1. INTRODUCTION

1.1 Parasites and disease as the major constraints of fish health and growth

The intensification and expansion of fish culture is facing a severe threat from pathogens as they are the prime cause for mass mortalities and poor growth thus, affecting the yield and marketability of fishes. Rural farmers are mostly resource poor with little or no knowledge of health management and have inadequate opportunities to improve management skills. Their ability to respond effectively to fish disease problem is also very limited. The prevalence of fish diseases has negative impacts on fish production. As a result, they suffer from financial losses due to fish disease. Disease cause deterioration in the food value of fish and may even result in their mortality. The occurrence of parasitic diseases in the form of epidemic is a great threat to the major protein supply in global scenario. It is not only disturbing the supply of protein but also brings about a pessimistic impact on country's economy.

Most parasites are opportunistic and may be omnipresent time in a culture unit or on fish hosts in low numbers and only cause disease when fish are stressed. Parasites multiply rapidly under favorable conditions, distressing fish health, causing high mortality and inflicting economic losses (Snieszko, 1974; Klesius and Rogers, 1995). Most parasitic diseases occur as a result of poor water quality. Parasitic infestation and disease outbreaks occupies peak level to prove themselves as the major constrains to aquaculture production which may cause the heavy loss to aqua- pond farmers. Such loss affects the livelihood of people involved in aquaculture and the community in which they occur through reduced food availability and loss of the income as well as other associated social consequences (Subasinghe*et al.*,2001).

Parasitic infections often give an indication of the quality of water since parasites generally increase in abundance and diversity in more polluted waters (Poulin, 1992; Avenant-Oldewage, 2002). However, five factors namely age, diet, abundance of fishes, independent number of a parasite within the fish and season, directly influence the parasite fauna of fishes (Kabata, 1985). Characteristic of any water body can influence and determine its parasitic fauna and when environmental conditions, such as water, food and temperature become favorable for mass reproduction of parasites, the disease may spread very quickly (Shrivastava, 1975). The parasitic community of fish show considerable variation with the environmental conditions in which fish live.

Along with carps all the freshwater species found more or less to suffer with different types of diseases while15%-20% are associated with parasite infestation. Indian major carps are highly susceptible to disease in comparison to Chinese and European carps (Lilley *et al*., 1992). The intensity of fish parasitic infection is greatly influenced by seasonality, which affects host ecology as well as physiology. Intense parasite infection can cause ulceration and upset the normal course of reproduction (Rahaman and Jahan, 2002). Parasites interfere with host nutrition, metabolism and secretary functions of the alimentary canal and can even damage the host nervous system. All these effects may reduce normal growth of the fish and finally induce the host mortality. The parasitic infection tend to decrease the growth rate resulting in the stunting of fish (Cross, 1933).

Parasites of fish are a concern since they often produce a weakening of the host`s immune system thereby increasing their susceptibility to secondary infections, resulting in the nutritive devaluation of fish and subsequent economic losses (Onyedineke *et al*., 2010).

The treatment or control of fish parasitic disease can be best achieved, if the approach could be made through following logical patterns: (i) identifying the parasite, (ii) obtaining a thorough knowledge of the life histories which may be simple or very complicated, (iii) learning the ecological requirements of the parasite, such as host specificity, optimum temperature, pH, nutrition and other metabolic requirements, (iv) mapping the geographic range of the parasite (v) determining the effect of immunological mechanisms of the host on the parasite (vi) studying control and treatment method (Hoffman, 1967)

All fish are potential hosts to many different species of parasites. From the view point of fish as food, fish diseases are important for two main reasons:

(a) The number of fish available for consumption is reduced.
(b) The diseased fish may look unsightly, both conditions making them unacceptable for human consumption.

The fish diseases may be due to parasitic or non- parasitic causes, the former are the most numerous and important for the pathological as well as economical view point. The study of the fish disease is more significant since the fish are the important part of human diet. Parasites may be found in all tissue of the host, but they are particularly common on the skin and gills because these external surfaces are easily invaded. The protozoan invades the external surface of the fish integument as the parasites. The larger parasites such as *Argulus* (fish louse) and *Lernea* (anchor worm) are also the parasites on the external surfaces. Some parasites are restricted to the internal organs causing the diseases and harms to the host.

