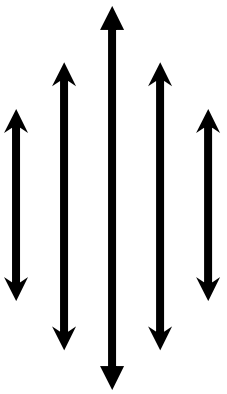
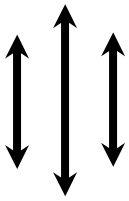
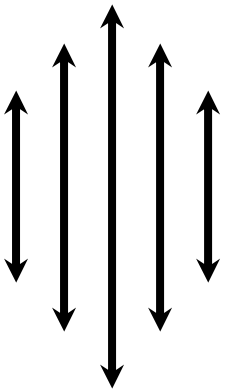
ECTOPARASITIC INFESTATIONS IN HUMANS AND ANIMALS OF CHITWAN AND KATHMANDU, NEPAL



A thesis
submitted for the partial fulfillment of Master's Degree of Science in Zoology
with special paper Parasitology



Submitted by
Mr. Raj Kumar Shahu



Submitted to
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TRIBHUVAN UNIVERSITY
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RECOMMENDATION

The dissertation entitled **"ECTOPARASITIC INFESTATIONS IN HUMANS AND ANIMALS OF CHITWAN AND KATHMANDU, NEPAL"** of Mr. Raj Kumar Shahu is approved for examination and is submitted to the Central Department of Zoology, Tribhuvan University, Kirtipur, Kathmandu in partial fulfillment of the requirements for Master's Degree of Science in Zoology with special paper Parasitology.

.....

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Date: 27th Feb. 2008

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RECOMMENDATION

On the recommendation of supervisor Associate Professor, Dr. Ranjana Gupta, the dissertation entitled **"ECTOPARASITIC INFESTATIONS IN HUMANS AND ANIMALS OF CHITWAN AND KATHMANDU, NEPAL"** of Mr. Raj Kumar Shahu is approved for examination and submitted to the Tribhuvan University in partial fulfillment of the requirements for M Sc Degree in Zoology with Parasitology as a special paper.

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APPROVAL

We, the members of the expert, evaluated the dissertation work entitled **"ECTOPARASITIC INFESTATIONS IN HUMANS AND ANIMALS OF CHITWAN AND KATHMANDU, NEPAL"** and approved that Mr. Raj Kumar Shahu is qualified for awarding **Master's Degree of Science in Zoology with special paper Parasitology.**

Expert Committee

1. **Head of the Department: Professor Dr. Vasanta Kumar Thapa.**.....

2. **Internal Examiner.** .....

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ABBREVIATIONS AND ACRONYMS

BHC	**–**	Benzene hexa-chloride
CI	**–**	Confidence Interval
CLM	**–**	Cutaneous larva migrans
CPS	**–**	Committee, Canadian Paediatric Society
DDT	**–**	Dichlorodiphenyltrichloroethane
DNA	**–**	Deoxyribose nucleic acid
GDP	**–**	Gross Development Productivity
KDR	**–**	Knockdown resistance
PHCC	**–**	Primary Health Care Centre
PP	**–**	Pediculosis pubis
VDC	**–**	Village development committee
WHO	**–**	World Health Organization

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ABSTRACT

Ectoparasites such as ticks, fleas, mites, lice, bedbugs, biting flies are the major arthropods that infect humans and animals in most part of the world. Diseases transmitted by these arthropods are among the major causes of illness and death of humans and animals in many tropical, subtropical and temperature zones. The general objective of this study was to find out the prevalence rate of ectoparasitic infestation in humans and animals of Gunjanagar VDC in Chitwan and Pharping VDC and Dhumbarahi Area in Kathmandu.

The present study was a cross-sectional descriptive study based on random sampling. One hundred and seventy seven humans and 193 animals were studied from the two different study areas. From Gunjanagar Village Development Committee (VDC), a total of 53 households were selected for the conduction of research which contains cows: 27, dogs: 29, goats: 59, buffaloes: 44, cats: 6, fowls: 11 and humans: 62. Similarly, from Kathmandu, a total of two monasteries in Pharping VDC, with the total of 115 children of age 8-22 years were studied. Similarly, from the Dhumbarahi area, a total of 12 households were observed that contained 12 dogs and 5 cats. Questionnaires and direct observation, collection, preservation and identification of ectoparasites were conducted by entomologists, veterinary and medical personnel on the basis of oculo-stage micrometer and photography of specimens in permanent and temporary slides. The data were analyzed by using Microsoft Excel Sheet Charts XP-2000, tables, diagrams and chi-square (χ^2-test) at 95% Confidence Interval ($\chi^2 < 0.05$, 95% CI).

The prevalence of hosts infested with different ectoparasites was as follows: ticks: 5.5 %, lice: 4.2 %, mites: 0.4%, bedbugs: 0.4% and biting flies: 1.3% in Gunjanagar (χ^2=36.705, P<0.05). The total prevalence of lice was 6.5% (4/62) in which the prevalence in males was 3.6% (1/ 28) and in females was 8.8% (3/34) with the highest prevalence 16.7% in the persons of age-groups ≥40 years in Gunjanagar ($\chi^2 = 2.6$, P> 0.05). Out of 132 hosts, the respective prevalence of ticks, lice, mites and fleas were as follows: 9.1%, 75.8%, 1.5% and 9.1%. Out of 115 humans, the prevalence of lice was 87.0% in Kathmandu valley. Itching, swelling, soreness, sleeplessness, restlessness, lethargy and psycho-disturbances were the symptoms and scabies was the pathogenicity found which was caused different by ectoparasites.

Quick treatment of scabies and sores by distributing drugs, anti-inflammatory creams, free insecticides, shampoos and lotions is needed for the humans and animals in the studied areas.

INTRODUCTION

1.1 Background of the study

Nepal is an independent nation full of ancient glories bearing testimony to her rich culture and civilization. With an area of about 147,000 square kilometres, it has a strategic location in south Asia between two big nations, India and China. The country is situated align the south scopes of the Himalayas between the Tibetan plateau in the north and the Gangatic plain in the south, it stretches between longitudes 80°44” to 88°12”east and latitudes 26°22” to 30°27” north. The nation has an elongated shape roughly north–west to south-east orientation (Shrestha, 1981).

Nepalese people have their own unique language, culture, social organization, myths, legends, customs, moral values and traditions. They have different creeds, tribes and ethnic groups which are settled in different parts of Nepal from plain of south to the high Himalayas of the north. Few countries exhibit such social, ethnical, linguistic and cultural diversity within such a small compass as Nepal so that the country may rightly be called the ethnic turntable of Asia (Hagen, 1961).

Life in Nepal like in most of the third world countries is characterized by poverty, ignorance and diseases. Literacy, poverty, malnutrition, inadequate health facilities, poor water supply and unsanitary conditions have led the country to a very poor socio-economic condition (Chhetri, 1993). The health status is also dominated and badly affected by parasitic diseases.

Besides, there are many zoonotic parasites which are transmissible between vertebrate animals and humans. Nepal being an agricultural country has many domesticated animals and these animals are the reservoir as well as hosts for the zoonotic ectoparasites such as ticks, lice, mites etc. So, the veterinary health status is also highly aggravated by the presence of these parasites.

In most cases, parasites damage or cause disease in the host. The parasites remain closely associated with their hosts biologically and ecologically. In its medical usage, it is an association in which one animal, the host, is injured in some degree through the activities of the parasites. In such condition, the parasites are called pathogens and the condition that results from the damage constitutes disease.

Strictly speaking, all organisms causing infections and infestation, thus also viruses, bacteria and fungi are parasites. However, for reasons of tradition only, in medicine and veterinary medicine, protozoa, helminths and arthropods are subsumed under the term “parasites”. Among these are numerous pathogens, particularly in tropical and sub-tropical regions, that cause misery disease and millions of deaths (Aspock, 2002).

Members of phylum Arthropoda represent the largest number of known animals. There are at least 760,000 species of arthropods in existence. Most arthropods are free living and are found in an array of aquatic and terrestrial habitats. However, some members of the subphylum Crustacea (i.e., Copepoda, Isopoda, Cirripedia, Amphipoda) and classes Arachnida and Insecta are parasitic. In addition, the larvae of most species of class Pycnogonida are parasitic.

Although many of these arthropod parasites are of little medical and economic importance, they are of considerable interest to biologists, specifically parasitologists, from the biologic standpoint. On the other hand, some of these parasitic arthropods, such as certain ticks, mites and insects, are of considerable medical and veterinary importance because they cause direct injury to their hosts. Besides they serve as vectors for various pathogens, including numerous microorganisms and viruses.

1.2 Statement of purpose

Ectoparasites such as ticks, fleas, mites, lice, bedbugs, biting flies are the major arthropods that infect humans and animals in most part of the world. The effects produced by the arthropod bites are brought about mainly by direct or indirect reactions to the salivary secretions. Many insects in biting create a subcutaneous pool of blood from which they suck instead of directly from a capillary. The results are that in most parasites, viruses, bacteria and rickettsia that are transmitted being locally deposited in the tissues, and not directly in the circulation (Gordon *et al.*, 1948).

Diseases transmitted by arthropods are among the major causes of illness and death in many tropical and subtropical countries, and to a lesser extent, in temperate zones also. In addition to the toll they exact in terms of premature death and disability, such diseases-which include malaria, plague, typhus fever, filariasis, leishhmaniasis, dengue, trypanosomiasis-represent a significant impediment to economic development, as a result of lost working hours, and the high

costs of treating the sick and controlling the vectors of disease. Besides, there is significant loss of blood, edema, paralysis and sores resulting into anemia and toxemia.

Nepal is an agricultural country and most of the people depend on the products of animal husbandry and poultry keeping. The domesticated birds and animals suffer the great loss of life due to parasitic infestation. Because of the scarcity of veterinary health workers and researchers in different remote areas, the diseases and illness are prevalent in this area. Besides, there are several zoonotic transmissions of ectoparasites such as ticks, mites and lice that may be transmitted between humans and animals. The people of Nepal especially the children have low socio-economic status because of illiteracy, political instability, centralized human and veterinary health system, poverty, low Gross Development Productivity (GDP), poor environmental sanitation etc. To these workers and the children who live in the groups such as Gumpas and nurseries, the ectoparsitic infestation is the major cause of nuisance. The favorable condition of the sub-tropical climate of Nepal induces the development of the lifecycle stage of the ectoparasites. The different previous works do not include the well-documented epidemiological study. They only describe the taxonomic details. Therefore, a well-documented study linked with prevalence, symptoms distribution and preventive options of ectoparasites is necessary in Nepal.

This study describes the prevalence of the ectoparasites in different animals and age and sex-wise distribution of these organisms in humans in Hilly area - Kathmandu valley and Terai area Gunjanagar VDC, Chitwan of Nepal.

AIMS AND OBJECTIVES

2.1 General objective

To find out the prevalence rate of ectoparasitic infestation in humans and animals of Gunjanagar VDC in Chitwan and Pharping (Dakshinkali VDC,and Talku Dudechaur VDC) and Dhumbarahi Area in Kathmandu.

2.2 Specific objectives

- To identify different ectoparasites in the study areas
- To find distribution of human lice in different age group and sex
- To find out the prevalence of different ectoparasites with respect to their frequency in the hosts
- To find out the awareness of ectoparasitic infestation in humans
- To find out the preventive measures adopted by the people against ectoparasitic infestation
- To aware the people of study area about the ectoparasitic infestations

LITERATURE REVIEW

3.1 Literatures in context of the world

Hewitt *et al.* (1971) carried out a preliminary survey in a Cornish rural population that showed animal ectoparasites were a common cause of human skin disease. They described the results of this investigation and its relative importance in human dermatology.

Walter (1978) reviewed that there were three species of bed bugs that commonly attacked man. *Cimex letularius*, the most common, may also use other hosts, including bats, chickens and occasionally other domestic animals. *Cimex hemipterus* was apparently confined to tropical regions (including Florida) and may also infest chickens and bats. *Leptocimex boueti* attacked bats and humans in West Africa.

Crissey (1984) studied about scabies and pediculosis pubis in detail. Scabies and pediculosis pubis are ectoparasitic infestations often transmitted by sexual contact. The distinctive clinical features that characterize these infestations were described, along with laboratory diagnosis. Entomologic, epidemiologic, and pathogenetic essentials were also considered, and safe and effective methods of treatment were presented for the clinician.

Burns (1987) explained the investigation and management of arthropod bites in home. This study described the essentiality of some knowledge of medical and veterinary entomology and familiarity with certain aspects of veterinary dermatology. This article was designed to give the dermatologist some guidelines to follow in the investigation and management of arthropod bites acquired in the home environment.

Kalter *et al.* (1987) conducted a research on the treatment procedures of pediculosis. Pediculosis pubis (PP) is a common sexually transmitted disease. Current therapy with 1% lindane or various synergized pyrethrins as a single dose has been accepted as adequate by the medical community. They treated 53 men with the diagnosis of PP with either 1% lindane (Kwell) shampoo for four minutes or 1% permethrin (Nix) creme rinse for ten minutes, according to random assignment. All patients combed with fine-toothed combs immediately after therapy.

They were examined for tolerance and efficacy of lindane and permethrin at 24 to 48 hours and again at ten days (eight- to 12-day range). Both treatments were well tolerated, with one mild adverse reaction in each group. They concluded that both agents were equivalent in the treatment of PP. On the basis of the high failure rate, they proposed that the therapy of PP with any agent should include a second treatment at ten days.

Valenzuela et *al.* (1996) explained the life cycle of bedbugs. Bedbugs depend on blood for their complete nutrition. Feeding occurs during each of 5 nymphal stages prior to moulting, and before each session of egg-laying. The bugs apparently locate the host by detecting warmth and carbon dioxide. The bug grasps the skin with the saw-toothed modified mandibles or stylets and penetrates with the two tubes that are modified maxillae. One of the tubes injects saliva containing an anticoagulant.

Babjee *et al.* (1998) reported some ectoparasites like *Haemaphysalis wellingtoni*, *Megninia cubitalis*, *Menacanthus stramineus*, *Neoschongastia gallinarum*, *Menopon gallinae*, *Liperus caponis*, *Cuclotogaster heterographus*, *Goniodes gigas*, *G. dissimilis* and *Goniocotes gallinae* as infesting village chickens in Malaysia. The tick, *H. wellingtoni* and the trombiculid, *N. gallinarum*, were also commonly observed in high numbers and caused skin lesions. The prevalence and degree of ectoparasites infestation were closely related to the age of the birds, with higher infestation in older birds. The high prevalence of ectoparasites observed in this study was thought due to the free-range system, which exposed the birds to more species of ectoparasites, compared to those kept under the intensive system.

