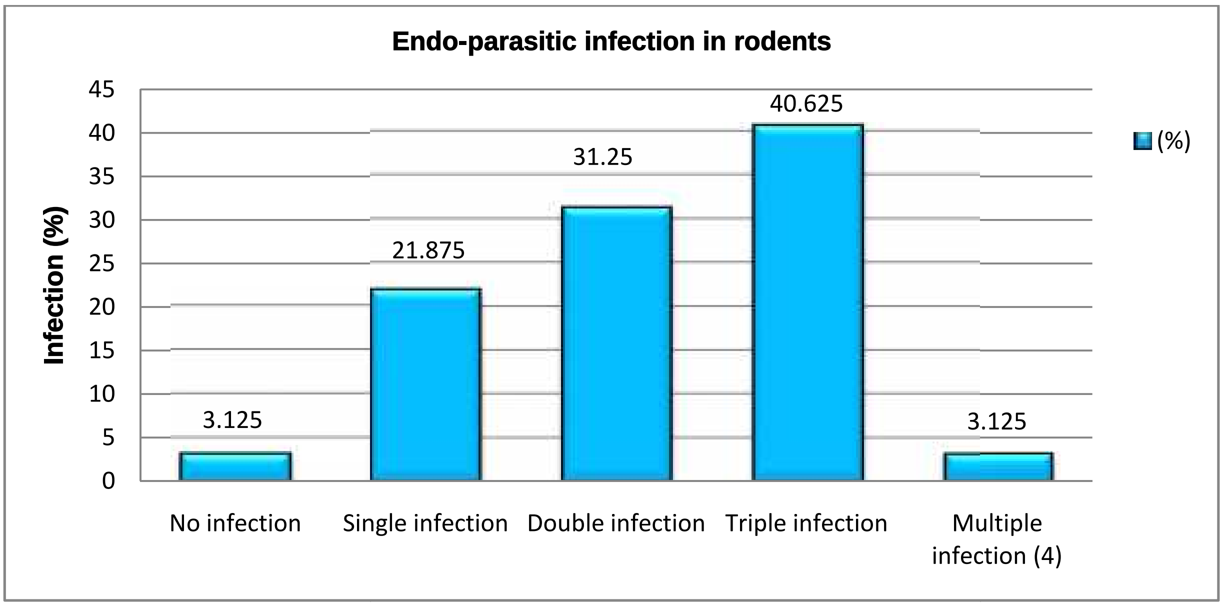


Figure 7: Endo-parasitic infection in rodents.

5.5 SPECIES-WISE PARASITIC PREVALENCE:

A total of 32 rodents comprising of 12 *Rattus turkestanicus*, 6 *Rattus nitidus*, 6 *Rattus rattus*, 3 *Niviventer fulvescens*, 3 *Bandicota bengalensis*, 1 *Bandicota indica* and 1 *Mus cervicolar* were collected and examined.

5.5.2 *Prevalence of ecto-parasites in different rodent species:*

- Among the four ecto-parasites found, the prevalence of ***Polyplax spinulosa*** was found to be the highest in *R. turkestanicus* (37.5%), followed by *R. nitidus* (18.75%), *R. rattus* (12.5%), *B. bengalensis* (9.375%), *N. fulvescens* (6.25%) and *M. cervicolar* (3.125%).
- Simillarly the prevalence of ***Ornithossus bacoti*** was found to be the highest in *R. rattus* (12.45%), followed by *R. turkestanicus* (6.25%), *R. nitidus* (6.25%) and *B. indica* (3.125%).

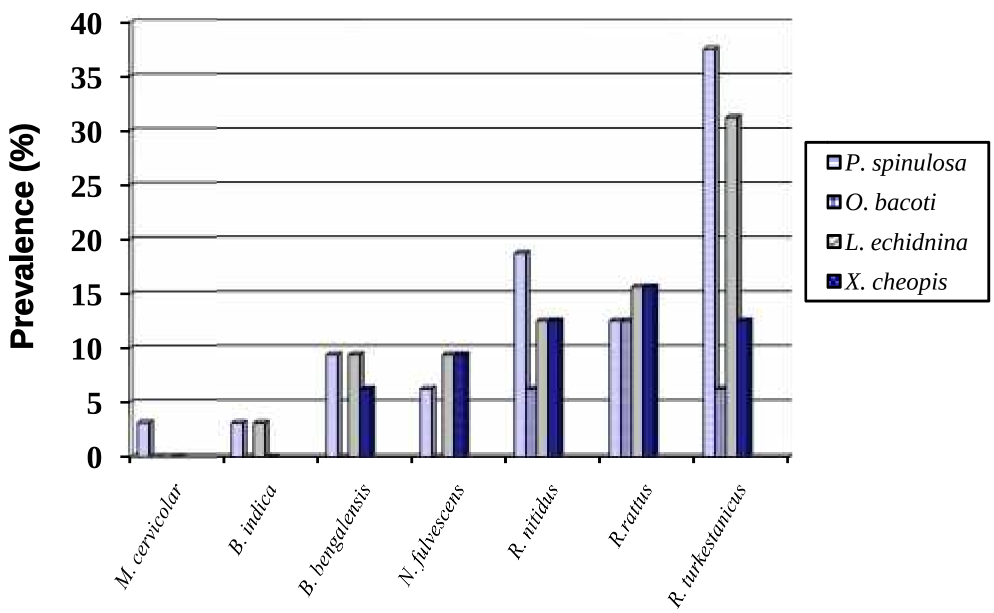


Figure 8: Prevalence of ecto-parasite in different rodent species.

- Like wise the prevalence of ***Laelaps echidnina*** was found to be the highest in *R. turkestanicus* (31.25%), followed by *R. rattus* (15.625%), *R. nitidus* (12.5%), *B. bengalensis* (9.375%), and *N. fulvescens* (9.375%).

- The prevalence of ***Xenopsylla cheopis*** was found to be the highest in *R. rattus* (15.625%), followed by *R. turkestanicus* (12.5%), *R. nitidus* (12.5%), *N. fulvescens* (9.375%), *B. bengalensis* (6.25%) and *B. indica* (3.125%).
- ***Polyplax spinulosa*** was found to be the most common ecto-parasite among all Rodent species except in *B. indica*.
- Likewise ***Xenopsylla cheopis*** was found to be common among all Rodent species except in *M. cervicolar*.
- ***Laelaps echidnina*** was not found in *B. indica* and *M. cervicolar*. Where as ***Ornithossus bacoti*** was not found in *N. fulvescens*, *B. bengalensis* and *M. cervicolar*.

5.5.3 *Prevalence of nematodes in different rodent species:*

- All together six species of nematodes were found out of which the prevalence of ***Syphacia*** sp. was found to be high in *R. turkestanicus* (25%), followed by *B. bengalensis* (9.375%), *N. fulvescens* (6.25%), *R. rattus* (6.25%), *R. nitidus* (3.125%) and *M. cervicolar* (3.125%).

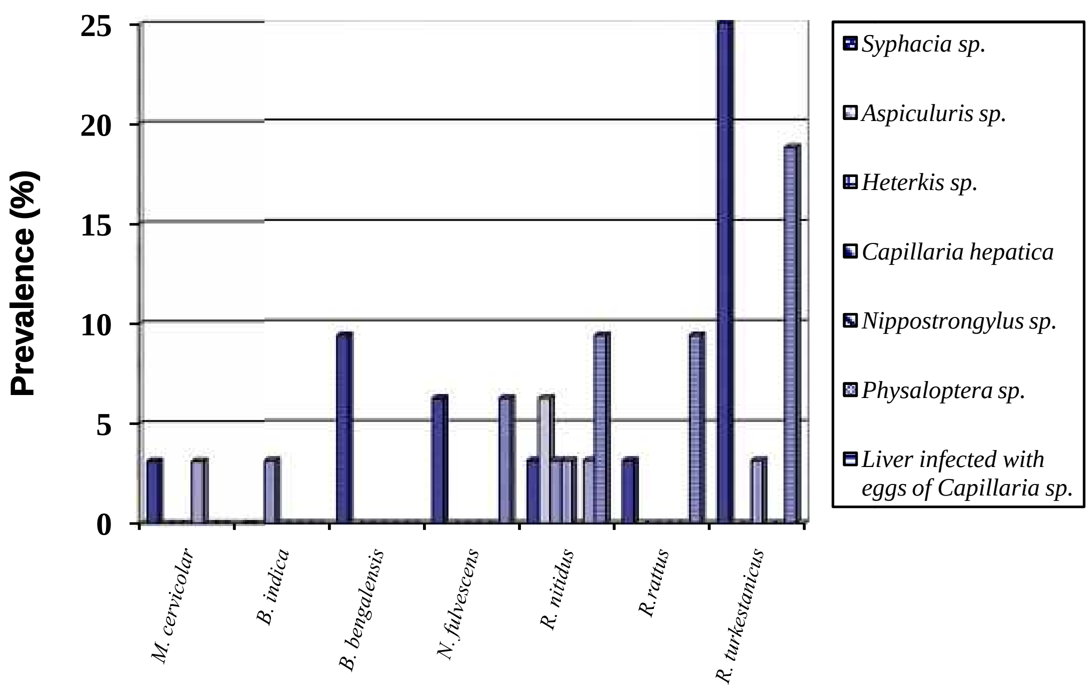


Figure 9: Prevalence of nematodes in different rodent species.