The presence of parasites to a large extent is detrimental for a fish population and consequently, imposes high losses of fish. Parasitic invasion on fishes may cause high mortality, weight losses and reduced fecundity (Grabda, 1991). To prove the fish to be nutritionally perfect, it is necessary to be free from parasitic or other diseases. For the prevention of diseases it is important to study the nature of fish disease. Several parasites including protozoan, crustaceans, copepods, trematodes and nematodes can cause infection to fish.

Protozoan parasites are an important group. There are more than 50, 000 species and only a portion of them are parasitic. They are found in all organs of the fishes, including skin, fins, gills, eyes, kidney, liver, intestine, spleen, heart and brain. The protozoan parasites are harmful not only due to their own activity but also because of disseminating agents of some infection. Protozoan parasites in fish damage the body surface and internal organs, causing wounds and ulcerations.

The helminthes are a large group of parasites which includes skin and gill flukes (monogeneans). Monogenitic trematodes are parasitic flatworm mostly found on the gills, fins, skin, eggs of fresh water and salt water fishes. They hold on to their host via a combination of hooks, anchors, and suckers at their posterior end the opisthaptor, and use the anterior end the prohaptor for feeding and assisting in moving to other locations on the host.

Crustacean copepods *Argulus* and *Lernaea* are the most widely spread skin parasites. They infest, damaging and killing small fingerlings as well as large fish, especially in crowded populations. Crustacean ectoparasites on fish provide an excellent model for studying parasite distributions within a host population due to the relative ease in identifying and counting them. Parasites from the genus *Argulus* are regarded as the most widespread and problematic parasites in freshwater fish culture (Kearn, 2004; Walker *et al*., 2004). This species has been responsible for significant economic losses in aquaculture (Menezes *et al*., 1990) and recreational fishery operations (Taylor *et al*., 2006). Despite this there are still huge gaps in our understanding of the way in which these parasites interact with their hosts.

Fungal diseases are usually external and are always secondary to break in the integrity of epidermis and associate mucus coating. The common pathogen is *Saprolegnia.*

1.2 Different Parasite of fish

Crustacean copepod parasites

A number of crustacean copepods are parasites of fishes. More than one thousand species of parasitic copepod crustaceans are known. Crustacean is an important disease producing parasite of freshwater fishes. Some of them are very common and can be debilitating lethal in large numbers. The crustacean copepods are found on the body surface and fin bases. They show inflammatory reaction at the site of attachment. Copepods include "fish lice" or "anchor worms". The more common fish lice include *Lepeophtheirus, Caligus, Argulus,* and *Lernaea*. The *Argulus* sp. and *Lernaea* sp. are important crustacean parasites of tropical fish. All of these are external parasites which affect the fish by imbibing blood from the host fish causing localized skin and soft tissue damage. They may also allow for secondary bacterial infection of the skin or musculature which may ultimately cause the demise of the fish.

Lernaea sp.

Lernaea is commonly known as "Anchorworm", is modified copepod parasite which infects large scaled fresh water tropical and temperate species of fish. This parasite possesses a life cycle that includes microscopic pelagic larval stages that molt and grow several times before attacking the fish host. On the host the female anchor worm mature and produces two large egg sacs containing hundreds of *Lernaea* eggs. This parasite is easily visible to the naked eye and may be more than 2 cm in length. They get their name from the attachment organ which is highly modified structure which resembles the anchor on a ship. This structure is buried in the host's musculature and allows for the invasion of pathogenic bacteria. The tissue around the anchor turns into a granuloma or necrotic lesion, and is later transformed into a fibrotic encapsulation (Kabata, 1970, 1985).

Argulus sp.