Maunder (1998) explained that scabies mites were only distantly related to human lice. Nevertheless, the two groups had much in common as regards to structure and life-style. These similarities resulted from the two groups using parallel adaptations in order to solve some of the problems of being parasites.

Birk (1999) explained on pseudoscabies transmitted by red fox. Pseudoscabies, i.e. infestation of human skin with animal mites may occasionally occur and should be considered in the differential diagnosis of pruritic and papular skin disease. They reported a 52-year-old woman with pseudoscabies or canine scabies (*Sarcoptes scabiei var. canis*), transmitted by indirect contact with a red fox in the urban area of Berlin. Red foxes might live in inhabited areas of metropolitan large cities, i.e. in garages, car wrecks and cellars. Full remission of the prolonged

and pruritic rush was seen after topical administration of lindane together with systemic corticosteroids.

Downs *et al.* (1999) described the double resistance of permethrin and malathion in head lice. A rising prevalence of head lice among school children and rising sales of insecticides with anecdotal evidence of their treatment failure, led them to examine whether head lice in Bristol and Bath were resistant to the insecticides available for treating head lice. They concluded that there was a high resistance to permethrin and malathion, but head lice remain fully sensitive to carbaryl. This was the first report of doubly resistant head lice. As permethrin, phenothrin (a very similar synthetic pyrethroid) or malathion were the active ingredients in all the over-the-counter head lice treatments in the UK, then it was likely that head lice prevalence would continue to increase. The resistance against permethrin employed by the head louse was probably the KDR (knockdown resistance) mechanism, and an enzyme-mediated malathion-specific esterase is the likely mechanism against malathion.

Gary *et al.* (2000) assessed a study on pediculosis, which explained that the drug of choice in the treatment of pediculosis or pubic lice is permethrin because it has a high level of effectiveness and a low level of toxicity. Lindane should be avoided if possible due to its increased toxicity and the availability of safer and more effective treatments. Resistance to lindane had been reported in parts of the world, but not in the United States. It is necessary that all sex partners should be treated to prevent reinfestation. Household contacts may also need to be treated depending on the degree of exposure.

Förster *et al.* (2000) explained that the economic, medicinal and therapeutic value of neem (*Azodirachta indica*) tree. Neem was widespread and well known as a traditional medicinal plant in many rural areas in Asia and Africa. Teas and infusions made from leaves are used to alleviate intestinal complaints, malaria attacks and other febrile illnesses and also to treat numerous skin diseases. The use of aqueous extracts from seeds to treat head lice was widely known. The good repellent effect made from neem oil was an ideal material for mosquito repellent products. Pharmaceutical products included neem skin tonic, neem body lotion, neem soap, neem haircare products including shampoo, conditioner and lice treatments, neem cosmetics and neem toothpaste. Other products included. Neem mosquito repellent, Neem pet food and flea powder.

Canadian Pediatric Society (CPS), 2001 explained the scabies management. Scabies had been a problem for humans since before the first millennium and was reported by the earliest writers who described mankind's health problems. It was estimated that there might be 300×10^6 cases of scabies worldwide each year. In some areas, scabies has a much higher prevalence than diarrhea or upper respiratory disease. It was particularly a problem in situations of overcrowding, and in less developed countries and communities. Noncompliance or a lack of adequate treatment could result in scabies as a public health problem. It could be a 'marker' disease for immunocompromised patients. Secondary infection due to scratching complicated the diagnosis, but once the diagnosis was confirmed, the first-line treatment was 5% permethrin creme and the control of contacts.

Balashov (2001) assessed the host specificity of arthropod parasites with the terrestrial vertebrates. In arthropods, the phylogentic specificity and coevolution were characteristic to a greater extent for permanent hosts (lice, Mallophaga, cheyletoid and feather mites). A coevolutionary phylogenesis was disturbed by transfers of parasites onto new hosts, by different rates of speciation in filial lines or by an extinction of several parasite taxa.

Koch *et al.* (2001) reviewed head lice infestation, which was a public health issue. In the effort to compile an evidence-base about the physiology, detection, treatment, effects and management strategies of head lice infestations, they reviewed current literature. This literature signaled significant evidence gaps and these gaps provide incentives for further research. Their conclusions from the literature were that parents of children were responsible for head lice detection and treatments but had varying access to advice about how best to treat this condition. Concern was exacerbated by misconceptions surrounding the circumstances of infestation. Head lice were a low priority for health professionals in Australia, whereas parents and teachers believe the problem necessitates greater attention. It was important to provide a unified evidence-based approach to good information and it was timely for health care professionals to re-examine and prioritize this public health issue.

Plastow *et al.* (2001) reviewed traditional treatment of head lice infestation. The two main methods of managing head lice infestation in the UK were head lice lotions and bug busting; there was no conclusive evidence as to which of these methods was most effective. The aim of this study was to compare the effectiveness of the bug busting method with lotion. A pilot study in the form of a randomized controlled trial involving two semirural general practices was used.

Thirty children aged 4±16 years were randomly assigned to two intervention groups. After initial dry combing to detect the presence of head lice, one group was treated with phenothrin lotion. The bug-busting group received combing using special combs provided in the bug busting pack and hair conditioner. The main outcome measure was the number of adult live lice and nymphs at day 14.

Akucewich *et al.* (2002) studied to determine the potential feline ectoparasites in domestic cats by using a cohort of feral cats from north central Florida that had not received veterinary care and had no known exposure to insecticide application. A total of 200 feral cats were randomly selected for this study. Five minutes flea combing revealed that 185/200 (92.5%) of the cats were infested with fleas. The cat flea, *Ctenocephalides felis* was the most common flea infesting 92.5% feral cats. *Pulex simulans* was identified on 9/200 (4.5%). *Echidnophaga gallinacea* was found on 11/200 (5.5%) of cats. The number and species of ticks recovered were: one adult female *Rhipicephalus sanguineus*; one adult female *Amblyomma americanum*; one adult male *A. americanum*; five adult female *Dermacentor variabilis*; and one adult female *Ixodes scapularis*. All superficial skin scrapes were negative. Hair clippings from the abdomen of all cats revealed 2/200 (1%) of the cats were infested with *Felicola subrostratus.*

Moyer *et al.* (2002) described that a parasite's potential effect, or ''pressure'', could influence the life history strategy of its host. In environments with high parasite pressure, hosts invested more in anti-parasite defense, which might limit their investment in other life history components, such as survival. This tradeoff was difficult to study in natural populations because pressure was hard to quantify. Their results confirmed that an abiotic factor could cause substantial variation in parasite pressure among host populations. They suggested that humidity may influence host life history evolution through its impact on ectoparasites.

Fawcett (2003) discussed the role of antiscabies drugs. Oral ivermectin was an effective and cost-comparable alternative to topical agents in the treatment of scabies infection. It might be particularly useful in the treatment of severely crusted scabies lesions in immunocompromised patients or when topical therapy has failed. The safety of oral ivermectin in pregnant and lactating women and young children had yet to be established.

Heukelbach *et al.* (2003) conducted two studies to assess disease perception and health care seeking behavior in relation to parasitic skin diseases and to determine their public health

importance. The first study comprised a representative cross-sectional survey of the population of a slum in north-east Brazil. Inhabitants were examined for the presence of scabies, tungiasis, pediculosis and cutaneous larva migrans (CLM). The second study assessed health care seeking behavior related to these ectoparasitoses of patients attending a Primary Health Care Centre (PHCC) adjacent to the slum. The physicians of the PHCC only diagnosed a parasitic skin disease when it was pointed out by the patient himself. In all cases patients were correctly informed about the ectoparasitosis they carried. The results showed that tungiasis and pediculosis, and to a lesser extent scabies and CLM, were hyperendemic but neglected by both population and physicians, and that prevalence rates of tungiasis and scabies at the PHCC did not reflect the true prevalence of these diseases in the community.

Liebold *et al.* (2003) explained a case study of symptom of infection caused by bed bugs. Bedbugs seemed to have become more common due to international trade and traveling. They reported on a 37- year-old man who developed a bullous reaction with fever and general malaise due to bites of the common bedbug, *Cimex lectularius*. Fortunately, bullous and systemic reactions were rare.

Razmi *et al.* (2003) conducted a study to determine the population of ticks in infested cattle and to identify the tick vectors of bovine theileriosis in an endemic area of Iran from 1998 to 1999. A total of 120 suspected cattle suffering from theileriosis were clinically examined and investigated for the presence of *Theileria annulata* in blood smears and the presence of any tick species on the body of cattle. In this study, 680 ticks were collected from 107 cattle infested with *T. annulata*. The prevalence of ticks infesting cattle was 92.35% *Hyalomma anatolicum excavatum*, 5.14% *H. marginatum marginatum*, 1.17% *H. asiaticum asiaticum* and 1.32% *Rhipicephalus sanguineus*. The examination of 510 tick salivary glands revealed that 51% of *H. a. excavatum* and 1.3% of *H. a. asiaticum* were infected with sporozoites of *T. annulata.*

Wappler *et al.* (2003) explained that out of the 30 extant orders of insects, all but one, the parasitic lice (Insecta: Phthiraptera), had a confirmed fossil record. They reported the discovery of what appeared to be the first bird louse fossil: an exceptionally well-preserved specimen collected from the crater of the Eckfeld maar near Manderscheid, Germany. The 44-million-year-old specimen showed close phylogenetic affinities with modern feather louse ectoparasites of aquatic birds. The crown group position of this fossil in the phylogeny of lice confirmed the

group's long coevolutionary history with birds and points to an early origin for lice, perhaps inherited from early-feathered theropod dinosaurs.

Burgess (2004) explained the human lice and their control. Current research on human louse biology had focused on the longstanding debate about speciation of head and body lice but using new tools of DNA and enzyme analysis. These studies had indicated that head and body lice from the same geographical zone may be more closely allied than insects inhabiting the same ecological niche in other regions. However, the majority of research over the past decade had involved clinical aspects including transmission, treatment, and the appearance and identification of resistant strains within populations of lice. Despite advances, there was a need for a better understanding of louse biology, as existing therapies failed and lice remained potential vectors of disease for millions of people.

Johnson *et al.* (2004) described a genetic study of origins of parasitism in lice. A major fraction of the diversity of insects was parasitic, as herbivores, parasitoids or vertebrate ectoparasites. Parasitic lice (Phthiraptera) were the only major group of insects in which all members were permanent parasites of birds or mammals. They inferred from these results that parasitism of vertebrates arose twice independently within Psocodea, once in the common ancestor of Amblycera and once in the common ancestor of all other parasitic lice.

Jörg *et al.* (2004) reviewed the ectoparasitoses (infestations with parasites that live on or in the skin) that could cause considerable morbidity. Whereas pediculosis and scabies were ubiquitous, cutaneous larva migrans and tungiasis (sand-flea disease) occurred mainly in hot climates. The prevalence of ectoparasitoses in the general population was usually low, but could be high in vulnerable groups. For head lice and scabies the situation was daunting, because resistance of *Pediculus humanus capitis* and *Sarcoptes scabiei* to insecticides was spreading and unpredictable. A better understanding of local epidemiology was required to develop control measures. This knowledge had to be applied in combination with environmental sanitation, health education, and culturally acceptable interventions that were affordable by the underprivileged.

Paulette (2004) recorded all available records are compiled for three orders of ectoparasites of mammals in New Mexico: fleas (Siphonaptera), sucking lice (Anoplura), and chewing lice

(Mallophaga). They listed 99 species of fleas, 27 species of sucking lice, and two species of chewing lice. They reported at least four new state host records for fleas.

Perotti *et al.* (2004) described the sex ratio distortion in the human head louse**.** At the turn of the 19th century the first observations of a female-biased sex ratio in broods and populations of the head louse, *Pediculus humanus capitis*, had been reported.

Saxena *et al.* (2004) assessed the prevalence of phthirapteran ectoparaistic insects on domestic hens of Rampur, Utter Pradesh, India. As many as 60.9% of the fowls (510) examined in twelve localities of district Rampur (during July 2000 to August 2002) were found infested with one or other kind of Phthiraptera. The order of prevalence of seven species has been found to be *Menopon gallinae* (51.3%) > *Goniocotes gallinae* (25.4%) > *Lipeurus lawrensis tropicalis* (15.8%) > *Lipeurus caponis* (11.5%) > *Menacanthus cornutus* (8.1%) > *Goniodes dissimilis* (7.9%) >*Lipeurus heterographus* (6.9%). Significant positive correlation existed between mean monthly prevalence rate and mean monthly temperature as well as photoperiod. The prevalence rate was significantly higher on birds having poor health and poor plumage.

Thomas *et al.* (2004) reviewed on the morphologic and epidemiologic characters of the nocturnal ectoparasites, the bedbugs. They were a particular concern in Africa and the tropics as they might be vectors for endemic infectious diseases such as American trypanosomiasis, also known as Chagas' disease.

Whiteman *et al.* (2004) explained the positive relationship between parasite infection intensity and host density. Two louse (Phthiraptera) species were collected: *Colpocephalum turbinatum* (Amblycera), with 53 host species, and *Degeeriella regalis* (Ischnocera), with 10 host species, although *B. galapagoensis* was the only known Galapagos host. Sixty territorial adult male hawks from 26 groups of 1–6 males were quantitatively sampled for lice. These are the first results to demonstrate significant differences in a suite of population responses between these louse suborders in the context of host sociality.

Hagos *et al.* (2005) studied on identification of ectoparasites of local chickens that was conducted from October 2000 to April 2001, on 190 chickens raised under traditional management system in central Ethiopia, namely Jeldu, Sebeta and Awash Melka Kontire. The study indicated that 178 (93.7%) of the examined chickens were infested by diverse species of

ectoparasites. Parasitic examination revealed the presence of fourteen species of ectoparasites (fleas, lice, mites and ticks). The prevalence of ectoparasite infestation accounted as: 84.4%, 98.4% and 100% in the highland, midland and lowland sites, respectively with statistical significance ($p<0.05$). This study showed that ectoparasites were the highly prevalent infestation on traditionally managed local chickens in the study area.