- The prevalence of ***Aspiculuris*** sp. was only confined to *R. nitidus* (6.25%).
- The prevalence of ***Heterkis*** sp. was confined to *R. nitidus* (3.125%) and *B. indica* (3.125%).
- Like wise the prevalence of ***Capillaria hepatica*** was confined to *R. turkestanicus* (3.125%), and *R. nitidus* (3.125%).
- ***Nippostrongylus*** sp. was found only in *M. cervicolar* (3.125%).
- ***Physaloptera*** sp. was only confined to *R. nitidus* (3.125%).
- The liver infected with the eggs of ***Capillaria*** sp. was found to be high in *R. turkestanicus* (18.75%), followed by *R. rattus* (9.375%), *R. nitidus* (9.375%) and *N. fulvescens* (6.25%).

5.5.4 *Prevalence of trematode, cestode and acanthocephala in different rodent species:*

- The only one trematode, ***Schistosoma*** sp. was found in *R. turkestanicus* (3.125%).

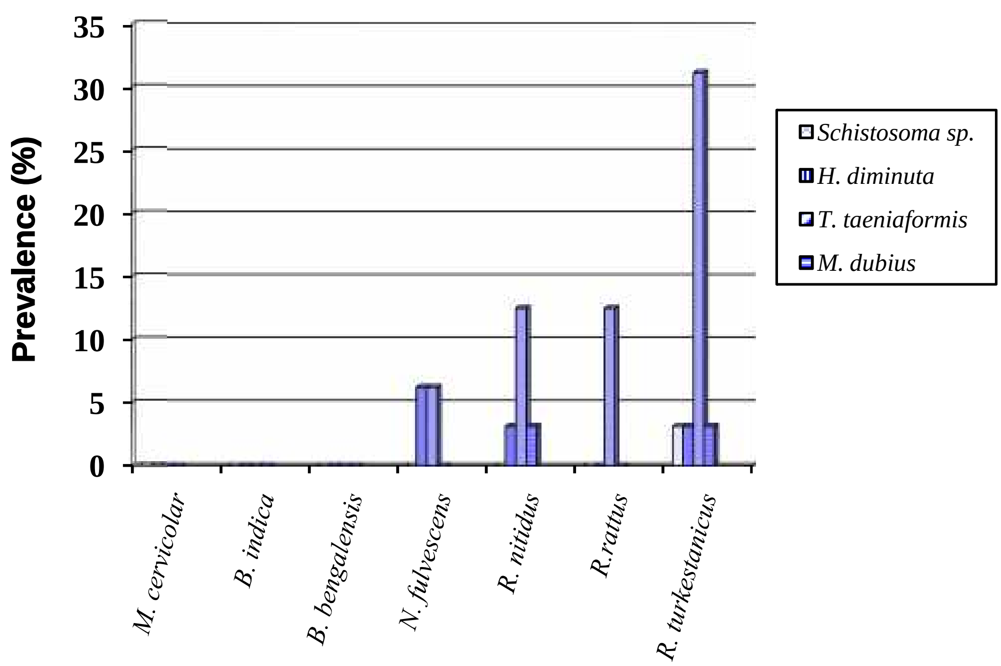


Figure 10: Prevalence of trematode, cestode and acanthocephalan in different rodent species.

- Out of two species of cestodes, the prevalence of ***Hymenolepis diminuta*** was found to be high in *N. fulvescens* (6.25%), followed by *R. turkestanicus* (3.125%) and *R. nitidus* (3.125%).
- The prevalence of ***Taenia taeniaformis*** was found to be high in *R. turkestanicus* (31.25%), followed by *R. rattus* (12.5%), *R. nitidus* (12.5%) and *N. fulvescens* (6.25%).
- The only acanthocephalan found was ***Moniliformis dubius***, which was found to be confined in *R. turkestanicus* (3.125%) and *R. nitidus* (3.125%).

5.5.5 *Overall prevalence of parasite in different species of rodents:*

5.5.5.1 *Ecto-parasite infection:*

Among the seven different species of rodents captured, *R. turkestanicus* (37.5%) was found to be heavily infested by ecto-parasites followed by, *R. rattus* (18.75%), *R. nitidus* (18.75%), *B. bengalensis* (9.375%), *N. fulvescens* (9.375%) and with low prevalence in *B. indica* (3.125%) and *M. cervicolar* (3.125%).

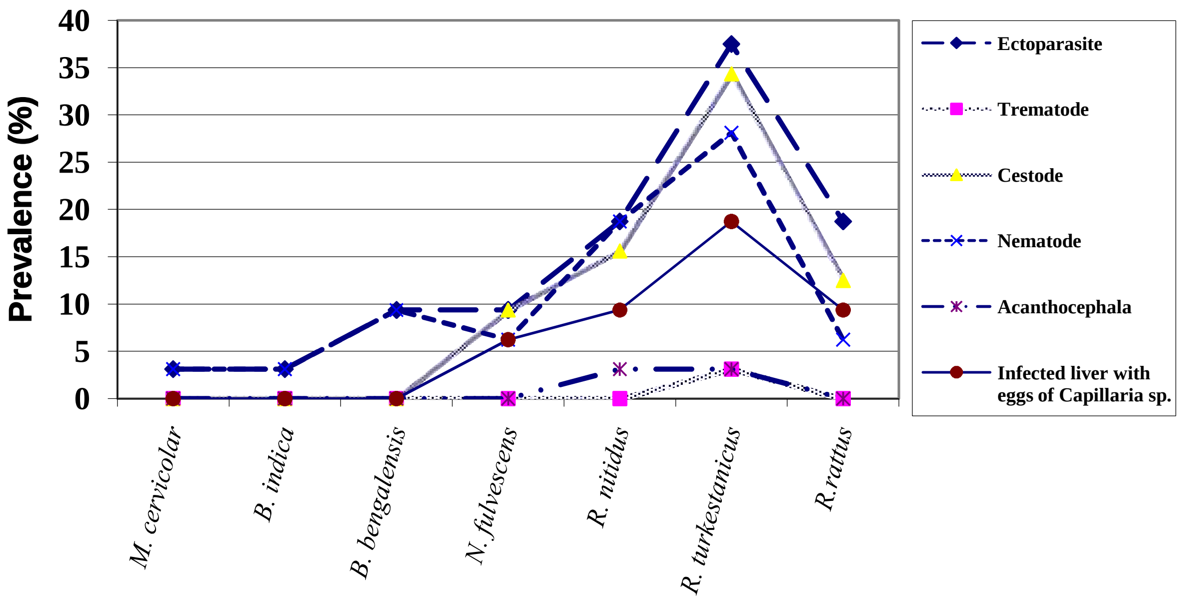


Figure 11: Prevalence of parasites in different rodent species.

5.5.5.2 *Trematode infection:*

Only one species i.e. *R. turkestanicus* (3.125%) was found to be infected with trematode.

5.5.4.3 *Cestode infection:*

R. turkestanicus (34.375%), *R. nitidus* (15.625%), *R. rattus* (12.5%) and *N. fulvescens* (9.375%) were found to be infected with cestodes.

5.5.4.4 *Nematode infection:*

R. turkestanicus (28.125%), *R. nitidus* (18.75%), *B. bengalensis* (9.375%), *N. fulvescens* (6.25%), *R. rattus* (6.25%), *B. indica* (3.125%) and *M. cervicolar* (3.125%) were found to be infected with nematodes.

5.5.4.5 *Acanthocephalan infection:*

Acanthocephalan infection was found in *R. turkestanicus* (3.125%) and *R. nitidus* (3.125%) only.

5.5.4.6 *Liver infected with eggs of Capillaria* **sp.:**

Liver infected with eggs of *Capillaria* sp. was found in *R. turkestanicus* (18.75%), *R. nitidus* (9.375%), *R. rattus* (9.375%), and *N. fulvescens* (6.25%).

Statistical calculation for seven different Rodent species (for $v_1 = 6$ and $v_2 = 84$) at 5% confidence level was calculated to be **11.196**, which is found to be greater than the tabulated value, $\mathbf{F_{(0.05)} = 2.1750}$. This signifies that there is significant difference between the prevalence of parasite in different rodent species.

Similarly the statistical calculation for different parasites (for $v_1 = 14$ and $v_2 = 84$) at 5% confidence level was calculated to be **5.62**, which is found to be greater than the tabulated value, $\mathbf{F_{(0.05)} = 1.429}$. This signifies that there is significant difference between the different types of parasites infecting rodents.

Table 2: Prevalence of parasites in different rodent species.