*Argulus*is branchiuran crustacean and commonly known as "Fish Louse". Fish lice are dorsoventrally flattened and covered dorsally by a rounded or horse shoe-shaped carapace, ventrally positioned head appendages, are developed for attachment, four thoracic segments each bear a pair of bifid swimming legs. They have a pair of eye spots and are about 5-10 μ in length. They move about on the skin of fish very effectively and camouflage themselves well on the host. They attach to fishes with aid of two suction cup-like appendages (first maxillae) and abundant little spines located over much of their underside. They have a long, slender preoral sting which they use to pierce the fish skin and inject a toxin then they use their mouth and mandibles to consume the blood, mucous tissue at the puncture "site" resulting in hemorrhagic and inflamed wounds. Attachment to and crawling on the skin also causes irritation and abrasions leading first to proliferations and later to desquamation and erosion of the epithelium. In heavy infections, the infected surface of the integument ulcerates, the epithelium is destroyed and the dermis becomes exposed (Kabata, 1970, 1985; Paperna and Zwerner, 1976)). These parasites are specially harmful to small fishes. The pathogenicity of *Argulus* can kill a larval eel by a single sting which injects a cytoplasmic toxin into the host. It is also reported that this parasite creates ulceration and hemorrhagic changes to the host skin providing ready access to secondary infections by other parasites, bacteria, fungi and viruses (Hoffman, 1977)

Helminthectoparasites

Monogenetic trematodes are a group of flat worms that complete their life cycle on a single host and have direct life cycle. There are more 100 families of monogeneans found on fish of the world, in fresh and salt water, and at a varying of temperature. They vary in size from about 100 μ 2 to 3 to 3 cm in length. A major identifying characteristic of these helminthes is their organ of attachment, the haptor, this is at the posterior end and may have 2 pair of anchors and a number of small hooklets around the periphery. Other identifying characteristic include the presence or absence of "eye spot". The monogeneans are important as gill and skin parasites of marine fishes. They feed mostly on host blood, mucus, and skin cells. Large numbers of monogeneans on either the skin or gills may result in significant damage and mortality. Secondary infection by bacteria and fungus is common on tissue that has been damaged by monogeneans. Species of monogeneans genera common in fish belong to *Gyrodactylus* and *Dactylogyrus*, which differ markedly in their reproductive strategies as well as their preferred attachment sites on host fish.

***Dactylogyrus*sp.**

Members of the genus *Dactylogyrus* attach to gills of host fish, unlike *Gyrodactylus*, they are egg layers.

***Gyrodactylus*sp.**

The parasite is smaller, rarely reaching a maximum length of over 0.4mm. Body is flattened and leaf like, no eye spot, cepahalic end v shaped has an attachment organ (haptor) and two large anchors with 16 marginal hooklets. This parasite is more commonly found on the skin and less commonly present in the gill. They cause lesions hemorrhage and necrosis of epithelial tissue of skin. *Gyrodactylus* are viviparous (produce live young). Each individual parasite has both male and female reproductive organs.

Fungal infection:

Fungal infections of the fish skin are also known as ‘mycoses” They are common and generally mild. Fungi can sometimes cause serious disease. Fungi are parasites or saprophytes. They live on living or dead organic matter. The three most common fungal diseases are known as Saprolegniasi, Branchiomycosis and Ichthyophonus infection.

***Saprolegnia* sp.**

Saprolengniasis is a fungal disease of fish and fish egg and is most commonly caused by the *Saprolegnia* species called water molds. They are common in fresh or brackish water. *Saprolegnia* can grow at temperature ranging from 0 to 35 ºC but seem to prefer temperature of 15 to 30 ºC. The disease will attack an existing injury on the fish and can spread to healthy tissue. Saprolegniasis is often first noticed by observing fluffy tufts of cotton –like white to shade of gray material and brown on skin, fins, gills or eyes of fish or on fish eggs.

***Icthyophonus* sp.**

Icthyophoniasis is caused by fungus *Icthyophonus hoferi* (Plehn and Mulsow, 1911). It grows in fresh and salt water in wild and cultured fish, but is restricted to cool temperature (2.2 to 20 ºC). The disease is spread by fungal cysts which are released in the feces and by cannibalism of infected fish. Fish with a mild to moderate infection will show no external signs of the disease. In severe cases, the skin may have a “sand paper texture” caused by infection under the skin and in muscle tissue. Some fish may show curvature of the spine. Internally, the organs may be swollen with white to gray-white sores. It is common in aquarium of hot climatic weather conditions.