Hwang *et al.* (2005) conducted a research on bed bugs, which had been considered uncommon in the industrialized world. This study determined the extent of reemerging bed bug infestations in homeless shelters and other locations in Toronto, Canada. Toronto Public Health documented complaints of bed bug infestations from 46 locations in 2003, most commonly apartments (63%), shelters (15%), and rooming houses (11%). At one affected shelter, 4% of residents reported having bed bug bites. Bed bug infestations could have an adverse effect on health and quality of life in the general population, particularly among homeless persons living in shelters.

Krasnov *et al.* (2005) established a negative interspecific correlation between the degree of habitat specialization and the size of a species' geographic range. In contrast, practically nothing was known about the geographic range sizes of parasitic organisms and their determinants. In the context of the niche breadth hypothesis, parasites represent ideal study systems, because of the well documented variation in host specificity among parasite species. Overall, these results provided strong support for the niche breadth hypothesis, although other explanations cannot be ruled out.

Mallory *et al.* (2005) studied the prevalence and intensity of infestation of ectoparasites on northern fulmars (*Fulmarus glacialis* L.) from a breeding colony in Arctic Canada in June-August 2003. No fleas or ticks were found on any fulmars, but three species of chewing lice (Phthiraptera) were recorded: Ischnocera: *Perineus nigrolimbatus* (Giebel, 1874), Ischnocera: *Saemundssonia occidentalis* (Kellogg, 1896) and Amblycera: *Ancistrona vagelli* (Fabricius, 1787). Non-breeding birds had a higher prevalence of lice than breeding birds, and prevalence varied markedly among louse species. Their study was an important baseline for the occurrence of ectoparasites on northern fulmars in the high Arctic, a region undergoing extensive environmental change due to global warming, and an area where parasites were expected to extend ranges or increase in prevalence under changing annual temperature regimes.

Poorten *et al.* (2005) discussed epidemiology, entomology, presentation, and treatment of bedbugs and their bites. They explained that the incidence of skin disease secondary to infestation with the human bedbug, *Cimex lectularius,* had increased dramatically in the United States and in the United Kingdom. They described a child with a recurrent pruritic eruption of urticarial, erythematous papules on the face, neck, and extremities. The etiology of her cutaneous lesions was discovered to be a bedbug infestation in the home.

Brouqui *et al.* (2006) discussed the epidemiology, diagnosis, prevention, and treatment of some arthropod parasites such as lice, fleas like *Ctenocephalides felis, Xenopsylla cheopis,* and *Pulex irritans,*, ticks *Dermacentor, Rhipicephalus,* and *Ixodes,* and mites *Sarcoptes scabiei var. hominis, Liponyssoides sanguineus,* bedbugs like *Cimex lectularius* in homeless persons.

Cumming *et al.,* (2006) examined the effects of climate change with the occurrences of tick species in Africa. The climate change would disrupt not only the geographic location of communities but also their structure. Changes in tick communities were also likely to influence tick-borne pathogens.

Diaz *et al.* (2006) reviewed the ectoparasitic diseases (afflicted parts of skin such as the scalp, facial, and pubic hairs; external ears; nares; orbits and eyelids; and genitourinary and rectal areas, which had been reported in travelers returning from both developed and developing nations.

3.2 Literature review in context of Nepal

Atkinson (1974) compiled insect fauna of the Himalayas containing a number of insects (Coleoptera, arthropoda, hemiptera, Hymenoptera, Diptera and Neuroptera) from Nepal, Tibet and Burma.

Emery (1974) collected ticks, fleas and lice from Arun Valley, Nepal.

Prasad (1974) studied dmesostigmatic mites from Nepal.

Snil (1974) revised siphonaptera collected by Dr. J. martens in Nepal.

Clifferd *et al.* (1975) studied the Ixodes ticks of Nepal.

Maskey (1976) has traced a very useful history of Entomology in Nepal since 1831- 1976 in her dissertation work.

Mishra (1976) reviewed and compiled various references dealing with Nepalese fauna including insects.

Smith (1976) revised siphonaptera collected by Dr. M. David in Nepal.

Shrestha (1977) studied twenty-three ectoparasites from birds and mammals belonging to various orders.

Rauniyar (1981) studied the distribution of hard ticks at Kathmandu valley. He collected six species belonging to five genera from cow, buffalo, and sheep.

Malla (1982) studied the parasitizing livestock in and around Kathmandu Valley and recorded 11 species of hard ticks (Ixodids belonging to six genera).

Pandey (1985) observed the human parasites of order Anuplura Siphonaptera from Kathmandu Valley.

Inaoka (1989) reported three species of Tabanids (Diptera/ Tabanidae) from Nepal.

Poudel *et al.* (2004) conducted a research to find out the prevalence of different species of pediculus in Kathmandu and Pokhara. The prevalence of infestation with head lice and body lice, *Pediculus spp*. (Phthiraptera: Pediculidae) and pubic (crab) lice *Pthirus pubis* (L.) (Phthiraptera: Pthiridae), was recorded from 484 people in Nepal. The prevalence of head lice varied from 16% in a sample of people aged 10–39 years of age, to 59% in street Children. Simultaneous infestations with head and body lice (double infestations) varied from 18% in slum children to 59% in street children.

MATERIALS AND METHODS

4.1 Study area

4.1.1 Gunjanagar village development committee

Gunjanagar is an agricultural area located in the western part of Chitwan District and is about 161 km southwest of Kathmandu, the capital of Nepal. This village is situated in about 15 km west of Bharatpur Municipality. It is surrounded by the Sharadanagar VDC in east, Shukranagar VDC in south and Dibyanagar VDC in the west and Narayani River in the north (Ghimire *et al.,* 2005).

4.1.2 Pharping area

Pharping is a populated place in Kathmandu district of Bagmati zone. This area is about 2.5 km to Dakshinkali and is about 7.6 km to Kirtipur. Pharping is unexpectedly large and lively for this distant corner of the valley. It is about 14 km south of capital city. This area comprises of six VDCs that include Chalnakhel, Saukhel, Sheshnarayan, Dakshinkali, Chhaimale and Talku Dudechaur. It is divided between an unattractive modern commercial strip along the road and the more villager original centre, reached by a side road where the main road swerves left.

4.2 Study design

The study design used during the study of ectoparasitic infestation was cross-sectional descriptive.

4.3 Ethical consideration

Before data collection, the purpose and the procedure of this study were explained to the household head or key informant and other interested family members. Participation of the subjects in all kinds of data collection was voluntary. Similarly, the students and the principals of the Monasteries in Pharping areas were informed the purposes of the study. Confidentiality of each case was maintained.

4.4 Data collection

In the present study, 177 humans and 193 animals were considered as samples from the different study areas. From Gunjanagar VDC, Chitwan, a total of 62 humans were studied and a total of 176 animals were studied. Similarly, from Kathmandu (Pharping, and Dhumbarahi), a total of 115 humans and a total of 17 animals were studied. Random sampling was used during the households survey of ectoparasitic infestation of humans and animals.

4.4.1 Questionnaires

Two types of questionnaires were prepared: one type was for the ectoparasitic infestation from humans and another type was for the ectoparasitic infestation in animals. These questionnaires were distributed in different households and the head person or literate persons were asked to fill these questionnaires.

4.4.2 Observation

Direct observation methods were applied for the detection of ectoparasitc infestation in animals and humans. With the help of health workers and veterinary officers, clinical examinations of ectoparasitic infested humans and animals were conducted.

4.4.3 Collection of ectoparasites

The ectoparasites were collected from humans and different animals by means of forceps and brush dipped in alcohol. The collected species were preserved in different concentration of alcohol according to the guidelines given by Kapoor, 2005.

4.4.4 Confirmation

4.4.4.1 Confirmation of infestation

The sores and other symptoms caused by ectoparasitic infestation in humans and animals were confirmed by the direct observation and studying the photographs with the help of medical and veterinary officers.

4.4.4.2 Confirmation of species

The different ectoparasitic species were confirmed by the macroscopic and microscopic observation of the temporary and permanent slides preparation and oculo-stage micrometer and by studying the photographs with the help of entomologists and professors of Central Department of Zoology, Tribhuvan University, Kirtipur, Kathmandu.

4.5 Statistical methods

The data were analyzed by using Microsoft Excel Sheet Charts XP-2000, diagrams and chi-square (χ^2-test). The results were found to be statistically significant if the χ^2 value was less than 0.05 at 95% confidence interval (95%CI).

4.6 Data processing and analysis

4.6.1 Data editing

Data were edited as soon as possible to detect errors, missing and to make sure that the data were accurate, uniform and well arranged.

4.6.2 Coding

Information was coded so that they were easily classified and tabulated.

4.6.3 Classification and tabulation

All the data were classified according to the need of the objectives and tabulation was done for summarizing the data and displaying statistically.

4.6.4 Data analysis

Data were analyzed by means of chi-square test (χ^2), table, bar diagram, multiple bar diagram. Data were found to be significant if the chi-square value was less than 0.05 ($P<0.05$, 95% Confidence Interval)

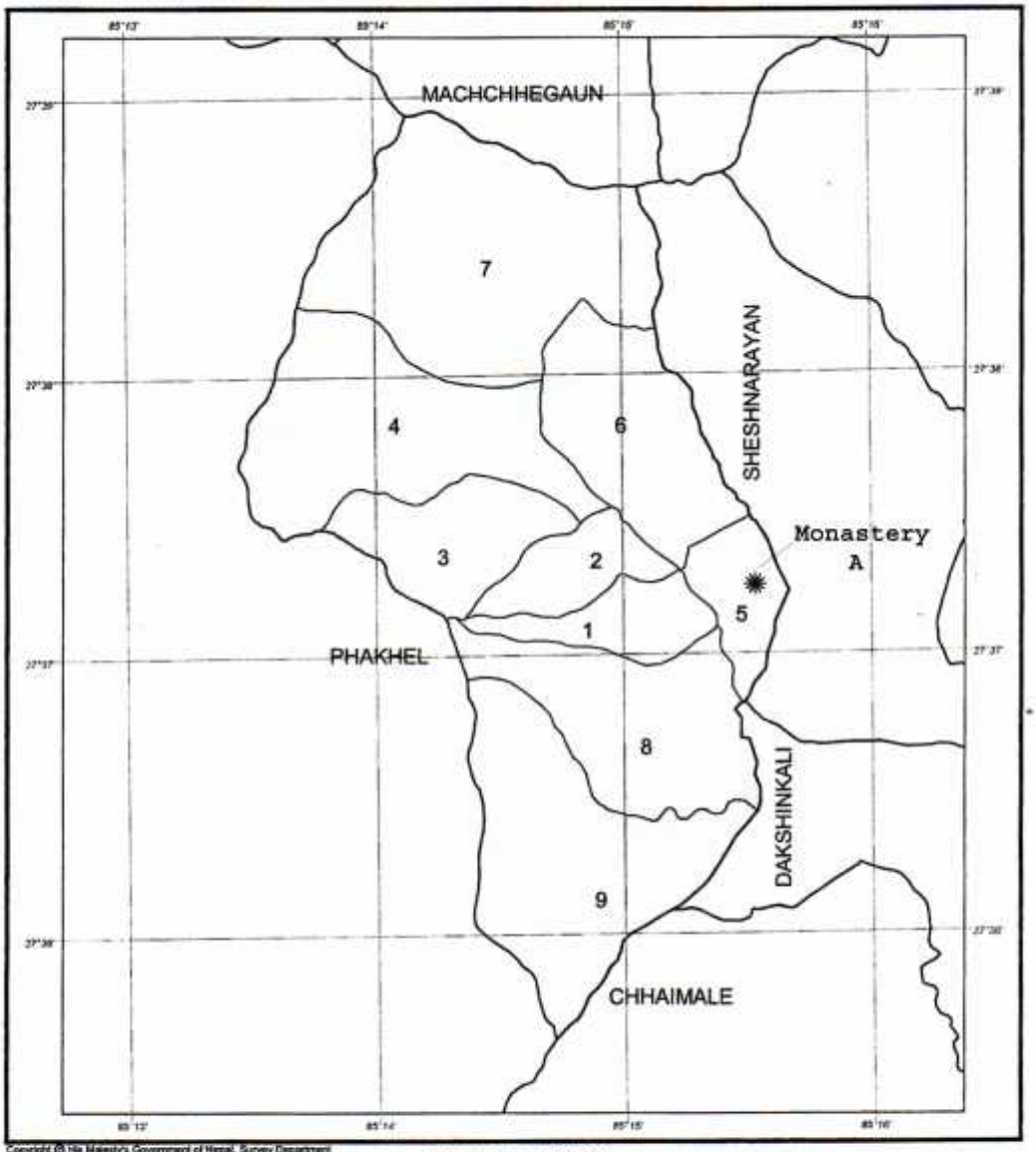
4.7 Validity and reliability

- Quality control on specimen collection, processing and confirmation of the different species were maintained throughout the research.
- All reagents, equipments and laboratory methods were standardized.
- The study was properly instructed and guided by the supervisor and medical and veterinary personnel.
- Questionnaires were filled by the respondents in guidance of the investigator.
- Symptoms and pathogenicity of the patients and animals were proved by the medical and veterinary doctors.

TALKU DUDECHAUR VDC

DISTRICT : KATHMANDU

VDC Code : 27054



SCALE 1 : 37500

750 0 750 1500 Meters

LEGEND

———	VDC Boundary
———	Ward Boundary
BUKHEL	VDC Name
5	Ward Number

TALKU DUDECHAUR VDC
Area :11 Sq.Km.(Approx.)