Parasite species	Rodent species with prevalence (%) of parasitic infection							Total
	R. turkestanicus	*R. rattus*	*R. nitidus*	*N. fulvescens*	*B. bengalensis*	*B. indica*	*M. cervicolar*	
ECTOPARASITES:								
P. spinulosa (Burmeister, 1839)	37.50	12.50	18.75	6.25	9.375	-	3.125	87.50
O. bacoti (Hirst, 1913)	6.25	12.5	6.25	-	3.125	-	-	28.125
L. echidnina (Koch, 1836)	31.25	15.625	12.5	9.375	9.375	-	-	78.125
X. cheopis (Rothschild, 1903)	12.50	15.625	12.50	9.375	6.25	3.125	-	59.375
TREMATODE								
Schistosoma sp. (Weinland, 1858)	3.125	-	-	-	-	-	-	3.125
CESTODES:								
H. diminuta (Rudolphi, 1819)	3.125	-	3.125	6.25	-	-	-	12.50
T. taeniaformis (strobilocercus larvae) (Linnaeus, 1758)	31.25	12.50	12.50	6.25	-	-	-	62.50
NEMATODES:								
Syphacia sp. (Seurat, 1916)	25.0	6.25	3.125	6.25	9.375	-	3.125	53.125
Aspiculuris sp. (Schulz, 1924)	-	-	6.25	-	-	-	-	6.25
C. hepatica (Bancroft, 1893)	3.125	-	3.125	-	-	-	-	6.25
Nippostrongylus sp.	-	-	-	-	-	-	3.125	3.125
Heterakis sp. (Duj, 1845)	-	-	3.125	-	-	3.125	-	6.25
Physaloptera sp. (Rud, 1819)	-	-	3.125	-	-	-	-	3.125
ACANTHOCEPHALAN:								
M. dubius (Meyer, 1932)	3.125	-	3.125	-	-	-	-	6.25
Liver infected by Eggs of *Capillaria* sp.	18.75	9.375	9.375	6.25	-	-	-	43.75

5.6 SITE-WISE PREVALENCE OF PARASITES:

5.6.1 *General prevalence of parasites (ecto and endo):*

A total of 32 rodents were captured from five different sites viz; two from garbage site, five from vegetable market, seven from departmental area, eight from agricultural fields and ten from household areas. The highest prevalence of parasitic (ecto as well as endo) infection in rodents was found in household areas (28.125%), followed by agricultural field (25%), departmental stores (21.875%), vegetable market (15.625%) and garbage site (6.25%).

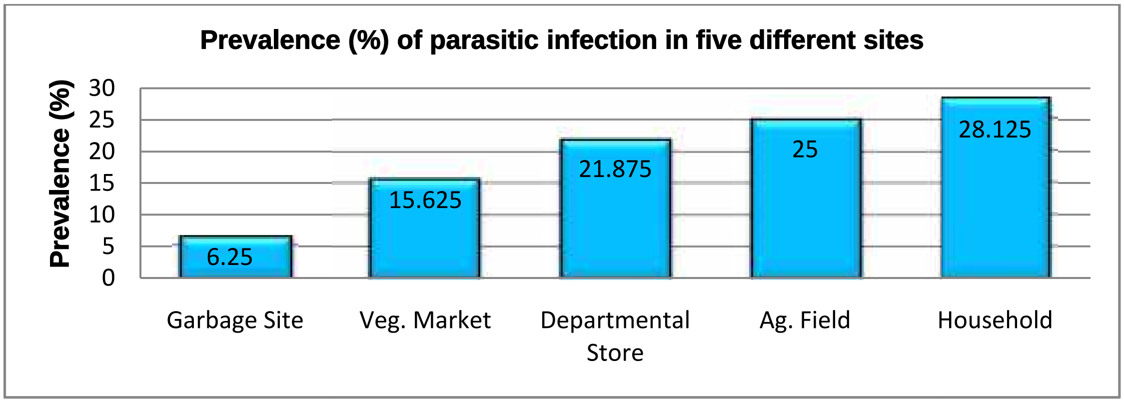


Figure 12: Prevalence (%) of parasitic infection in Rodents of five different sites.

5.6.2 *Prevalence (%) of ecto-parasites in rodents of five different sites:*

Among the five sites the overall prevalence of ecto-parasite was found to be the highest in household areas (31.25%), followed by agricultural field (25%), departmental stores (21.875%), vegetable market (15.625%) and garbage site (6.25%).

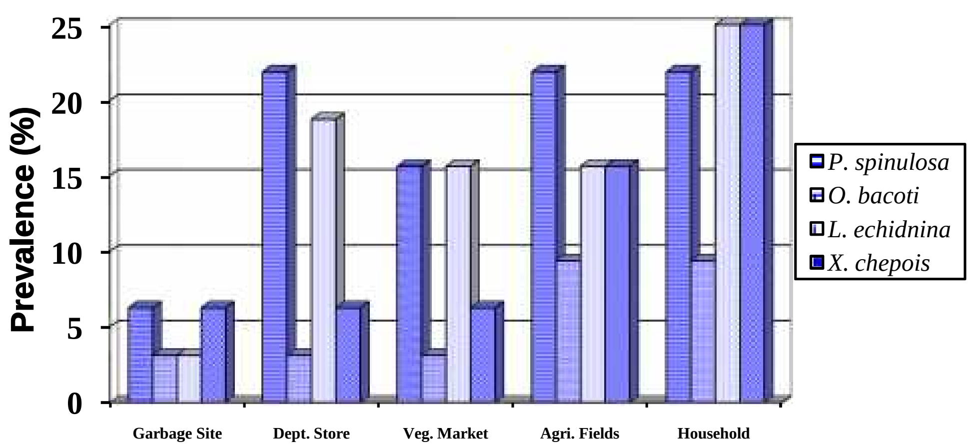


Figure 13: Prevalence (%) of ecto-parasites in rodents of five different sites.

5.6.3 ***Prevalence (%) of nematodes in rodents of five different sites:***

- Prevalence of nematodes is found higher in household areas (18.75%), agricultural field (18.75%) and in departmental store (18.75%), followed by vegetable market (12.5%) and with low prevalence in garbage site (6.25%).
- Liver infected with eggs of *Capillaria* sp. was higher in household areas (18.75%), followed by vegetable market (12.5%), agricultural field (9.375%) and with low infection in departmental store (3.125%).

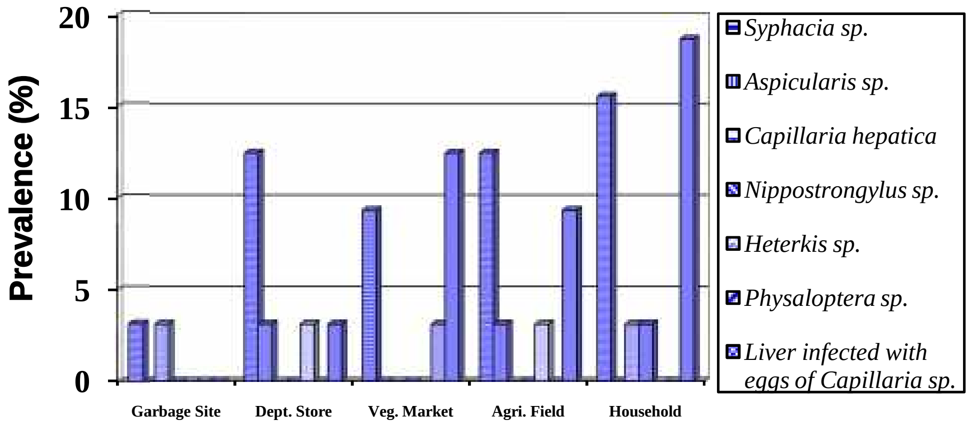


Figure 14: Prevalence (%) of nematodes in rodents of five different sites.

5.6.4 ***Prevalence (%) of trematode, cestode and acanthocephalan in rodents of five different sites:***

- Only one trematode species i.e. *Schistosoma* sp. was recorded from departmental store (3.125%).

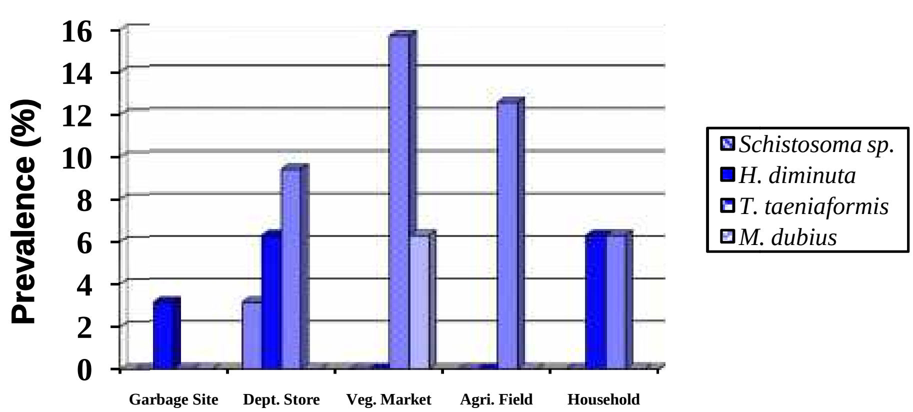


Figure 15: Prevalence (%) of trematode, cestode and acanthocephalan in five different sites.

- ➢ Prevalence of cestode was found to be higher in household areas (25%), followed by departmental store (15.625%), vegetable market (15.625%), agricultural field (12.5%) and garbage site (3.125%).
- ➢ Prevalence of acanthocephalan was limited to vegetable market (6.25%) only.