HORIZONTAL DATUM

Spheroid Everest 1830
Projection MUTM
Origin Longitude 84° E., Latitude 0° N.
False coordinates of origin 500 000 m. Easting, 0 m. Northing
Scale Factor at Central Meridian 0.9999

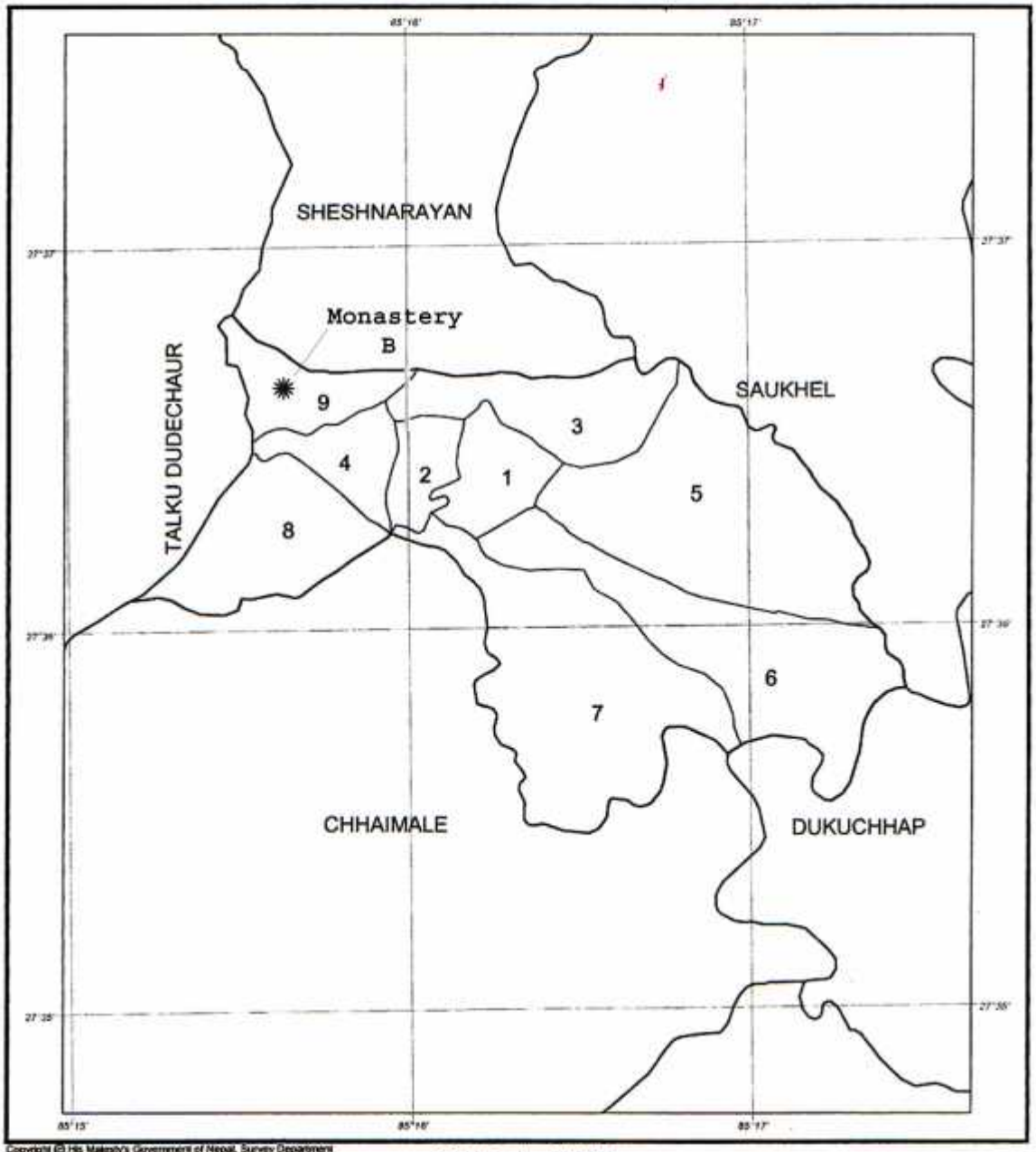
Map compiled from National Topographic Database at scales 1:25 000 and 1:50 000. Internal administrative boundaries are not demarcated on the ground. Map produced by the Survey Department, National Geographic Information Infrastructure Programme, (NGIIP). Kathmandu, 2003

KATHMANDU DISTRICT
VDC Location Map

DAKSHINKALI VDC

DISTRICT : KATHMANDU

VDC Code : 27013



SCALE 1 : 27500

550 0 550 1100 Meters

LEGEND

———	VDC Boundary
———	Ward Boundary
BUKHEL	VDC Name
5	Ward Number

DAKSHINKALI VDC

Area :4 Sq.Km.(Approx.)

HORIZONTAL DATUM

Spheroid Everest 1830
Projection MUTM
Origin Longitude 84° E., Latitude 0° N.
False coordinates of origin 500 000 m. Easting, 0 m. Northing
Scale Factor at Central Meridian 0.9999

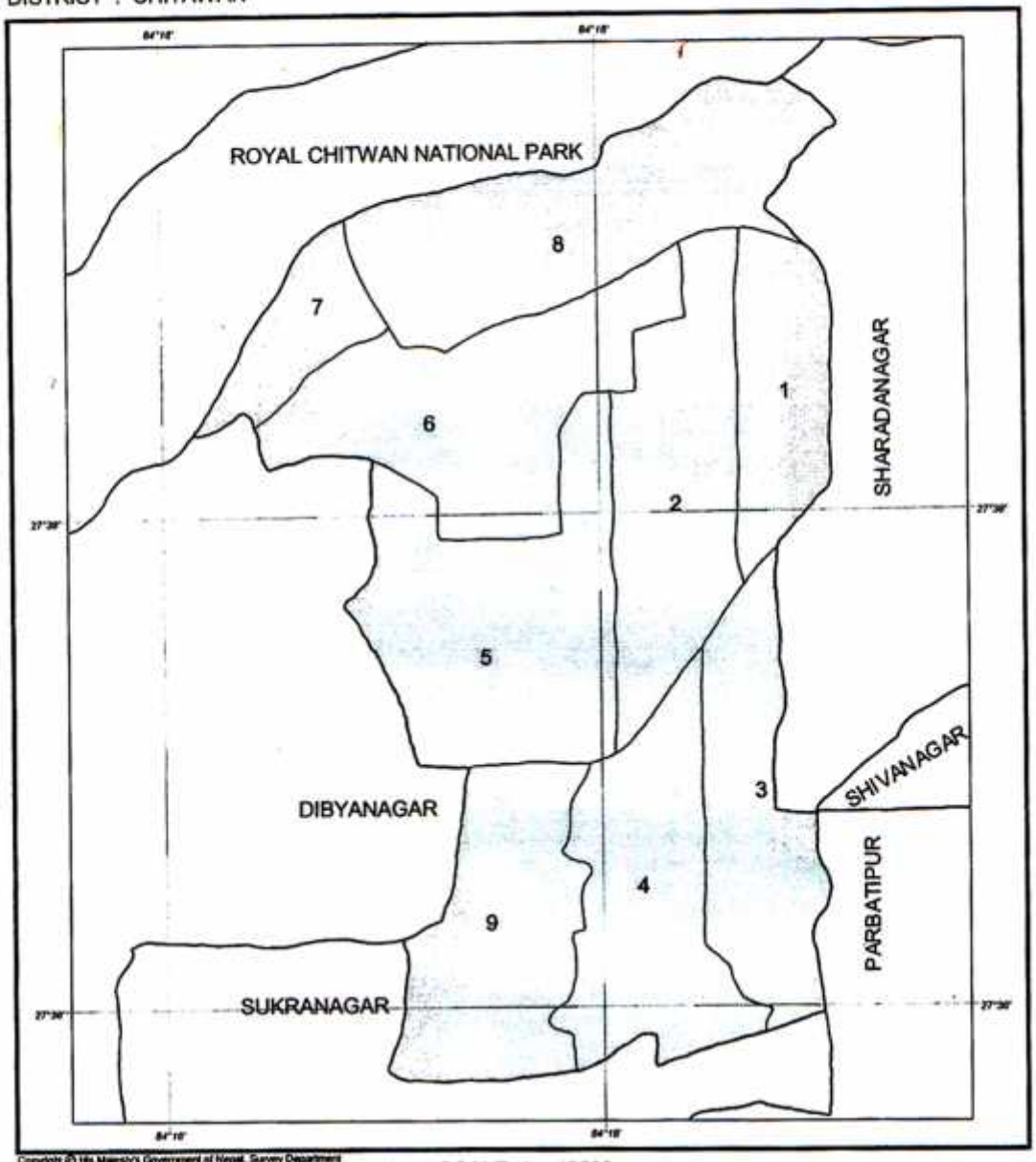
Map compiled from National Topographic Database at scales 1:25 000 and 1:50 000. Internal administrative boundaries are not demarcated on the ground. Map produced by the Survey Department, National Geographic Information Infrastructure Programme, (NGIIP). Kathmandu, 2003

KATHMANDU DISTRICT
VDC Location Map

GUNJANAGAR VDC

DISTRICT : CHITAWAN

VDC Code : 35015



SCALE 1 : 42500

850 0 850 1700 Meters

LEGEND

———	VDC Boundary
———	Ward Boundary
BUKHEL	VDC Name
5	Ward Number

GUNJANAGAR VDC

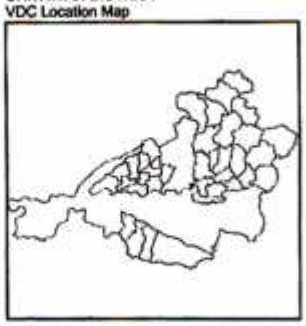
Area :22 Sq.Km.(Approx.)

HORIZONTAL DATUM

Spheroid Everest 1830
Projection MUTM
Origin Longitude 84° E., Latitude 0° N.
False coordinates of origin 500 000 m. Easting, 0 m. Northing
Scale Factor at Central Meridian 0.9999

Map compiled from National Topographic Database at scales 1:25 000 and 1:50 000. Internal administrative boundaries are not demarcated on the ground. Map produced by the Survey Department, National Geographic Information Infrastructure Programme, (NGIIP). Kathmandu, 2003

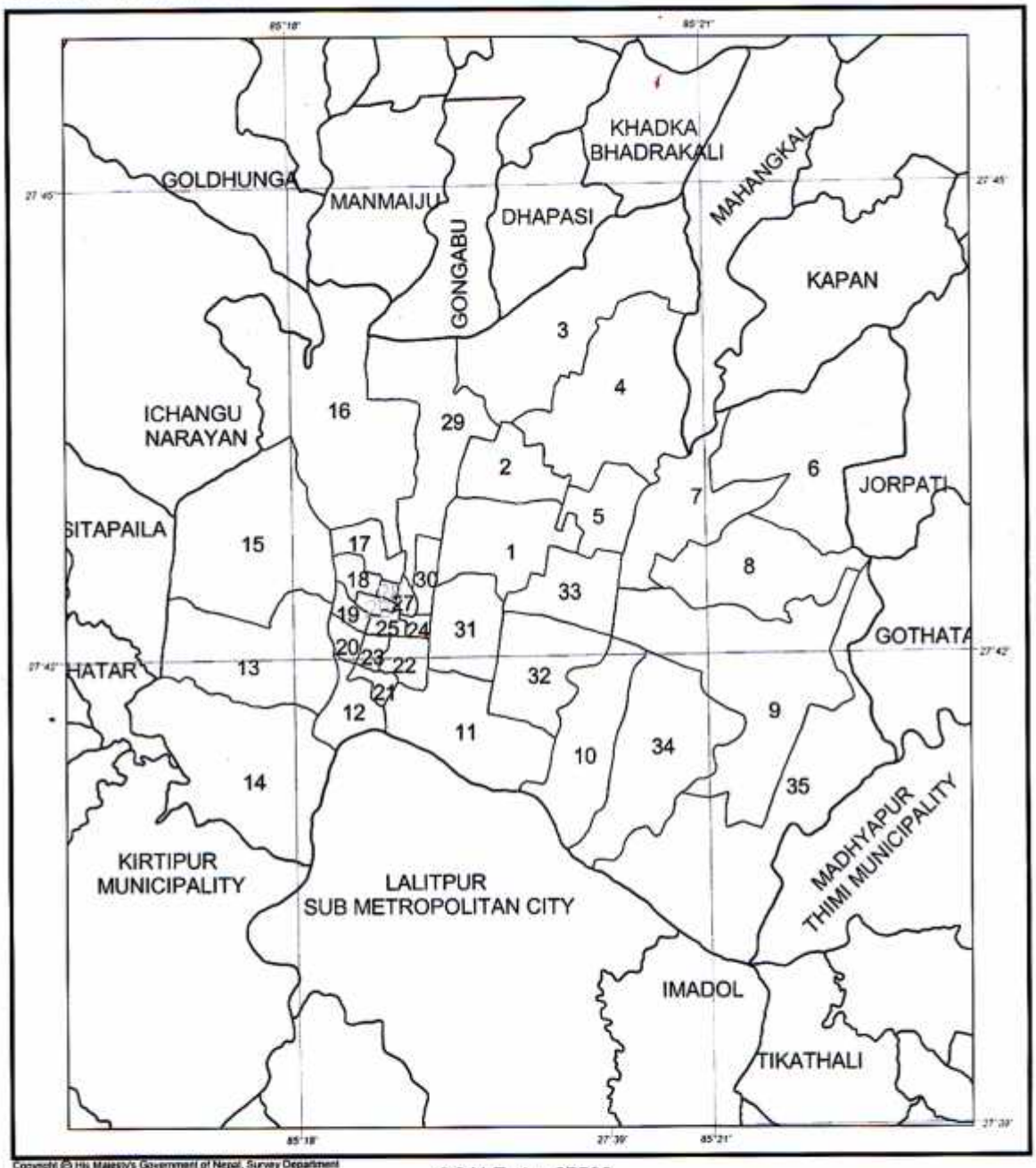
CHITAWAN DISTRICT
VDC Location Map



KATHMANDU METROPOLITAN CITY

DISTRICT : KATHMANDU

VDC Code : 27028



SCALE 1 : 67500

1350 0 1350 2700 Meters

LEGEND

———	VDC Boundary
———	Ward Boundary
BUKHEL	VDC Name
5	Ward Number

KATHMANDU METROPOLITAN CITY

Area :49 Sq.Km.(Approx.)

HORIZONTAL DATUM

Spheroid Everest 1830
Projection MUTM
Origin Longitude 84° E., Latitude 0° N.
False coordinates of origin 500 000 m. Easting, 0 m. Northing
Scale Factor at Central Meridian 0.9999

Map compiled from National Topographic Database at scales 1:25 000 and 1:50 000. Internal administrative boundaries are not demarcated on the ground. Map produced by the Survey Department, National Geographic Information Infrastructure Programme, (NGIIP). Kathmandu, 2003

KATHMANDU DISTRICT
VDC Location Map

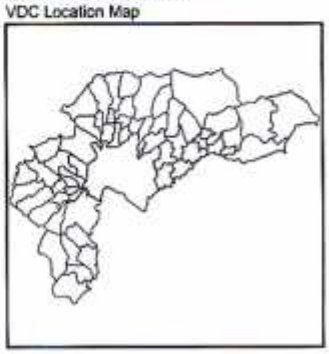


Plate 1: Interviewing students in Monastery A

Plate 2: Interviewing students in Monastery B

Plate 3: Interviewing students and collecting lice

Plate 4: Collecting lice from blankets

Plate 5: Collecting lice from cloth

Plate 6: Collecting ectoparasites from dog

Plate 7: Collecting lice from fowl

Plate 8: Collecting ectoparasites

Plate 9: Investigating cat for ectoparasites

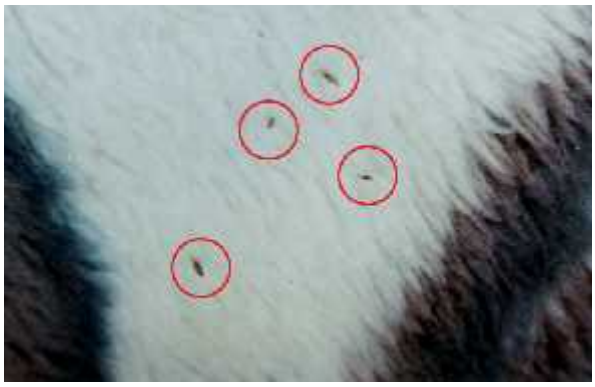


Plate 10: Lice on a blanket in Monastery A

Plate 11: Ticks in a dog

Plate 12: Taking photographs of lice infected children

Plate 13: Ticks in dog

Plate 14: Secondary infection after mite infestation

Plate 15: Investigating mites in a fowl

Plate 16: Investigating for mite infection in dog

Plate 17: Investing tick infestation in dog

Plate 18: Ticks in the crevices

RESULTS

The study was carried out in one VDC of Terai and one VDC and one ward of Kathmandu Metropolitan City of hilly area of Nepal. Gunjanagar VDC (Ward no.-2) of Chitwan District was from Terai Area. Kathmandu Metropolitan ward no. 4 (Dhumbarahi area) and Pharping (Dakshinkali VDC-9 and Talku Dudechaur VDC-5) Kathmandu Valley were from hilly area.

5.1 Collections of samples from different areas

From Gunjanagar VDC of Chitwan district, a total of 53 households were randomly selected for the study which included 27 cows, 49 dogs, 59 goats, 6 cats, 11 fowls and 62 humans.

Similarly, from Kathmandu district, two monasteries in Pharping (Monastery A in Talku Dudechaur VDC-5 and Monastery B in Dakshinkali VDC-9), with the total of 115 children of age 8 to 22 years were studied. From the Dhumbarahi area of Kathmandu district, a total of 12 households were observed. From this area, a total of 12 dogs and a total of 5 cats were observed for the ectoparasitic infestations. This is depicted in Table 1.

Table 1. List of different locations and hosts at Chitwan and Kathmandu, observed for ectoparasites

Location and Hosts	**Chitwan**	**Kathmandu**	**TOTAL**
Monasteries	**0**	**2**	**2**
Total households	**53**	**12**	**65**
Total cows	27	0	**27**
Total dogs	29	12	**41**
Total goats	59	0	**59**
Total buffaloes	44	0	**44**
Total cats	6	5	**11**
Total humans	62	115	**177**
Total fowl	11	0	**11**
Total samples	**238**	**132**	**370**

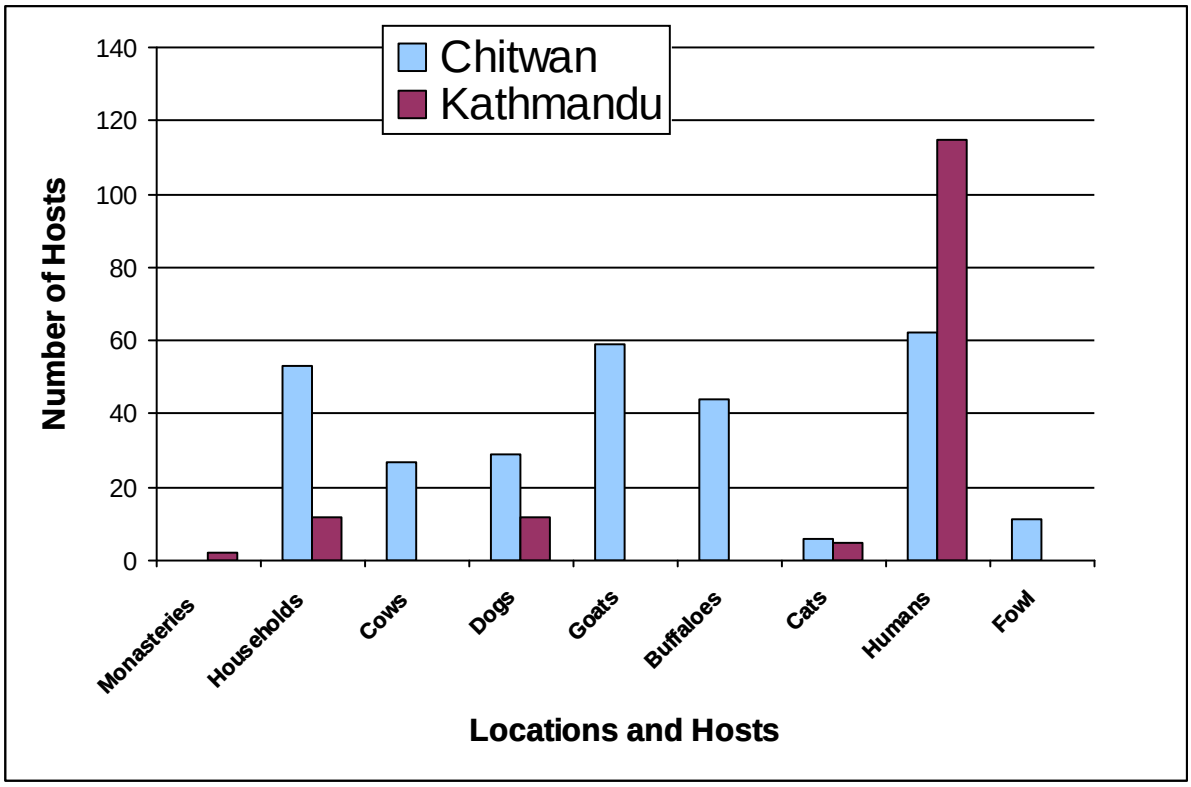


Figure 1: Graph of different locations and hosts at Chitwan and Kathmandu, observed for ectoparasites

5.2 Prevalence of ectoparasites in Gunjanagar VDC

From Gunjanagar VDC, Chitwan, out of total 238 hosts examined, 28 hosts were found to be infested by one or more ectoparasites and the prevalence was about 11.8%. The total numbers of particular ectoparasites infested hosts observed were as follows: 13 hosts with ticks, 10 hosts with lice, 1 host with mite, 1 host with bedbug and 3 hosts with biting flies (out of total 238 hosts). This is shown in Table 2.

The prevalence of ectoparasites was statistically significant with respect to different animal species and humans (χ^2=36.705, P<0.05, degree of freedom=20, 95% CI).

Table 2. Number of different hosts species infested by different parasites

Species	Total no. Examined	Hosts infested by one or more ectoparasites	Prevalence	Infested by				
				Ticks	Lice	Mites	Bedbugs	Biting flies
Cows	27	5	18.5 %	3	0	0	0	2
Dogs	29	5	17.2 %	3	2	0	0	0
Goats	59	6	10.2 %	5	0	0	0	1
Buffaloes	44	5	11.4 %	2	3	0	0	0
Cats	6	0	0.0%	0	0	0	0	0
Fowls	11	2	18.2 %	0	1	1	0	0
Humans	62	5	8.1 %	0	4	0	1	0
Total	**238**	**28**	**11.8 %**	**13**	**10**	**1**	**1**	**3**

5.3 Prevalence of different ectoparasites with respect to their frequency in the hosts:

The Table 3 shows the prevalence of different ectoparasites with respect to their frequency in their respective hosts. The maximum prevalence of + frequency was those of ticks (60.0%, 3 ticks out of 5 ectoparasites). The maximum prevalence of ++ frequency was those of lice (45.5%, 5 lice out of 11 ectoparasites). Similarly, the maximum prevalence of +++ was those of ticks (50.0%, 6 out of 12 ectoparasites).

Prevalence of different ectoparasites was not statistically significant with respect to their frequency in the hosts (χ^2= 5.58, P>0.05, degree of freedom = 8, 95% CI).

Table 3. Prevalence of different ectoparasites with respect to their frequency in the hosts:

Frequency[Ψ]	**Types of parasites**					**Total**
	Ticks	**Lice**	**Mites**	**Bedbugs**	**Biting flies**	
+	3 (60.0%)	2 (40.0%)	0 (0.0%)	0 (0.0%)	0(0.0%)	5
+ +	4(36.4%)	5 (45.5%)	0(0.0%)	1 (9.1%)	1 (9.1%)	11
+ + +	6(50.0%)	3 (25.0%)	1 (8.3%)	00(0.0%)	2 (17.7%)	12
Total	**13 (46.4%)**	**10(35.7%)**	**1 (3.6%)**	**1 (3.6%)**	**3 (10.7%)**	**28**

[Ψ] + means frequency of 1 to 10 parasites/host body
++ means frequency of parasites 11 to 25 parasites/ host body
+++ means frequency of parasites > 25 parasites /host body

5.4 Lice Infestation in the age and sex wise of humans

In the present study, the total prevalence of lice was 6.5% (4 out of the total 62 persons). The total prevalence of lice in males was 3.6% (1 out of 28 persons) and the total prevalence of lice in females was 8.8% (3 out of 34 persons). Out of 28 males, only one person of 30-39 year age groups was infested with lice with frequency more than 25 lice per body. He was found to be infested with pubic lice (*Phthirus pubis*). Similarly, out of 34 females, one child (0-10 years) with 1 to 10 lice was infested, 1 adolescent (11-19 years) with 11-25 lice was infested and one adult (≥40) infested with 11 to 25 lice. All these females were found to be infested with head lice (*Pediculus humanus capitis*). The maximum prevalence of lice was among the persons of age more or equal to 40 years. The prevalence of lice according to the age groups was: 4.5%, 6.7%, 0.0%, 5.9%, 16.7% in the age groups of 0 **–** 10, 11 – 19, 20 – 29, 30- 39 and ≥40 respectively. This is depicted in Table 4 and Figure 2.

Age-and sex-wise prevalence of lice infestation was not statistically significant in humans (χ^2 = 2.6, P> 0.05, degree of freedom = 4, 95% CI).

Age-and sex-wise prevalence of lice infestation was not statistically significant with frequency (χ^2 = 4.0, degree of freedom= 4, P>0.05, 95% CI).

Table 4. Frequency[β] and prevalence of lice infestation in the age and sex wise of humans.

Age groups (years)	Samples from Males		Samples from Females		Total samples	
	Total Numbers	Positive (n/N)	Total Numbers	Positive (n/N)	Total Numbers	Total Positive (n/N)
0 – 10	9	0 (0.0%)	13	1 (+) (7.7%)	22	**1 (4.5%)**
11 – 19	7	0 (0.0%)	8	1 (+ +) (12.5%)	15	**1 (6.7%)**
20 – 29	3	0 (0.0%)	2	0 (0.0%)	5	**0 (0.0%)**
30- 39	7	1(+ + +) (14.3%)	7	0(0.0%)	17	**1 (5.9%)**
≥40	2	0 (0.0%)	4	1 (++) (25.0%)	6	**1 (16.7%)**
Total	**28**	**1(3.6%)**	**34**	**3 (8.8%)**	**62**	**4 (6.5%)**

[β] + means frequency of 1 to 10 parasites/host body
++ means frequency of parasites 11 to 25 parasites/ host body
+++ means frequency of parasites > 25 parasites /host body

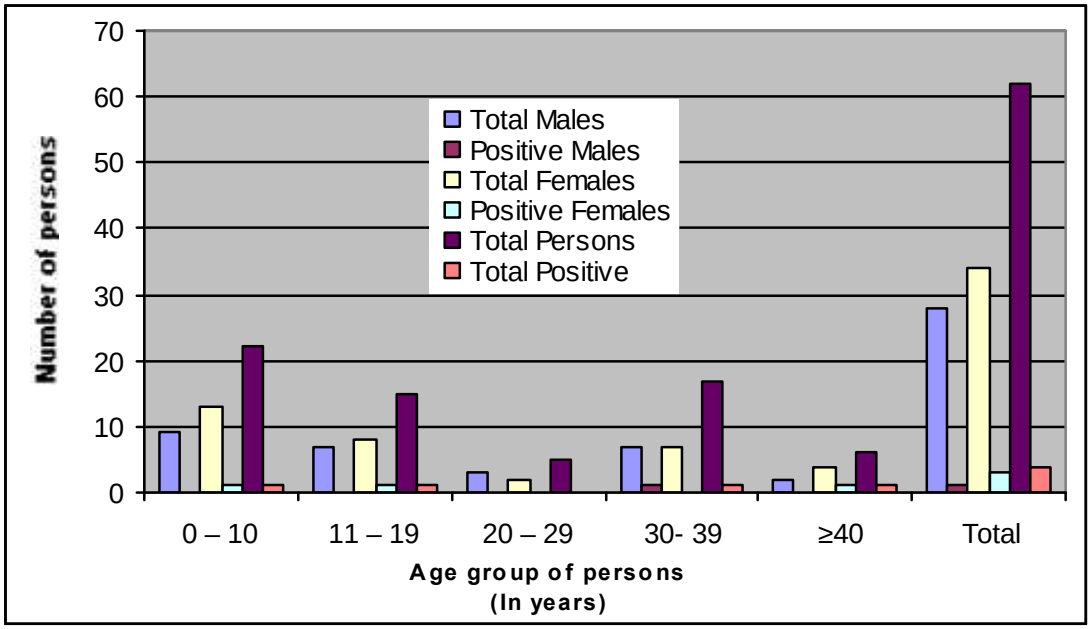


Figure 2: Graph of frequency and prevalence of lice infestation in the age and sex wise of humans

5.5 Host Sex-wise infestation of lice in different frequency

In the present study, the Table 5 reflects the maximum numbers of persons having lice infestation with ++ frequency or with 11 to 25 lice/ host body.