5.6.5 *Prevalence of different groups of parasites in rodents of five different sites:*

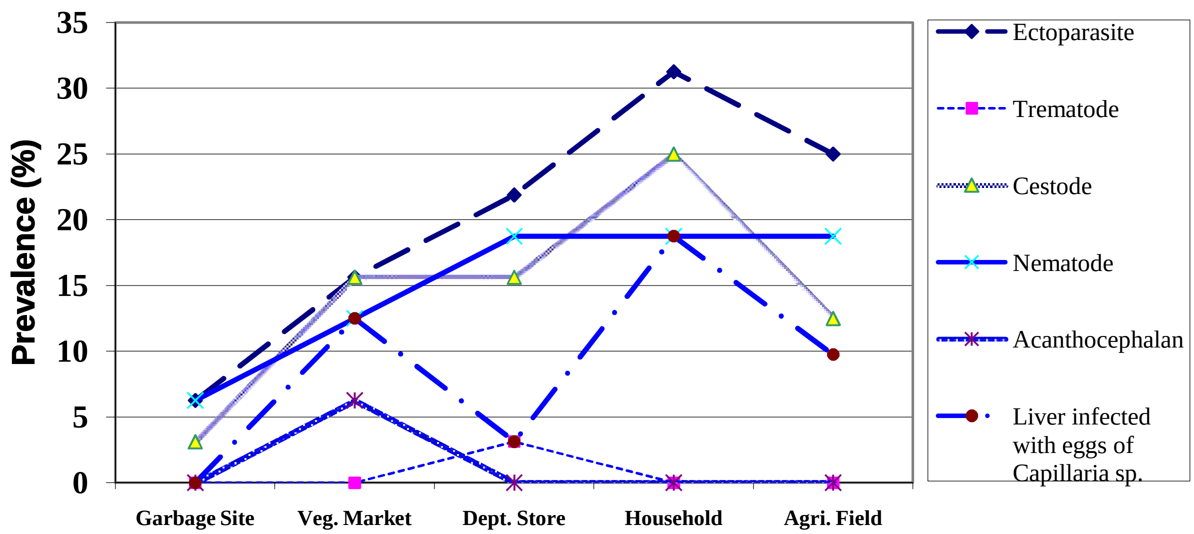


Figure 16: Prevalence of different groups of parasites in Rodents of five different sites.

Statistical calculation for five different sites (for $v_1 = 4$ and $v_2 = 56$) at 5% confidence level was calculated to be **7.80**, which is found to be greater than the tabulated value**,** $\mathbf{F_{(0.05)} = 2.447}$. This signifies that there is significant difference between the prevalence of parasites in rodents of five different sites.

Similarly the statistical calculation for different parasites (for $v_1 = 14$ and $v_2 = 56$) at 5% confidence level was calculated to be **11.442**, which is found to be greater than the tabulated value, $\mathbf{F_{(0.05)} = 1.429}$. This signifies that there is significant difference between the different types of parasites infecting the rodents of five different sites.

Table 3: Prevalence (%) of parasite in five different sites.

Parasite Species	Prevalence (%)					Total
	House	**Agri. Fields**	**Veg. Market**	**Dept. Stores**	**Garbage Sites**	
ECTOPARASITES:						
P. spinulosa (Burmeister, 1839)	21.875	21.875	15.625	21.875	6.250	87.50
O. bacoti (Hirst, 1913)	9.375	9.375	3.125	3.125	3.125	28.125
L. echidnina (Koch, 1836)	25.00	15.625	15.625	18.750	3.125	78.125
X. cheopis (Rothschild, 1903)	25.00	15.625	6.250	6.250	6.250	59.375
TREMATODE						
Schistosoma sp. (Weinland, 1858)	-	-	-	3.125	-	3.125
CESTODES:						
H. diminuta (Rudolphi, 1819)	6.250	-	-	6.250	-	12.50
T. taeniaformis (strobilocercus larvae) (Linnaeus, 1758)	21.875	12.50	15.625	9.375	3.125	62.50
NEMATODES:						
Syphacia sp. (Seurat, 1916)	15.625	12.50	9.375	12.50	3.125	53.125
Aspiculuris sp. (Schulz, 1924)	-	3.125	-	3.125	-	6.25
C. hepatica (Bancroft, 1893)	3.125	-	-	-	3.125	6.25
Nippostrongylus sp.	3.125	-	-	-	-	3.125
Heterakis sp. (Duj, 1845)	-	3.125	-	3.125	-	6.25
Physaloptera sp. (Rud, 1819)	-	-	3.125	-	-	3.125
ACANTHOCEPHALAN:						
M. dubius (Meyer, 1932)	-	-	6.250	-	-	6.250
Liver infected by Eggs of *Capillaria* sp.	18.750	9.375	12.50	3.125	-	43.75

5.7 IDENTIFICATION AND MEASUREMENT OF EGGS OF ENDO-PARASITES:

Following types of eggs were recorded.

- **Eggs of *Syphacia* sp.:** (Photograph No.: 28 and 29)

  The eggs measure 33.54 X 74.82 µm, thick shelled and convex in shape.

- **Eggs of *Physaloptera* sp.:** (Photograph No.: 30)

  The eggs measure 46.44 µm, thin shelled and round in shape.

- **Eggs of *Capillaria hepatica:*** (Photograph No.: 31 and 32)

  The eggs measure 30.96 X 51.7 µm, barrel shaped, containing unsegmented embryo, colorless shell and having thick shell.

- **Eggs of *Aspiculuris* sp.:** (Photograph No.: 33)

  The eggs measure 28.38 X 117.39 µm, thin shelled and convex in shape.

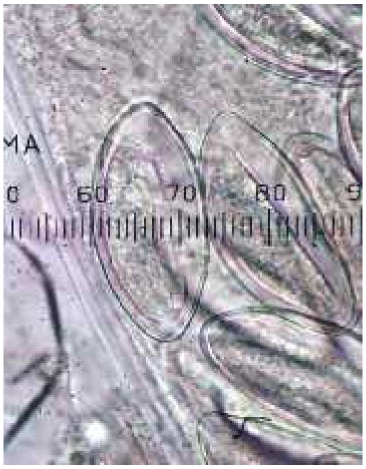
- **Eggs of *Hymenolepis diminuta*:** (Photograph No.: 34 and 35)

  The eggs measure 51.7 µm inside the mature proglottid where as it measures 67.21 µm in stool sample, with embryonated onchosphere and three pairs of hooks, spherical in shape, brown to dark yellow in colour and thick shelled.

- **Eggs of *Moniliformis dubius*:** (Photograph No.: 36)

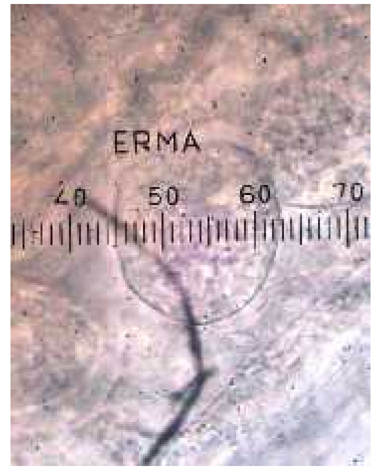
  The eggs measure 30.96 X 79.98 µm, elongated and cylindrical with thick shell.

PLATE - IV



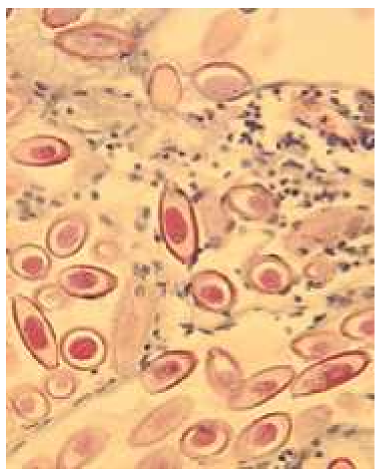
PN. 28: Eggs of *Syphacia* sp. in ovi-sac.

PN. 29: Eggs of *Syphacia* sp. in stool.

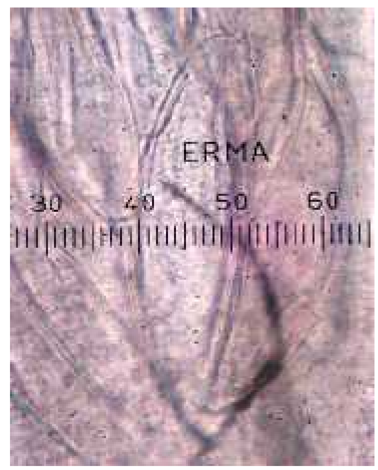


PN. 30: Eggs of *Physaloptera* sp. in ovi-sac.

PN. 31: Eggs of *C. hepatica* in ovi-sac.



PN. 32: Eggs of *Capillaria* sp. in liver.



PN. 33: Eggs of *Aspiculuris* sp. in ovi-sac.

PN. 34: Eggs of *H. diminuta* in proglottid.

PN. 35: Egg of *H. diminuta* in stool.

PN. 36: Eggs of *M. dubius* in ovi-sac.

5.8 PREVALANCE OF ZOONOTIC ENDO-PARASITES (HOST SPECIES-WISE AND SITE-WISE)

One of the B. indica, one R. nitidus and one R. rattus was not found to be infected with zoonotic endo-parasite.

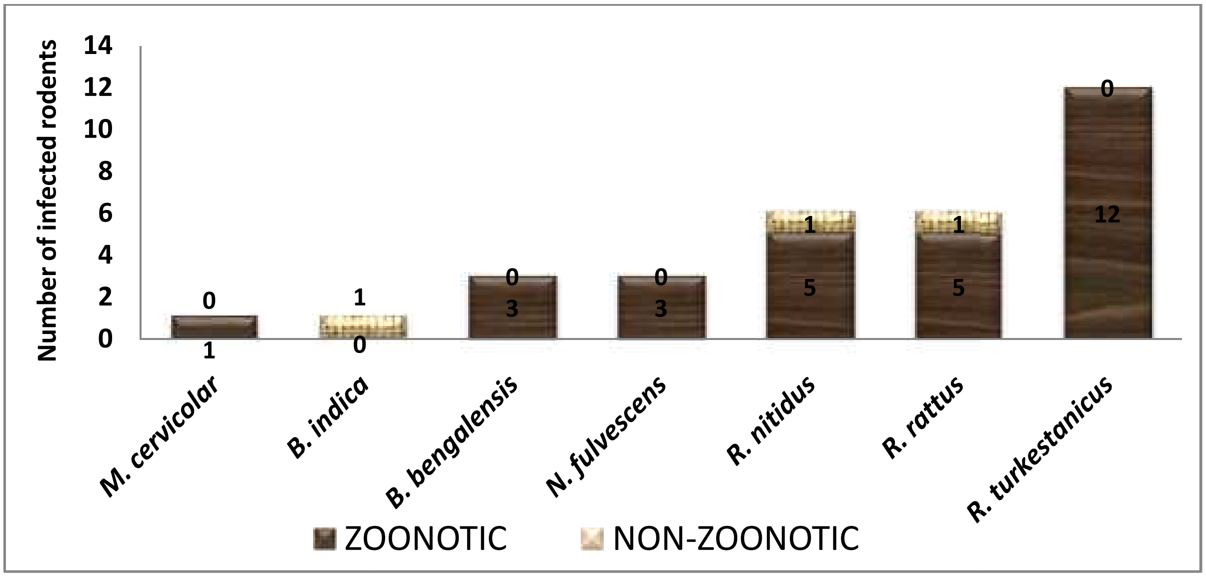


Figure 17: Prevalance of host species-wise zoonotically infected rodents.

One of the rodent from agricultural field and two of the rodents from departmental store were not found to be infected with zoonotic endo-parasite.

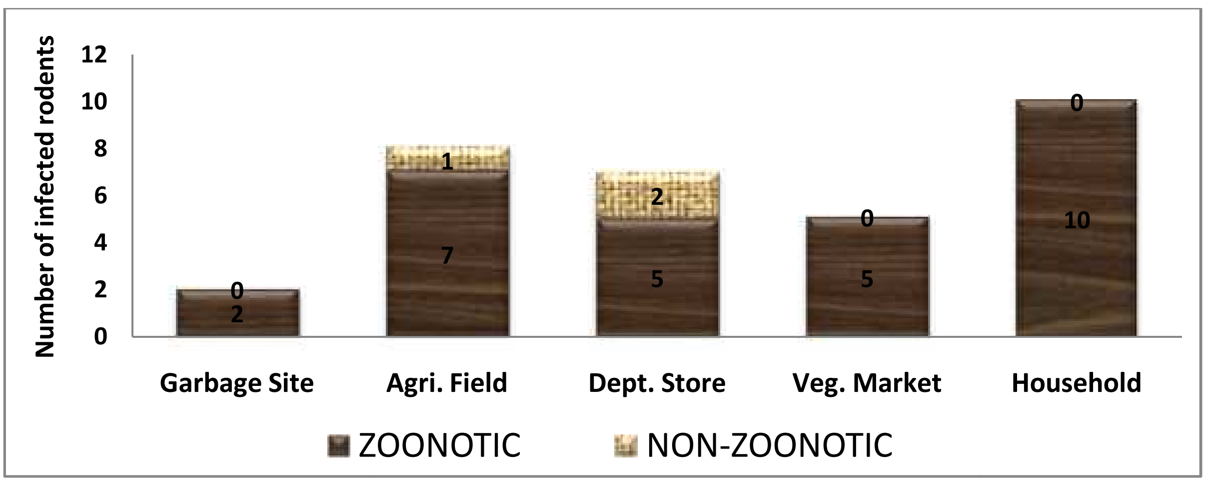


Figure 18: Prevalence of site-wise zoonotically infected rodents.

VI
DISCUSSION AND CONCLUSION

It is well known that parasites are cosmopolitan in distribution and all animals, whether humans, domestic animals or wild animals bear different kinds of parasites. Many researches have been carried out regarding the intestinal parasites of human because we are always eager to know about our health. Vetenarians are always interested to research about domestic animals, whereas very little attention is paid to the wild animals.

In the present study, the study of parasitic fauna of rodents (Rodentia: Muridae) has been carried out for the first time in Nepal. The research so far has not been adequate enough, especially in context to our country. The prevalence figures of the present work are compared with the work done in the rodents of different countries.

A total of 32 rodents (Rodentia: Muridae) belonging to seven species, (12 *Rattus turkestanicus*, 6 *Rattus nitidus*, 6 *Rattus rattus,* 3 *Niviventer fulvescens,* 3 *Bandicota bengalensis*, 1 *Bandicota indica* and 1 *Mus cervicolar*) were trapped and examined, with 16 males and 16 females. 15 (46.87%) out of 16 males were found to be infected by parasites where as all the 16 (50%) female rodents were infected. Statically **[¡$^2_{(cal)}$ = 2.0645 and ¡$^2_{(tab)}$ = 3.84, 1 d.f., P < 0.05]** there was no major difference in the infection rate among the males and females.

In the present study four ecto-parasites were obtained: *Polyplax spinulosa* (87.5%), followed by *Laelaps echidnina* (78.125%), *Xenopsylla cheopis* (59.375%) and *Ornithonyssus bacoti* (28.125%).

Polyplax spinulosa occurs worldwide and commonly infects its type host, the brown rat (*Rattus norvegicus*), and related species like the black rat (*Rattus rattus*), *Rattus pyctoris*, *Rattus nitidus, Rattus argentiventer*, *Rattus tanezumi*, *Rattus exulans,* and *Bandicota indica*. (Durden and Musser, 1994). It is also occasionally found in other rodents, such as the marsh rice rat (*Oryzomys palustris*) in North America (Durden, 1988).

In context to the ecto-parasites of rodents, only few studies have been found. In the present study of Philippines 67% infection with *Echinolaelaps echidnius* and 42% infection with

Polyplax spinulosa was found by Claveria *et al*. (2005) and only one species of ecto-parasite i.e. *Xenopsylla cheopis* with 4.76% infection was reported from Sri Lanka (Sumangali *et al*., 2007). The rat flea was one of the major causes of the Black death (Plague). It was collected in Egypt by N. C. Rothschild along with Karl Jordan and described in 1903 (Manuscript, Drawing and Photograph Collection of Nathaniel Charles Rothschild (1877–1923). He named it *cheopis* after the Cheops pyramids.

The result obtained from present study revealed total of ten different species of endo-parasitic infection in rodents, out of which six (60%) has been identified to be zoonotic. They are the trematode: *Schistosoma* sp.; nematode: *Syphacia* sp. and *Capillaria hepatica*; cestodes: *Hymenolepis diminuta* and *Taenia taeniaeformis* and acanthocephalan: *Moliniformis dubius.* Similar findings have been reported by Paramasvaran *et al*. (2009) in Malaysia. Out of 17 different species identified from three species of rats, 11 (65%) were identified to be zoonotic. The predominant endo-parasite obtained in this study was strobilocercus larva of *Taenia taeniaeformis* (62.5%), followed by *Syphacia* sp. (53.125%) and *Hymenolepis diminuta* (12.5%).

No such literature was found regarding the presence of trematode: *Schistosoma* sp. in rodents with which the present study could be compared, but in this present study, *Schistosoma* sp. (3.125%) infecting *R. turkestanicus* of the departmental store has been found. As this species is one of the zoonotic species it has a public health importance relating to the study area.

In contrast to the report by Chaisiri *et al*. (2010) in Thailand, as reported 14.7% infection of *Syphacia muris*, the present study shows 53.125% infection of *Syphacia* sp. which shows high prevalence with 15.625% infection in household area. Paramavaran *et al*. (2009) reported low infection (3.09%) of *S. muris* from Kuala Lampur, Malaysia. *Syphacia oryzomyos* is a nematode that infects the marsh rice rat (*Oryzomys palustris*) in Florida (Kinsella, 1988). A similar species of *Syphacia* has been recorded from the rice rats *Oligoryzomys fulvescens* and *Handleyomys melanotis* in San Luis Potosí, but because only females were found, this worm could not be identified to species (Underwood *et al*., 1986). *Syphacia* sp. is also considered to be the zoonotic species which was found to be more prevalent in the household areas (15.625%), followed by agricultural field (12.5%), departmental store (12.5%), vegetable market (9.375%) and garbage site (3.125%).

In the present study two mostly common liver infecting parasites i.e. strobilocercus larvae of *Taenia taeniaformis* and eggs of *Capillaria* sp. were found, which have also been reported in previous studies in in Korea (Seong *et al*., 1995), Philippines (Claveria *et al*., 2005) and in Malaysia (Paramasvarana *et al*., 2009). In the study the infection by strobilocercus larvae of *Taenia taeniaformis* was found to be highest (62.5%) among other endo-parasitic infection which was also shown in previous study in Korea with 65.12% infection (Seong *et al*., 1995). Surprisingly 100% infection was found in the study in Philippines (Claveria *et al.*, 2005), where as 24.74% infection was found by Paramasvarana *et al*. (2009) in Malaysia. Rodents are well known to serve as secondary host of *Taenia taeniaformis* (with felines as primary hosts). However, it has been found in a wide variety of mammals, including humans (Schmidt, 1989).

In case of *Capillaria* sp. manifesting heavy parasitie egg burden, the present study shows 43.75% infection, which shows close similarity to the result of Seong *et al*. (1995) showing 25.58% infection. Surprisingly 100% infection was found in the study in Philippines (Claveria *et al.*, 2005). Beside *Capillaria* sp. manifesting heavy parasitie egg burden in liver only two of the rodents were found with the adult worms of *Capillaria hepatica* with 6.25% infection limited to household and garbage sites, where as Paramasvarana *et al*. (2009) in Malaysia recorded 21.65% infection by *Capillaria hepatica*. This species was first described in 1893, from specimens found in the liver of *Rattus norvegicus,* and named *Trichocephalus hepaticus* (Bancroft, 1893). Various authors have subsequently renamed it *Trichosoma hepaticum*, *Capillaria hepatica*, *Hepaticola hepatica* and *Calodium hepaticum*. (Hall, 1916 and Moravec, 1982) Currently it is usually referred to as either *Capillaria hepatica* or, less often, *Calodium hepaticum*.