Frequency of ectoparasites was not statistically significant with sex of the patients (χ^2=3.33, P>0.05, 95%CI)

Table 5: Sex-wise infestation of lice in different frequency

Frequency[Ψ]	**Total persons**		
	Males	**Females**	**Total**
+	0	1	1
+ +	0	2	2
+ + +	1	0	1
Total	**1**	**3**	**4**

[Ψ] + means frequency of 1 to 10 parasites/host body
++ means frequency of parasites 11 to 25 parasites/ host body
+++ means frequency of parasites > 25 parasites /host body

5.6 Prevalence of ectoparasites in Kathmandu valley

In the present study, a total of 12 dogs, 5 cats and 115 humans were studied. Out of 12 dogs, the prevalence of ticks was 100.0% and that of flea was 100.0%. Cats were found to have no ectoparasites. Similarly, out of 115 humans, the prevalence of lice was 86.9%. Thus, out of total 132 hosts, the respective prevalence of ticks, lice, mites and fleas were as follows: 9.1%, 75.8%, 1.5% and 9.1%.

This has been depicted in Table 6.

Table 6. Prevalence of ectoparasites in Kathmandu valley

Species	**Total no. Examined**	**Hosts infested by one or more ectoparasites**	**Prevalence**	**Infested by**					
				Ticks	**Lice**	**Mites**	**Bedbugs**	**Biting flies**	**Flea**
Dogs	12	12	100.0%	12	0	0	0	0	12
Cats	5	0	0.0%	0	0	0	0	0	0
Humans	115	100	87.0%	0	100	2	0	0	0
Total	**132**	**112**	**84.8%**	**12**	**100**	**2**	**0**	**0**	**12**

5.7 Prevalence and frequency of ectoparasites on their hosts in Kathmandu

The Table 7 shows the prevalence and frequency of ectoparasites on their hosts in Kathmandu. Out of 126 parasitic infestation, 8 (6.3%) parasites showed frequency of 1 to 10 parasites/host body, 21(16.7%) parasites showed frequency of parasites 11 to 25 parasites/ host body and 97(77.0%) parasites showed frequency of parasites > 25 parasites /host body.

Prevalence of ectoparasites was not statistically significant with frequency (χ^2 = 7.2, degree of freedom= 10, P>0.05, 95% CI).

The table 7 shows the prevalence and frequency of ectoparasites in Kathmandu valley.

Table 7. Prevalence and frequency of ectoparasites in Kathmandu

Frequency[å] of the parasites	**Numbers of different parasites**						**Total**
	Ticks	**Lice**	**Mites**	**Bedbugs**	**Biting flies**	**Flea**	
+	0 (0.0%)	8 (100.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	**8 (6.3%)**
++	1 (4.8%)	20 (95.2%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	**21(16.7%)**
+++	11 (11.3%)	72(74.2%)	2 (2.1%)	0 (0.0%)	0 (0.0%)	12(12.4%)	**97(77.0%)**
Total	**12**	**100**	**2**	**0**	**0**	**12**	**126**

[♣] + means frequency of 1 to 10 parasites/host body
++ means frequency of parasites 11 to 25 parasites/ host body
+++ means frequency of parasites > 25 parasites /host body

5.8 Prevalence of lice in the different age groups of the persons of two monasteries of Kathmandu

In the present study, the students from the two monasteries were studied. Out of 71 students from Monastery A, 71 students were infested with body lice (*Pediculus humanus corporis*) and the prevalence was 100.0%. Similarly, out of 44 students from Monastery B, 29 students were found to be infested with body lice (*Pediculus humanus corporis*) and the prevalence was 65.9%. Thus, out of 115 total students, 100 students were found to be infested with lice (*Pediculus humanus corporis*) and the total prevalence was 87.0%.

The table 8 shows the age-wise prevalence of lice in the persons of the two monasteries of Kathmandu.

Age-wise prevalence of lice in the persons of the monastery A was statistically significant (χ^2=11.99, P<0.05, degree of freedom=2).

Age-wise prevalence of lice in the persons of the monastery B was statistically significant (χ^2 = 7.09, P<0.05, degree of freedom = 2).

Age-wise prevalence of lice in the persons of the monastery A and monastery B was statistically significant (χ^2=13.05, P<0.05, degree of freedom=2).

Table 8: Prevalence of lice in the different age groups of the persons of two monasteries of Kathmandu

Age-groups	Lice in Monastery A		Lice in Monastery B		Total	
	Numbers	Positive	Numbers	Positive	Numbers	Positive
8 – 12	10	10(100.0%)	17	12(70.6%)	27	22(81.5%)
13 – 17	32	32(100.0%)	21	14(66.7%)	53	46(86.8%)
18 – 22	29	29(100.0%)	6	3(50.0%)	35	32(91.4%)
Total	71	71(100.0%)	44	29(65.9%)	115	100(87.0%)

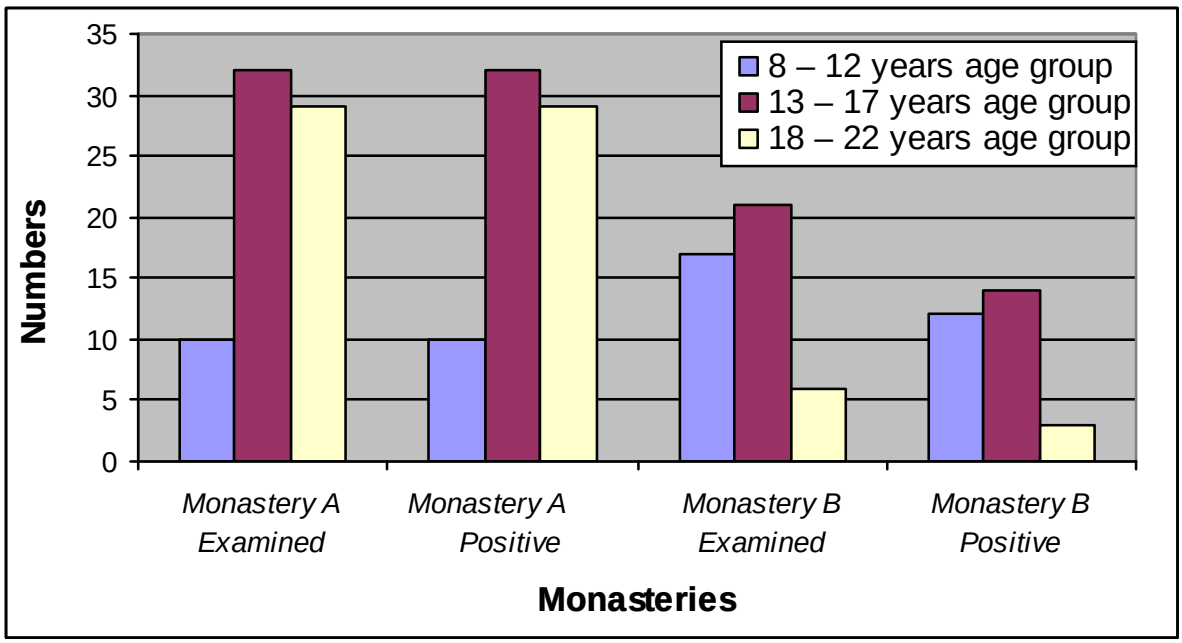


Figure 3: Graph of Prevalence of lice in the different age groups of the persons of two monasteries of Kathmandu

5.9 Prevalence and frequency of lice in the persons of monasteries in Kathmandu

In the present study, students from Monastery A showed the highest lice infestation rate (76.4%) in the frequency of parasites 11 to 25 parasites per host body. Similarly, students from Monastery B showed the highest lice infestation rate (50.0%) in the frequency of parasites more than 25 parasites per host body.

Table 9 shows the prevalence and frequency of lice in the persons in Kathmandu.

Prevalence of lice in the persons of the Monastery A was statistically significant with frequency (χ^2=25.47, P<0.05, degree of freedom=2).

Prevalence of lice in the persons of the Monastery B was statistically significant with frequency (χ^2=11.61, P<0.05, degree of freedom=2).

Prevalence of lice in the persons of the Monastery A and Monastery B was statistically significant with frequency (χ^2=8.0, P<0.05, degree of freedom=2).

Table 9. Prevalence and frequency of lice in the persons in Kathmandu

Frequency[~] of the parasites	**Numbers and prevalence of persons (n/N)**		**Total**	**Percentage %**
	Monastery A	**Monastery B**		
+	6(75.0%)	2(25.0%)	**8**	**8.0%**
++	10(50.0%)	10(50.0%)	**20**	**20.0%**
+++	55(76.4%)	17(23.6%)	**72**	**72.0%**
Total	**71**	**29**	**100**	**100.0%**

[α] + means frequency of 1 to 10 parasites/host body
++ means frequency of parasites 11 to 25 parasites/ host body
+++ means frequency of parasites > 25 parasites /host body

5.10 Observed symptoms and pathogenicity

In the present study, the people and health workers were asked about any symptoms and pathogenicity caused by ectoparasites that they have observed in the body of animals and of themselves.

The table reflects the symptoms and pathogenicity caused by different ectoparasites in different hosts as reported by households' heads, veterinary personnel of different study areas.

Table 10: Observed symptoms and pathogenicity due to ectoparasite infestation

Symptoms and pathogenicity	**Causative Parasites**	**Hosts**
Itching	Lice, ticks, fleas, bedbugs, biting flies	Dogs, cats, buffaloes, cows, goats, humans
Swelling	Ticks, bedbugs	Dogs, cats, buffaloes, cows, goats, humans
Pain	Mites	Humans
Sores	Ticks, mites	Dogs, cows, goats, humans
Sleeplessness, restlessness, lethargy	Lice, bedbugs	Humans
Psychodisturbances	Lice, bedbugs	Humans
Scabies	Mites	Humans

Plate 19: Scabies with secondary infection

Plate 20: Scabies on the finger web

Plate 21: Scabies on the buttocks

Plate 22: Scabies on finger with bacterial infection

Plate 23: An itching dog

5.11 Treatment and preventive measures of ectoparasites and their infestations

The table shows the optional measures of treatment of ectoparasites and their infestation (sores and skin damage) in the body of animals and humans themselves. This table reflects the methods applied by the people in the study areas.

Table 11: Treatment and preventive measures of ectoparasites and their infestations

Applied control methods	Applied against	Hosts
Chemicals (DDT, BHC, and others from Veterinary medicals)	Ticks, lice, mite, biting flies, bedbugs, fleas	Cows, buffalo, fowl, dogs, cats, goats
Herbs (Neem, Titepati, Kuro)	Ticks, lice, mite, bedbugs, fleas,	Cows, buffalo, dogs, cats, goats, humans
Smokes (green leaves)	Biting flies	Cows, buffaloes, goats
Bathing with hot water	Lice	Humans
Bathing with soap, shampoo	Lice	Humans, dogs
Mechanical (Killing with hands)	Ticks, lice, mite, bedbugs,	Cows, buffalo, dogs, cats, goats, humans
Biological (allowed to live insectivorous birds in body of hosts)	Ticks, lice	Cows, buffaloes, goats
Hair cutting	Lice, ticks, fleas	Humans, dogs
Basking and drying of clothes in sun	Lice, ticks, bedbugs	Humans, dogs
Mechanical (grooming)	Lice	Humans

Plate 24: Women picking lice

Plate 25: Cattle egrets (*Ardea ibis*) feeding on ectoparasites of cow

Plate 26:Neem (*Azadirachta indica*)

Plate 27: Titepati (*Artemisia vulgaris*)

Plate 28: Kuro (*Bidens biternata*)

Plate 29: Soap used for bathing ectoparasites infested dog

Plate 30:Acaricide used against mange and ectoparasites in dogs

5.12 Collected ectoparasites and infested hosts

In present study, different ectoparasitic species were collected from different hosts. They were identified with the help of microscopic study, taxonomic literatures, veterinary and medical doctors and entomologists.

This is shown in Table 12.

Table 12: Recorded ectoparasites and infested hosts

Ectoparasites		**Hosts**
Common Name	**Species**	
1. Lice	a. *Pediculus humanus capitis*	Humans
	b. *Pediculus humanus corporis*	Humans
	c. *Phthirus pubis*	Humans
	d. *Menopon gallinae*	Fowl
	e. Unidentified	Cow, buffalo
	f. Unidentified	Dogs
2. Mite	a. *Sarcoptes scabiei*	Humans
	b. *Dermanyssus gallinae*	Fowl
3. Bedbug	a. *Cimex lectularius*	Humans
4. Ticks	a. Soft ticks (Unidentified)	Dogs, Cows, Buffalos
	b. Hard ticks (Unidentified)	Dogs, Cows, Buffalos
5. Fleas	a. *Ctenocephalides canis*	Dogs
6. Biting flies	a. Unidentified	Cows

5.13 Frequency of lice infestation in humans in different locations

In the present study, the frequencies of recorded species of lice in humans were as shown in the table below.

Table 13: Frequency of different lice species infestation in humans in different locations

Lice	Frequency~					
	Chitwan			Kathmandu		
	+	+ +	+ + +	+	+ +	+ + +
Pediculus humanus capitis	1	2	0	0	0	0
Pediculus humanus corporis	0	0	0	8	20	72
Phthirus pubis	0	0	1	0	0	0
Total	1	2	1	8	20	72

[α] + means frequency of 1 to 10 parasites/host body
++ means frequency of parasites 11 to 25 parasites/ host body
+++ means frequency of parasites > 25 parasites /host body

5.14 Comparative situation of ectoparasitic infestation at Chitwan and Kathmandu

The present study was carried out in Gunjanagar VDC, Chitwan (Terai region) and Pharping (Dakshinkali VDC and Talku Dudechaur VDC) and Dhumbarahi area, Kathmandu (Hilly region). The table below shows comparative situation of ectoparasitic infestation in respective Relative humidity (RH), Rainfall and Average Temperature in these regions.

Table 14: Comparative situation of ectoparasitic infestation in two Gunjanagar and Kathmandu, Nepal

Hosts species	Chitwan			Kathmandu		
	RH = 83.2%, Rainfall = 548.9 mm, Average Temperature = 29.8^0 C			RH = 84.8 %, Rainfall = 347.0 mm Average Temperature = 24.8^0 C		
	Samples	Infected samples	% infested	Samples	Infected samples	% infested
Cows	27	5	18.5 %	0	0	0.0%
Dogs	29	5	17.2 %	12	12	100.0%
Goats	59	6	10.2 %	0	0	0.0%
Buffaloes	44	5	11.4 %	0	0	0.0%
Cats	6	0	0.0%	5	0	0.0%
Humans	62	5	8.1 %	115	100	87.7%
Fowl	11	2	18.2 %	0	0	0.0%
Total samples	**238**	**28**	**11.8 %**	**132**	**112**	**84.8%**

Since ectoparasitic infestations in only three types of hosts (dogs, cats and humans) have been studied in Kathmandu a complete comparison could not be done.