The first reported human infection of *Capillaria hepatica* was in a soldier from India (Sinniah *et al*., 1979). Worldwide about 30 cases of *C. hepatica* infections in human have been documented mostly in children from one to five years of age (Battersby, 2002). The parasite can cause an acute or sub-acute hepatitis with marked eosinophilia and persistent fever in humans. Hepatomegaly may develop, with eggs in the liver parenchyma including necrosis and abscess in infected humans (Miyazaki, 1991).

H. diminuta is prevalent worldwide, but only a few hundred human cases have been reported (Lo *e al.*, 1989; McMillan *et al*., 1971; Mercado and Arias,1995). Few cases have ever been reported in Australia, United States, Spain, and Italy. In countries such as Malaysia, Thailand, Jamaica, Indonesia, the prevalence is higher (Tena *et al*., 1998; Marangi *et al*., 2003; Kan *et al*., 1981). In 1989, a child from St. James Parish, Jamaica was the subject of the first documented case of *H. diminuta* occurring in Jamaica, West Indies (Cohen, 1989).

H. diminuta is well known as common parasites of rat all over the world. The rat is known as a normal host of these parasites. In this study, this parasite was found in various species of rodents viz: *N. fulvescens*, *R. turkestanicus* and *R. nitidus* with overall prevalence 12.5% in household and departmental store. In Korea, *H. diminuta* was found 16.0% out of 325 rats (Seo *et al*., 1964) and 6.1% out of 33 *R. norvegicus* (Seo *et al*., 1968), likewise Seong *et al*. (1995) found 32.55% prevalence of *H. diminuta* out of 43 rats. Sumangali *et al.* (2007) reported 9.52% infection of *H. diminuta* in his study from 21 rodents in Sri Lanka. Study in Thailand by Chaisira *et al*. (2010) revealed 11.8% infection of *H. diminuta* out of 68 Asian house rats, which is in close agreement with our study with 12.5% infection by *H. diminuta*.
H. nana and *H. diminuta* reported from rodents have been recovered from humans (Sinniah *et al.*, 1978). It is estimated that more than 21 million people in the world suffer from hymenolepiasis and the majority of them are in the tropics and sub-tropics (Parija, 1990).

In present study, two rats of species *R. turkestanicus* and *R. nitidus* were found to be infected with *Moniliformes dubius* with a low prevalence rate of 6.25% which shows comparability with the study by Chaisiri *et al*. (2010) in Thailand. A previous study in Malaysia revealed that 9.8% of rats were positive for *M. moniliformis* (Paramasvaram *et al*., 2009). In the study by Sumangali *et al*. (2007), prevalence rate of *M. moniliformes* was found to be 9.52%. The first human infection of *M. moniliformis* infection was reported in Japan in a 14 months old baby boy. It was speculated that the infection was associated with the high infection rate of this parasite in *R. norvergicus* in the baby's locality (Miyazaki, 1991). According to the report by Skjabin (1958), infection of *M. dubius* is often found in cities or near human living places because its life cycle needs cockroach as an intermediate host to complete its life cycle (Skrjabin, 1958). This can be correlated with present study as well since infection with *M. dubius* is found in the rats captured from vegetable markets. As the two species of *Moniliformis* i.e. *M. moniliformis* and *M. dubius* are alike in their life-cycle and both of them are considered as zoonotic, *M. dubius* found in this study may be one of the public health importances relating to the study area.

Like wise some of the endo-parasites found in this study with low prevalence are *Aspiculuris* sp. (6.25%), *Heterakis* sp. (6.25%), *Nippostrongylus* sp. (3.125%) and *Physaloptera* sp. (3.125%). In the similar study in Malaysia, Paramasvaran *et al*. (2009) also reported 7.21% infection of *Heterakis* sp. 13.4% infection of *Nippostrongylus* sp. and 3.09% infection of *Physaloptera* sp. These nematodes are considered to be non-zoonotic and less concerned to public health importance. This might be the reason that their prevalence was found to be low in comparison to that of the zoonotic parasites.

In the present study *R. nitidus* was found to be infected with diverse groups of endo-parasites which show wide range of host specificity to the parasites. Except *Schistosoma* sp. (found only in *R. turkestanicus* in this study) and *Nippostrongylus* sp. (found in *M. cervicolar* in this study) all other eight types of endo-parasites were found in *R. nitidus*. Like wise *R. turkestanicus*, *N. fulvescens* and *R. rattus* were also found to be more susceptible to parasitic infections. Statistically **[$F_{(cal)}$ = 11.196 and $F_{(tab)}$ = 2.175,(for v_1=6 and v_2=84), $P < 0.05$]** it was found that there was significant difference in the prevalence of parasites between the seven different rodent species. Despite heavy parasitic infection, the rodents appeared healthy and agile, reflective of a well established and presumably successful rodent host-parasite interrelationship.

The highest prevalence of infection was found in household areas (28.125%) followed by agricultural field (25%), departmental stores (21.875%), vegetable market (15.625%) and garbage site (6.25%). The diversity and prevalence of parasites were statistically **[$F_{(cal)}$ = 7.8**

and $F_{(tab)}$ = 2.447,(for v_1=4 and v_2=56), $P < 0.05$] found to be affected by the type of sites, with household area being at high risk area for zoonotic disease transmission.

Rodents have been studied for the prevalence of parasitic fauna (ecto as well as endo-parasite) in Europe, America, Australia, Africa and Asia including South east Asia. Surprisingly, not much work has been done in our country. Several species of helminth parasites are common to both man and rodents. Some are accidental infection and have little public health importance, while others naturally occur in a number of rodents and play a significant role in the prevalence of some of the important human parasite (Flynn, 1973). In Nepal, the scarcity of scientific documentation regarding rodents as well as the threat of rodent as a reservoir for zoonotic diseases emphasizes the necessity of this study. The close association of the rodent host species to human activities may facilitate the transmission of the zoonotic parasites to human. More studies should be conducted to evaluate the risk of zoonotic disease transmission to human.

VII
RECOMMENDATIONS

From the outcome of the study performed, following recommendations have been drawn.

- The sample size in this study was too small to identify the full aspect of natural zoonotic parasitic infection in the rodents. So proper sample should be maintained in relation to the study area.

- Specimens found in this study were difficult to determine to species level. Further identification using molecular tools should be done.

- Bacterial and protozoan parasites of rodents zoonotic to human health should be studied as well.

- Hospital and lab based stool examination result of people of related study area should be studied so as to compare the prevalence of zoonotic parasites in both rodents and human, which will help to evaluate the risk of zoonotic disease transmission to human.
- Information regarding role of rodents in zoonotic diseases transmission should be introduced in the text book of primary and secondary level as a compulsory subject.
- It is recommended that the present rat control measures to be reviewed by the relevant authorities and also to improve its rodent borne disease surveillance programmers.

- In Nepal, the scarcity of scientific documentation regarding rodents as well as the threat of rodent as a reservoir for zoonotic diseases emphasizes the necessity of this study. More studies should be conducted in other urban areas to evaluate the risk of zoonotic disease transmission to human.

VII
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- http://www.metapathogen.com/schistosoma/schistosoma-mansoni.html
- http://www.pet-informed-veterinary-advice-online.com/tapeworm-in-cats.html
- http://www.wrongdiagnosis.com/medical/nippostrongylus.htm
- Manuscript, Drawing and Photograph Collection of Nathaniel Charles Rothschild (1877–1923)

ANNEX - I

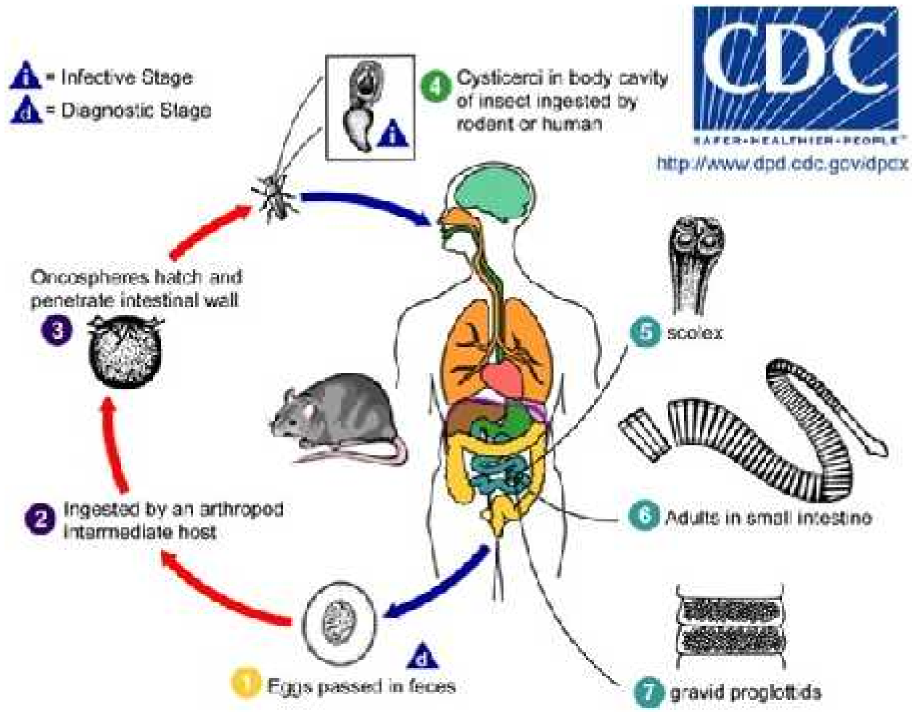

Figure 19: Life cycle of *Hymenolepis diminuta*

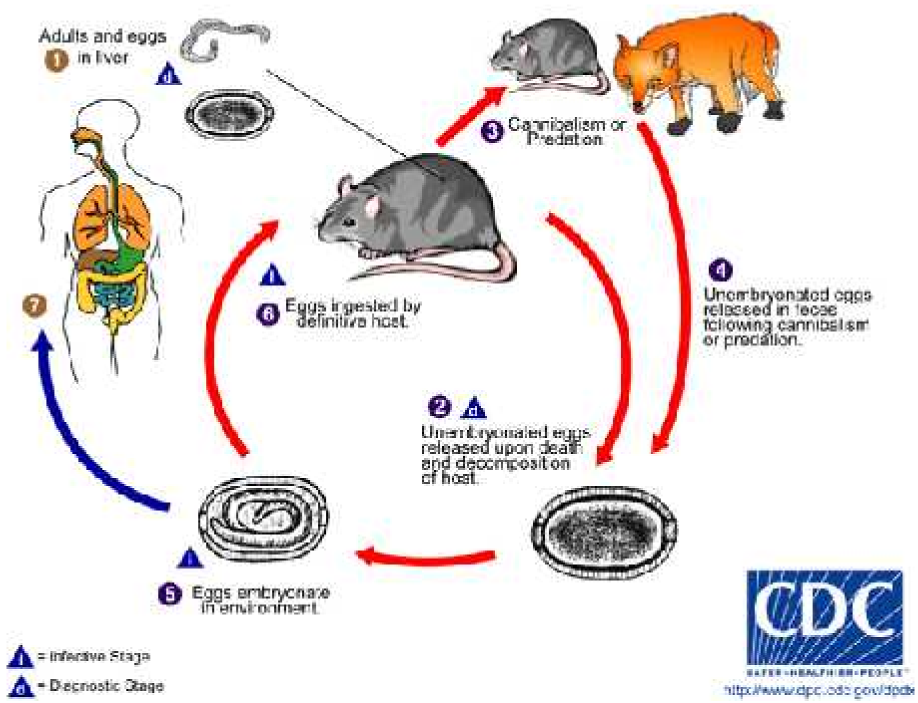

Figure 20: Life cycle of *Capillaria hepatica*

ANNEX – II

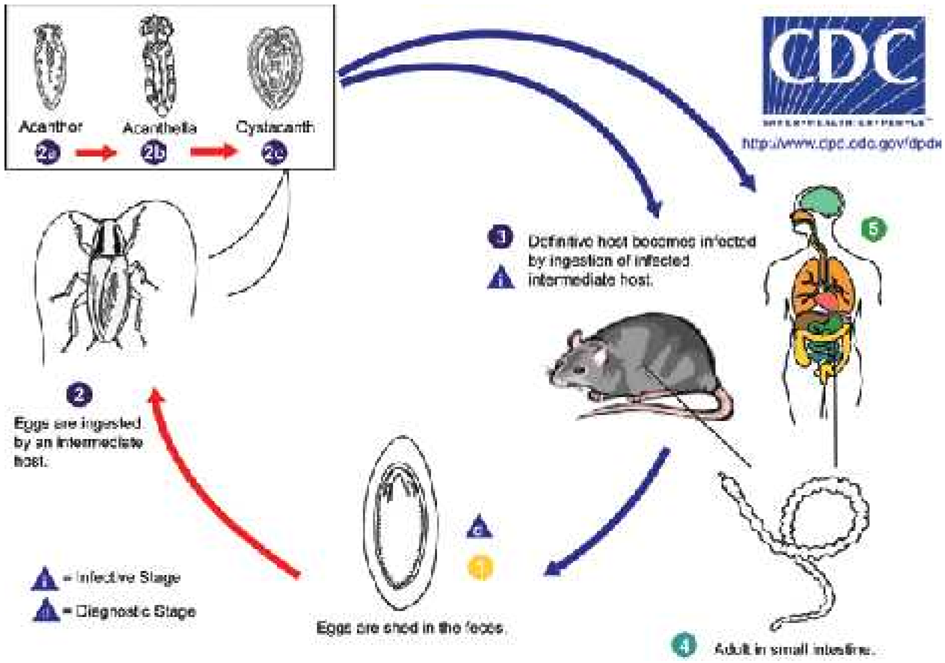

Figure 21: Life cycle of *Moniliformis dubius*

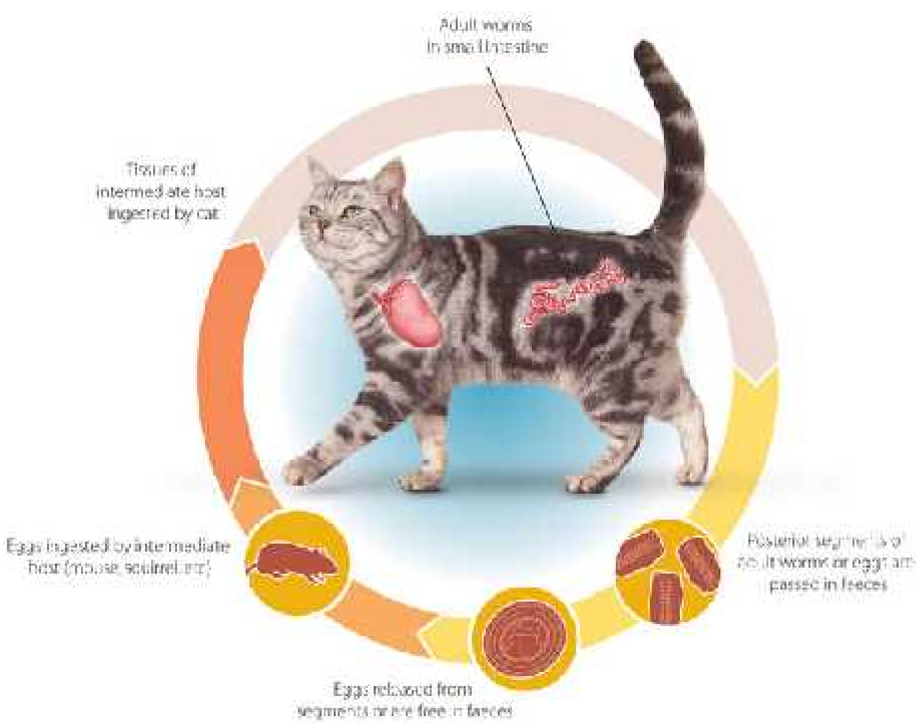

Figure 22: Life cycle of *Taenia taeniaformis*

ANNEX - III

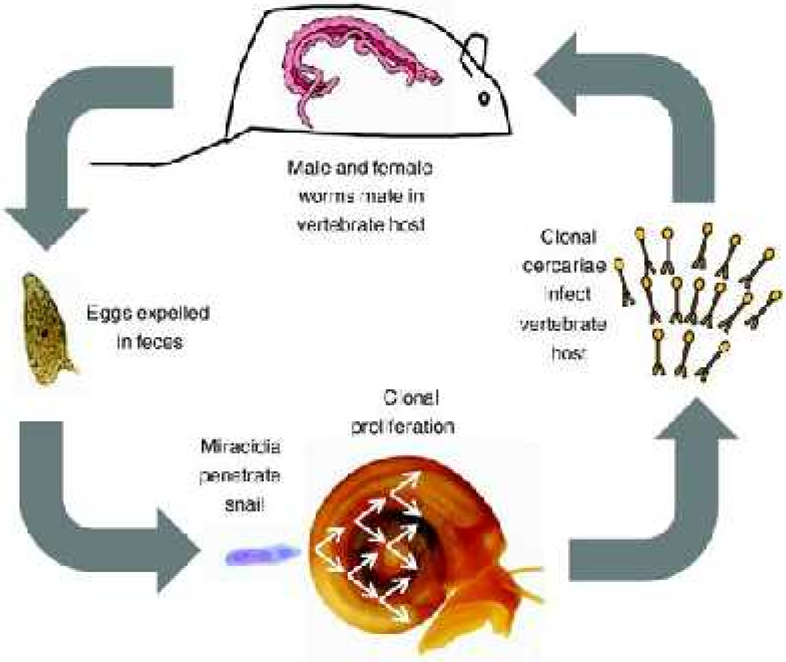

Figure 23: Life cycle of *Schistosoma* sp. (a)