DISCUSSION AND CONCLUSION

Ectoparasitic infestation is the major factor that determines the human and veterinary medicine. It is worldwide distribution and most of the symptoms and pathogenicity are symptomatic in humans. The symptoms caused by ectoparasites in animals are asymptomatic, but the pathogenicity and effects are symptomatic. Therefore, it includes the great loss of economy and life of animals and humans in the epidemic and endemic parts of the world (Chandler *et al*., 1960; Cheng TC, 1999; WHO, 1999).

In the present study, the highest prevalence was that of ticks (5.5%) and the lowest was that of mites and bedbugs (each 0.4%) in Gunjanagar. This is due to the fact that the study was conducted in the rainy season when humidity and temperature was high which might be more favorable for the reproduction of ticks (Moyer *et al.,* 2002). It shows that ticks are the common ectoparasitic species in this area. Cattle such as cows, buffaloes and goats are the important hosts for ticks (Razmi *et al.,* 2003; Brouqui *et al.,* 2006).

The prevalence of different hosts infested with different ectoparasites in Gunjanagar was as follows: 11.1% cows infested with ticks, 10.3% dogs infested with ticks, 6.5% humans infested with lice, 9.0% fowls infested with lice, 9.0% fowls infested with mites, 8.5% goats infested with ticks, 7.4% cows infested with biting flies, 6.9% dogs infested with lice, 6.8% buffaloes infested with lice, 4.5% buffaloes infested with ticks, 1.3% humans infested with bedbugs, 1.7% goats infested with biting flies. This shows that ectoparasites are highly prevalent among domesticated animals in this region.

Similarly, the prevalence of ectoparasites was statistically significant with frequency of these organisms in the study. About 42.9% (12 out of 28) parasites were present in the frequency of more than 25 parasites /host body. It shows the high parasitic pressures made while they infect their hosts. It proves that they are great nuisance to the animals and humans where they infect.

The total prevalence of lice in females (8.8%) than in the males (3.6%) in Gunjanagar shows that lice are more susceptible to the long and thick hair that has not been washed for many days. Besides, the females of the study area do not know the structure of eggs in roots of hairs and they rarely use the hair comb. The highest prevalence of lice of the age 40 or more shows the loss of

usual concentration of their mind in maintaining their health. Several studies show similar results for age-wise lice infection (WHO, 1999).

In Kathmandu valley, the prevalence of ticks 100% and that of flea 100% in dogs show that these parasites are prevalent in dogs. Similarly, the prevalence of lice 86.9% and that of mites 1.7% in humans show that lice and mites are important public health problem in this region. About 77.0 % hosts (97 out of 126) showed the highest prevalence of parasites in the range of more than 25 parasites per host body.

In the present study, in monastery A, the prevalence of lice was 100%. This is because of the children and other persons live very close to each other, they rarely bathe by using bathing soap, their every living pattern show that they sleep together. The persons living in Monastery B showed the 65.9% and this might be because their internal environmental condition was good than the persons living in Monastery A. The Buddhist Monks were found to contain only the body lice, *Pediculus humanus corporis*. Head lice were not found in there persons because they had cut the hairs completely. Head lice infestations may be transmitted by shared use of combs (Krupp *et al.,* 1974) and they need not use combs in this study. Pubic lice were not detected in the persons in the monasteries. Some of the students didn't show their pubic region and the students who showed us their pubic region were of lower ages and didn't have pubic hair for the habitat of pubic lice. Besides, Pediculosis pubis is transmitted by sexual contact (Crissey, 1984; Kalter, 1987) and these people replied that they haven't had any sexual intercourse.

The maximum prevalence of these lice (91.4%, 32 out of 35 persons) was in the age groups of 18-22 years. This is because of large surface area of the body of these persons. This species depend on the body part and is easily transmitted among different persons who share same blanket and other bedclothes. It comes on the skin only to feed and must be looked for in the seams of the underclothing. This explains the cause of detection of lice in blankets (Brouqui *et al.,* 2006). The occurrence of highest percentage 72.0% in the range of more than 25 lice per body shows the prevalent lice infestation in the studied Monasteries of Kathmandu Valley.

Bedbugs are the important ectoparasites that cause bullous reaction with fever and general malaise. They are more common in people of slum areas with rare hygienic practice such as infrequent washing of clothes and bathing (Leibold *et al.,* 2003; Hwang *et al.,* 2005; Thomas *et al.,* 2004; Poorten *et al.,* 2004; Walter; 1978; Brouqui *et al.,* 2006). This explains the detection of

bedbugs in the persons of slum areas of Gunjanagar, Chitwan. The absence of bedbugs in Kathmadu area might be due to lack of enough diurnal studies. Bedbugs are nocturnal and studies should be conducted at nighttime to detect them. Besides, the bugs locate the host by detecting warmth and CO_2 (Valenzuela *et al.,* 1996).

In the present study, out of 12 dogs, all (100%) dogs were found to be infested with fleas (*Ctenocophalides canis*) in Kathmandu area. They breed close to the resting and sleeping places of the host, in dust, dirt, rubbish, cracks in floors or walls, carpets, animal's burrows and bird's nest. In spite of the presence of these favorable means in Gunjanagar, fleas were not detected because either they were in developing stage of eggs or larva or in the resting stage of cocoons. They may survive in the cocoons up to a year (WHO, 1999).

In the present study, itching was the main symptom observed frequently in the hosts (dogs, cats, buffaloes, cows, goats, humans) caused by different ectoparasites (lice, ticks, fleas, bedbugs, biting flies). These animals except humans scratch their infected itching parts with their legs and teeth. This can be observed in the photographs too.

Sleeplessness, restlessness, lethargy and psycho-disturbances are the main symptoms caused by lice infestation in humans. Itching may be very intense in body louse infestations and scratching may result in deep excoriations over the affected area. Head lice can be found on the scalp or may be manifested as small nits resembling pussy-willow buds on the scalp hairs close to the skin. They are easiest to see above the ears and at the nape of neck (Krupp *et al.,* 1974). These points explain how normal uneducated women are able to identify the head lice. Due to the lice infestation, people, especially women, do not want to show and tell medical personnel their problems openly. These individuals are always in tension of their lice. This leads to the increased problems of lice infestation. They sometimes gather in a place and practice the mechanical method such as combing, grooming and direct killing of lice by hands in groups.

Scabies is one of the deadly contagious problems in the children living in the groups, nurseries transmitted from clothing and bed linen (CPS, 2001). In the present study, the persons in the monastery were found to have scabies. This is because these people live in groups and the mites are susceptible to the persons who are not careful to their external health (Krupp *et al.,*., 1974). Scabies is a common dermatitis caused by infestation with Sarcoptes scabiei, and obligate parasite of human skin (Brouqui *et al.,* 2006) in situations of overcrowding such as less

developed countries and communities. It is characterized by nocturnal itching and pruritic vesicles and pustules in “runs” or “galleries” especially on the sides of the fingers and the heels of the palms and pruritic papules on the scrotum in males and over the buttocks of the patients (Krupp *et al.*, 1974; Birk, 1999). Similar symptoms have been observed in the scabies patients in the present study.

In the present study, owners of domesticated animals and ectoparasites infested persons showed high awareness to their treatment methods. But these methods mostly based on the traditional methods (Fenemore et al., 1992 and WHO, 1999). Few people used chemicals such as DDT, BHC, Permethrin etc to control ticks, lice, mite, biting flies, bedbugs, fleas in cows, buffalo, fowl, dogs, cats, goats. Similarly, application of the sauce (sap or chlorophyll contents) prepared from different herbs such as Neem (*Azadirachta indica*), Titepati (*Artemisia vulgaris*), Kuro (*Bidens biternata*) in the sores and adult and egg stage of the ectoparasites were found in the Gunjanagar VDC. It is the usual method of throwing out of the ectoparasites from the body.

Similarly, application of smokes of green leaves of these plants during milking in the evening and night near the cowshed was the most important method for preventing the biting flies’ infestation. The presence of biting flies in Gunjanagar might be due to the specific host species such as cows, buffalos, goat domesticating practice. This is one of the nuisance ectoparasites active at evening and nighttime and disturbs the cows, buffalos very much. It shows the photoperiodicity and is one of the best methods of control in the shed areas (Fenemore et al., 1992 and WHO, 1999).

The mechanical and biological methods applied by the people of Gunjanagar shows that the people mostly follow the traditional methods of prevention of ectoparasites in the study areas. People take the animals in the open and bright fields where insectivorous birds such as crow come to live over the body of animals and feed on ticks, lice. This is the chief method used by the people (Fenemore et al., 1992 and WHO, 1999). Similarly, the mechanical methods such as killing with hands and hair cutting and grooming are the widely used preventive measures in this area. This method may represent the method used in whole of Nepalese people for the prevention of lice, ticks, fleas in dogs and humans.

Basking and drying of cloths are also good methods of lice and bedbugs prevention (Fenemore et al., 1992 and WHO, 1999). This method interfere the metabolism of parasites by the direct

effects of high light intensities and temperatures. Similarly, bathing with lukewarm water alone, lukewarm water and soap and water and some herbs such as Neem (*Azadirachta indica*), Titepati (*Artemisia vulgaris*), and Kuro (*Bidens biternata*) are also useful methods accepted by the lice infested persons in the study areas. Neem is a good herb used as repellent and against lice infestation (Förster *et al.*, 2000).

In the present study, the total infested percentage in Chitwan (Terai region) was 11.8% and that in Kathmandu (Hilly region) was 84.8%. It seems that the infested percentage was greater in hilly region than in the terai region. It is due to the fact that the number of studied human hosts were more in Kathmandu than in Chitwan and the human hosts from Kathmandu were only from crowed areas, the two monasteries and most of the hosts were infested. It is probably because the hosts were of aged below 22 years and because they spend most of their times playing, sitting, sleeping together and were careless of their personal hygiene. On the other hand, studied human hosts in Chitwan were less and among them, the numbers of infested hosts were less. It is because they were mostly of aged above 20 years who were able to take care of their personal hygiene and were of different houses. In addition, numbers of infested animals were less in Chitwan because the farmers had already treated the hosts with juices and smoke of different types of plants and insecticides against the ectoparasites.

At the time of study, the relative humidity of both the areas was similar that is 83.2% in Chitwan and that of 84.8% in Kathmandu but the infested percentage were different. There is no doubt that relative humidity is the key factor for the development of ectoparasites but the factor may work differently for different species of ectoparasites during their life cycle. Besides, the infestation cannot be determined only based on relative humidity, amount of rainfall and temperature but it depends on the other factors with respect to time.

Plate 31: Conducting awareness program in Monastery B

Plate 32: Study school in Monastery B where awareness program was conducted

RECOMMENDATIONS

- Quick treatment of scabies and sores by distributing of drugs, anti-inflammatory creams.
- Distribution of free insecticidal dusts, shampoos and lotions for the animals in the agricultural areas.
- Personal sanitation especially in the genital organs to check the pubic lice infestation,.
- Monastery should frequently ask medical doctors, physicians and sexologists to visit and to find out the lice and mite infestation and should encourage the children and adolescent to use impregnated mosquito nets, to cut the pubic hair and to break their life cycle by utilization of creams, cutting pubic hairs and bathing with anti-lice soap.
- Encouragement of the use of repellents such as smokes of leaves of Neem and Titepati around the home and sheds especially during nighttime.
- Distribution of vitamin B_{12} and other nutrients to the persons in monasteries in the lice infested areas.
- Medical, veterinary and natural scientific (biological and chemical) researchers should encourage on the study of effects of ectoparasites in humans and animals.

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Annex-I

An introduction to ectoparasites

Members of phylum Arthropoda represent the largest number of known animals. There are at least 760,000 species of arthropods in existence. Most arthropods are free living and are found in an array of aquatic and terrestrial habitats. However, some members of the subphylum Crustacea (i.e., Copepoda, Isopoda, Cirripedia, Amphipoda) and classes Arachnida and Insecta are parasitic. In addition, the larvae of most species of class Pycnogonida are parasitic.

Although many of these arthropod parasites are of little medical and economic importance, they are of considerable interest to biologists, specifically parasitologists, from the biologic standpoint. On the other hand, some of these parasitic arthropods, such as certain ticks, mites and insects, are of considerable medical and veterinary importance because they cause direct injury to their hosts. Besides they serve as vectors for various pathogens, including numerous microorganisms and viruses.

FLEAS

Fleas are small, wingless bloodsucking insects (order Siphonaptera) with a characteristic jumping movement. They feed mainly on mammals but also on birds. Of the 3000 species, only a dozen commonly attack humans. The most important species are the rat flea, the human flea and the cat flea. Their bites can cause irritation, serious discomfort and loss of blood. The rat flea is important as a vector of bubonic plague and flea-borne typhus. Cat fleas incidentally transmit tapeworms. The sand flea or jigger burrows into the skin of humans and may cause infections. Fleas that bite people occur in most parts of the world.

The life cycle of fleas has four stages: egg, larva, pupa and adult. Adult fleas are 1-4 mm long and have a flat narrow body. They are wingless with well-developed legs adapted for jumping. They vary in color from light to dark brown. The larvae are 4-10 mm long and white; they have no legs but are very mobile. The cocoon (pupal stage) is well camouflaged because it is sticky and soon becomes covered with dust, sand and other fine particles.

Both female and male fleas take blood meals. Fleas breed close to the resting and sleeping places of the host, in dust, dirt, rubbish, cracks in floors or walls, carpets, animal burrows and birds' nests. High humidity is required for development. The larvae feed on organic matter such as the faeces of the host, small dead insects and undigested blood expelled by adult fleas. At the end of the larval period, the larva spins a loose whitish cocoon within which it develops into a pupa.

The adult fleas are fully developed within 1-2 weeks but only emerge from the cocoons after receiving a stimulus, such as the vibrations caused by movement of the host. In vacant houses, they may survive in the cocoons for up to a year. People moving into a vacant house can cause many fleas to emerge simultaneously from the cocoons and attack people or animals in large numbers. Under optimal conditions, the development from egg to adult takes 2-3 weeks.

Fleas avoid light and are mostly found among the hairs or feathers of animals or in beds and in people's clothing. If possible, a flea will feed several times during the day or night. Heavy infestations with fleas are recognized by marks on clothing and bedding of undigested blood ejected by the fleas. Most flea species feed on one or two host species, but in the absence of their normal host they feed on humans or other animals. Adult fleas can survive several months without food. Fleas move around by jumping; some species can jump as high as 30cm.