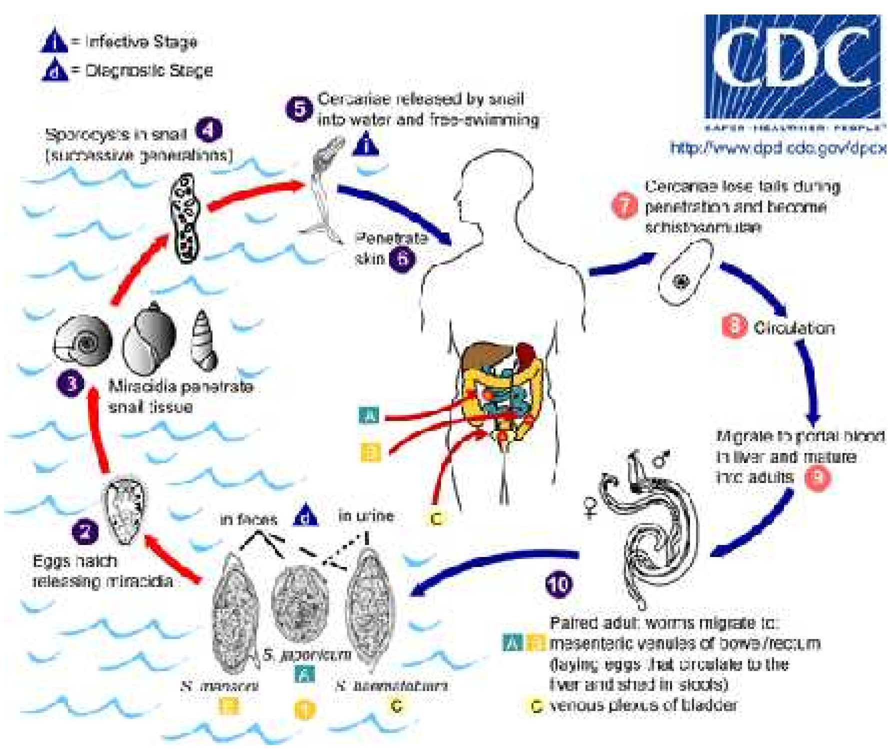

Figure 24: Life cycle of *Schistosoma* sp. (b)

ANNEX- IV

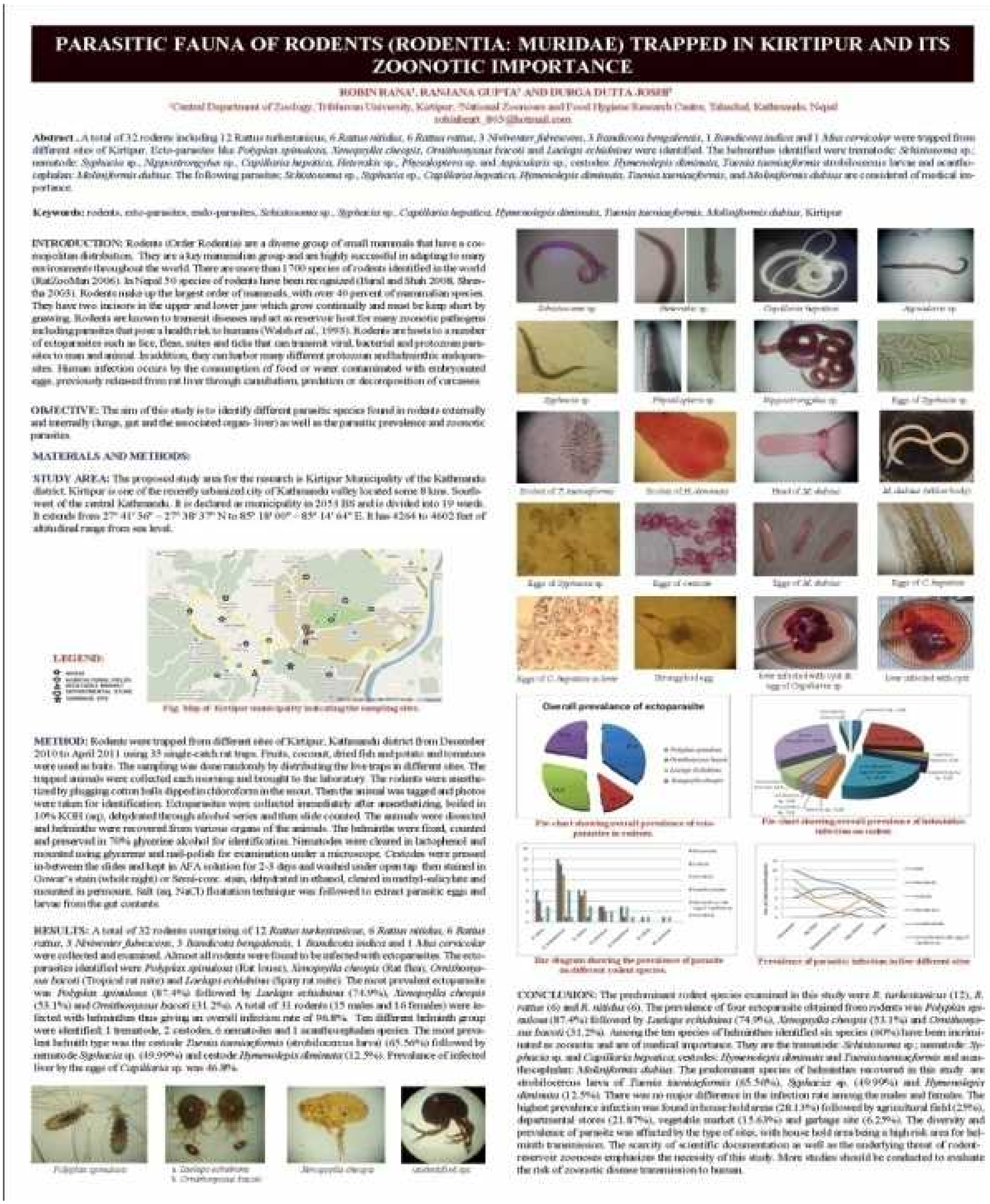

Figure 25: Poster presented in “2nd Annual Seminar” organized by SMCRF.

(4 X 3 feet square)

ANNEX- V

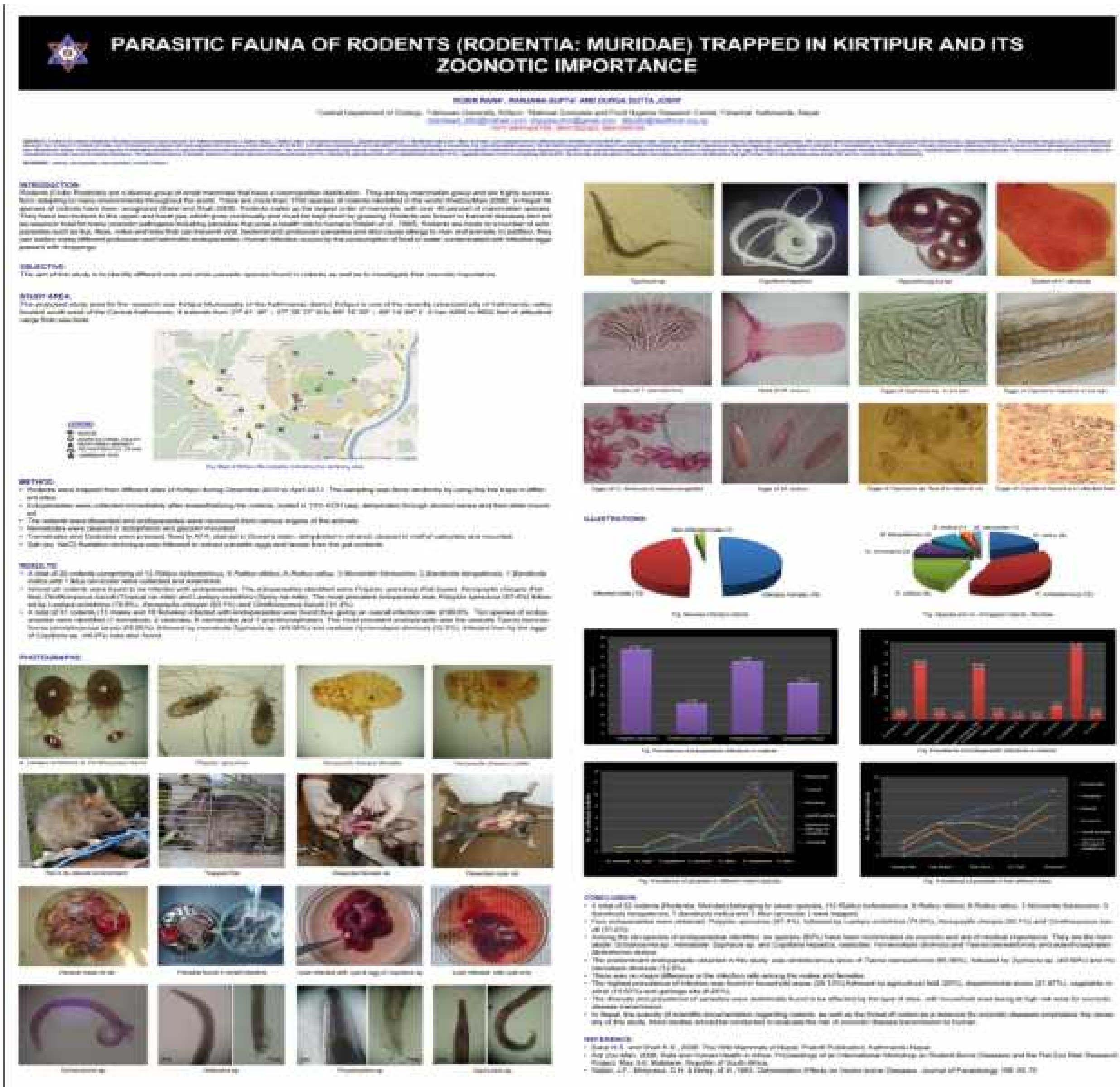

Figure 26: Poster presented in "Students' Conservation Conference & Exhibition" organized by NTNC (3.5 X 3 feet square)