LICE

Lice are small bloodsucking insects that live on the skin of mammals and birds. Three species of lice have adapted themselves to humans: the head louse (*Pediculus humanus capitis*), the body louse *(Pediculus humanus corporis*) and the crab or pubic louse (*Phthirus pubis*). They are cosmopolitan. Lice infestations can cause severe irritation and itching. In addition, the body louse can transmit typhus fever, relapsing fever and trench fever. Outbreaks of louse-borne typhus fever, sometimes claiming thousands of lives, have occurred in colder areas where people live in poor, crowded conditions, especially in some highland areas of Africa, Asia and Latin America.

Body lice *(Pediculus humanus corporis)*

Body lice are most commonly found in clothing, especially where it is in direct contact with the body, as in underwear, the crotch or fork of trousers, armpits, waistline, collar and shoulders. They attach themselves to body hair only when feeding. The eggs are attached to thin threads of clothing. Body lice are most common in colder areas where people do not frequently wash or change clothes.

Body lice are spread by close contact between people. They are most commonly found, therefore, on people living in overcrowded, unhygienic conditions, as in poorly maintained jails, refugee camps and in trenches during war. They also spread by direct contact between people in crowded transport vehicles and markets. Body louse infestations may also be acquired through sharing bedding, towels and clothing or by sitting on infested seats, chair covers or cushions.

Head lice *(Pediculus humanus capitis)*

The head louse is the most common louse species in humans. It lives only in the hair on the head and is most often found on children. The eggs (or nits) are finely glued to the base of hairs of the head, especially on the back of the head and behind the ears. Because the hairs grow about a centimeter a month it is possible to estimate the duration of an infestation by taking the distance between the scalp and the furthest egg on a hair. Infested persons usually harbor 10-20 adult head lice. The females lay 6-8 eggs per day. Head lice are spread by close contact between people, such as children at play or sleeping in the same bed. Head lice are also spread by the use of other people's combs that carry hairs with eggs or lice attached.

Crab or pubic lice *(Phthirus pubis)*

Crab lice, also called pubic lice, are grayish-white and crab-like in appearance. They are most often found on hair in the pubic region, and eggs are laid at the base of the pubic hair. Heavy infestations may spread to other hairy areas of the body, such as the chest, thighs, armpits, eyelashes, eyebrows and beard. Crab lice are mainly spread through sexual or other close personal contact, and are most common in young, sexually active adults.

MITES

There are usually four stages in the development of mites and ticks: the egg, the larva, the nymph, and the adult. The eggs are usually laid under the surface of the soil or in crevices or, in some parasites, under the skin of the host, but some species are ovoviviparous. After a varying period of incubation the larva hatches in the form of a six-legged creature, often quite unlike the parent. After a single good feed, or in many species without one, the larva molts and becomes an eight-legged nymph. In most parasitic Acarina except ticks this protonymph, after a blood meal, molts and becomes a deutonymph, which may or may not feed again before becoming an adult. No molting occurs after the adult stage is attained. There may be additional intermediate stages, and some mites have specialized devices for dispersal; the larvae may parasitize hosts that transport them, e.g., trombiculids on vertebrates and trombidiids, and some water mites on insects, or they may merely hitchhike on insects, e.g., the grain mites.

Some mites have become adapted to live as internal parasites in the lungs and air sacs of snakes, birds, and mammals, and there are records of mites, which are not normally parasitic at all living and multiplying in the human urinary bladder; but all the species normally infesting man are either external or subcutaneous in their operations.

Scabies mite

The scabies mite, *Sarcoptes scabiei*, causes an itching condition of the skin known as scabies. Infestations with scabies are common worldwide. The mites are between 0.2 and 0.4 mm long and virtually invisible to the naked eye. Practically the whole life cycle is spent on and in the skin of humans. In order to feed and lay eggs, fertilized females burrow winding tunnels in the surface of the skin. The tunnels are extended by 1-5 mm a day and can be seen on the skin as very thin twisting lines a few millimeters to several centimeters long. Development from egg to adult may take as little as two weeks. The females may live on people for 1-2 months. Away from the host they survive for only a few days.

Scabies mites are commonly found where the skin is thin and wrinkled, for instance between the fingers, on the sides of the feet and hands, the bends of the knee and elbow, the penis, the breasts and the shoulder blades. In young children, they may also be found on the face and other areas.

TICKS

Ticks have a life cycle that includes a six-legged larval stage and one or more eight legged nymphal stages. The immature stages resemble the adults and each of them needs a blood-meal before it can proceed to the next stage. Adult ticks live for several years, and in the absence of a blood-meal can survive several years of starvation. Both sexes feed on blood, the males less frequently than the females, and both can be vectors of disease. Disease organisms are not only passed from one host to another while blood is being taken: female ticks can also pass on certain disease agents to their offspring.

Soft ticks

The adults are flat and oval in outline and have tough, leathery, wrinkled bodies. The mouthparts are situated underneath the body and are not visible from above. The eggs are laid in the places where the adults rest, such as cracks and crevices in the walls and floors of houses and in furniture. The larva, the five nymphal stages and the adults all actively search for hosts from which to take blood-meals. After feeding, which lasts about 30 minutes, they drop to the ground. Most species can survive for more than a year between blood- meals, and some for more than 10 years.

The soft ticks live apart from their hosts and are most common in the nests and resting places of the animals on which they feed. Some species, such as the chicken tick and the pigeon tick (*Argas species*) may feed on humans when the preferred hosts are not available.

Species that commonly feed on humans are found around villages and inside houses. Their habits are comparable to those of bedbugs: ticks often emerge from hiding places at night to suck the blood of humans and animals. Some species are common on travel routes, in rest houses and camping sites, and in caves and crevices.

Hard ticks

The adult hard ticks are flat and oval in shape and between 3 and 23 mm long, depending on the species. The mouthparts are visible at the front of the body, differentiating them from the soft ticks. In contrast to the soft ticks they have a shield-like plate or scutum behind the head on the back of the body, and there is only one nymphal stage.

The eggs are deposited on the ground in large numbers. The larvae are very small, between 0.5 and 1.5 mm in length; they climb up vegetation, wait until a suitable host passes by, then climb on to it and attach themselves at a preferred feeding site, such as in the ears or on the eyelids.

After several days, when fully engorged, they drop to the ground, seek shelter and moult to the nymphal stage, which in turn seeks a blood meal, engorges, detaches itself and moults into an adult. The adult females climb up vegetation to wait for a suitable host, remaining on it for one to four weeks, then drop to the ground and seek shelter in cool places under stones and leaf litter, where they lay their eggs.

Most species of hard tick feed on three different hosts: one each for the larva, nymph and adult. However, some species feed on only one or two hosts. Because they remain attached to their hosts for several days, the hard ticks

may be carried over large distances. The combination of feeding on different hosts and traveling considerable distances partly explains their importance as disease vectors.

TABANIDS

The Tabanidae is one of two families of the Brachycera that includes bloodsuckers. The tabanid flies are large and stoutly built and are often beautifully colored. The more common colors are brown, black, orange, or metallic green. They are strong fliers and viciously attack cattle, horses, deer, and other warm-blooded animals, including humans. Only adult females are bloodsuckers; the males feed on plant juices and nectar. The mouthparts of the female are developed for cutting skin and sucking blood that oozes from the wound.

The life cycles of all tabanid flies follow a basic pattern. The cylindrical eggs are 1-2.5 mm long, are deposited in neatly arranged piles on stems and leaves of aquatic plants or on the leaves of trees, such as willows that hang over bodies of water. The number of eggs per pile varies from 100 to 1000, and these are cemented together with a glue-like secretion. Some species deposit their eggs in terrestrial habitats such as on logs and mud. These eggs are oviposited during the summer and early fall.

Embryonic development is influenced greatly by environmental conditions but during the heat of summer, the average time ranges from 5 to 7 days. The escaping larvae are vermiform, composed of the head and eleven body somites. Each segment bears a row of warts on which hairs and setae are inserted. Such larvae, upon hatching either drop into water and migrate to the substratum or burrow into the mud if the eggs are deposited thereon. These larvae are free living, feeding on organic debris while undergoing rapid growth during the summer and fall. They become quiescent with the onset of winter. By the following spring, the larvae will have passed through four to nine instars and are fully grown. The final larval stage migrates to dry ground in preparation for pupation.

Pupae are embedded under the surface of dryer ground. The enclosed pupal stage lasts 2 to 3 weeks in most species; however, the pupae of Chrysops metamorphose into adults in less than 2 weeks. The adults rupturing from the cocoon usually hide in foliage, and the females migrate from there as bloodsuckers.

The loss of blood (100-200 ml per day) by cattle resulting from tabanid flies is a serious problem. Weight loss and decline in milk production commonly result from the bites. In addition to the inflicted injuries, discomforts, and loss of blood, tabanids serve as vectors for bacterial, protozoan, and helminth parasites. Various tabanid flies serve as vectors for *Trypanosoma spp*. *Trypanosoma evansi*, the causative agent of "surra" in horses, cattle, and dogs, is transmitted by Tabanus striatus. Similarly, *Trypanosoma equiperdum*, the causative agent for "maldecaderas" in horses and other animals in South America. and *Trypanosoma theileri* of cattle can be transmitted by tabanids. Furthermore, *Trypanosoma vivax*, one of the haemoflagellates that cause sleeping sickness can be transmitted by tabanids.

Tularemia and anthrax, two bacterial diseases of humans and animals, are transmitted by tabanid flies, among other arthropod vectors. Tularemia is caused by Franeisella tularensis and anthrax by *Bacillus anthraris* Tularemia, or deerfly fever, is a disease of humans throughout the United States, Canada, northern Europe, (except Great Britain, Spain. and Portugal), the Soviet Union. Turkey, and Japan. One of the tularemia vectors is *Chrysops discalis*. Rabbits serve as natural reservoirs for the bacterium. Anthrax is a much dreaded disease of cattle, although various other animals and humans are susceptible. *Tabanus striatus* and other tabanids are suitable vectors. The African eye worm, Loa loa, transmitted to humans by *Chrysops dimidiata* and related species. Krinsky (1976) has contributed a review of pathogens known to be transmitted by tabanids.

Tabanid flies are attracted to hosts by carbon dioxide and can be captured on sticky traps baited with dry ice. In addition to CO_2, there is little doubt that vision plays an important role in host localization.

BEDBUGS

Two species of bedbug feed on humans: the common bedbug (*Cimex lectularius*), which occurs in most pans of the world, and the tropical bedbug (*Cimex hemipterus*), which occurs mainly in tropical countries. They are a severe nuisance when they occur in large densities, being commonest in places with poor housing conditions. They are not important in the transmission of diseases, although they possibly playa role as vectors of hepatitis B virus.

Bedbugs have a flat, oval-shaped body with no wings, and are 4 -7 mm long. Their color is shiny reddish-brown bur after a blood meal they become swollen and dark brown in color. There are three stages in the bedbug's life cycle: egg, nymph and adult. The eggs are white and about 1 mm long. The nymphs look like adults but are smaller. Complete development from egg to adult takes from six weeks to several months, depending on temperature and the availability of food. Both male and female bedbugs feed on the blood of sleeping persons at night. In the absence of humans, they feed on mice, rats, chickens and other animals. Feeding takes about 10-15 minutes for adults, less for nymphs, and is repeated about every three days. By day, they hide in dark, dry places in beds, mattresses, cracks in walls and floors, and furniture; they arc also found behind pictures and wallpaper; hiding places and also used for breeding. The bugs are frequently abundant in bedrooms in warm climates. Heated bedrooms in cooler climates are also favorable for the bugs, which cannot develop below 13^0C. Adults can survive for several years without food.

Because they have no wings, bedbugs travel only short distances. In poorly built houses with many suitable hiding places they crawl from one bedroom to another; they spread from one house to another mainly in second-hand furniture, bedding and, sometimes, clothes.

Bedbugs are not considered vectors of disease. It has been suggested that they play a role as vectors of the hepatitis B virus but this was denied in a recent study in the Gambia. They are mainly important as a biting nuisance. Some people, especially those exposed for a long time, show little or no reaction to the bites, which appear as small red spots that may not even itch. People never bitten before may suffer from local inflammation: intense itching and sleepless nights. The bite produces a hard whitish swelling that often continues to bleed. Scratching may cause secondary infections.

In heavily infested houses where people may receive, one hundred or more bites a night it is possible that the blood loss causes mild anemia in infants.

Pediculus humanus capitis
Length = 3 mm

Pediculus humanus corporis
Length = 3.5 mm

Phthirus pubis
Length = 2 mm

Menopon gallinae
Length = 2.5 mm

Buffalo louse
Length = 2.5 mm

Cimex lectularius
Length = 5.5 mm

Soft tick
Length = 5 mm

Hard tick
Length = 3 mm

Dermanyssus gallinae
Length = 0.6 mm

Biting fly
Length = 7 mm

Ctenocephalides canis
Length = 2.5 mm

Sarcoptes scabiei
Length = 0.3 mm

Annex-II

Questionnaires for survey of ectoparasitic infestation in humans and animals

Household number:
Interviewed date:
Sample collected date:
Type of houses kept for domestic animals:

Interviewed by:
Species of Ectoparasites Proved by:
Species of Ectoparasites Proved date:
Symptoms/Pathogenicity proved by:

Lists of animals and species of different ectoparasites

Hosts	Age/sex of hosts	Ectoparasites	Species	Frequency[å]	Parts of infestation	Symptoms/ pathogenicity	Treatment and preventive measures applied by farmers/owners

[♣] + means frequency of 1 to 10 parasites/host body
++ means frequency of parasites 11 to 25 parasites/ host body
+++ means frequency of parasites > 25 parasites /host body

Annex-III

Questionnaires for survey of lice infestation in students in two Monasteries in Kathmandu

Monastery: A or B
Interviewed date:
Sample collected date:

Interviewed by:
Species of Lice Proved by:
Species of Lice Proved date:
Symptoms/Pathogenicity proved by:

Name	Age/sex	Lice Species	Frequency[å]	Parts of infestation	Symptoms/ pathogenicity	Treatment and preventive measures applied by students

[♣] + means frequency of 1 to 10 parasites/host body
++ means frequency of parasites 11 to 25 parasites/ host body
+++ means frequency of parasites > 25 parasites /host body