This research is intended to investigate the parasitic diseases and estimation of economic losses due to infestation of parasites in aquaculture ponds of Rupandehi district. It is located in the southern plain area of Nepal and has great potential for pisciculture. The pond farmers of this area not getting the satisfactory carp growth because of the parasites and diseases. So, they are having the remarkable economic loss. There are several researches about the parasitic diseases and loss estimation of different marine and fresh water fish species in many countries of the world. But in context of Nepal, very few researches have been carried out regarding parasitic diseases and the economic loss imposed by the infestation of parasites. So, this research needs to be undertaken in this area. This research will account the parasitic diseases in two species of Indian major carps *Labeo rohita* and *Cirrhinus mrigala*, and also estimate loss due to the parasitic invasion. The study may help rural fish farmers and researchers to know the present status of fish health and approximate economic losses due to the diseases outbreak in fish farms. It may also be the supportive document for the nation to make the future plans and programmmes.

1.3 Objectives

1.3.1 General objectives

The general objective of this research was to determine the parasitic diseases and loss due to the infestation of parasites in two species of Indian major carp (*Labeo rohita* and *Cirrhinus mrigala*).

1.3.2 Specific objectives

The specific objectives of this study were:

- To detect the parasites and diseases
- To investigate the prevalence, abundance and mean density of parasites.
- To determine the chemotherapeutics used to control the parasites.
- To estimate the cost of treatment.
- To estimate the losses due to parasites.

1.4 Justification of the study

Rupandehi district has potential for the aquaculture system. It has total water surface area of 751 ha and 3581 numbers of the ponds. It has total fish yield of 4500 metric tons/ha /year. Fisheries center Bhairahawa and Mandal hatchery Patthardada have Hatchery system for the production of hatchling, fry, fingerlings and adult of different Indian, Chinese and exotic carps. Similarly the Dayanagar and Manmateria are main area for the production of adult or marketable sized fish. This is the carp oriented area where Chinese and Indian major carps are cultured successfully. But there is no optimistic result in terms of carp health and growth in aquaculture ponds of this district which may be due to the infestation of the parasites and diseases. The later might have posed the serious threats and the heavy economic losses to the aqua-pond farmers of this area. The small scale rural farmers are mostly resource poor with little or no knowledge of health management and also they may not know the causes, prevalence and treatment of the parasitic diseases. This may harm the carp production which may eventually cause the direct and indirect losses to the pond culture practioners. There is very little work carried out on this type of study and negligible attempts have been approached for exploration on such headings. Therefore the present study has been undertaken to collect the information about the fish parasites, parasitic diseases and the estimation of losses caused by the parasitic infestations in aquaculture ponds in Rupandehi. The present work also includes the study of the water quality (pH, DO and temperature) and the prevalence, abundance and the mean density of the parasites. Thus, this will be helpful for any further studies, research works on fish health management and development plans.

2. LITRATURE REVIEW

Most parasites play the adverse role to their hosts causing some sorts of diseases. These diseases in fish are caused by protozoan, crustaceans copepods, helminthes and fungi. Parasite affects the movement, growth, reproduction and health of fishes and sometimes death may occur due to parasitic infections. The ectoparasites form the largest group of the pathogenic organism.

Parasites cause deterioration in the food value of fish and may even result in their mortality. Tripathi *et al.* (1978) estimated the losses due to mortality and retardation / cessation of growth of fish in ponds in west Bengal as a result of epidemic infections.It has been reported that losses due to Epizootic Ulcerative Syndrom in several Asian countries before 1990 exceeded US$10 million (Chainabut, 1994).

Das (1994) calculated the economic loss due to the impact of Epizootic Ulcerative Syndrome (EUS) during its initial two–three years of occurrence. The economic loss in Bihar during 1990 was US$ 150,000; in Orissa during 1989-91, it was estimated as US$ 95,000; and in Kerala during 1991-92, as US$ 625,000.

Subasinghe *et al.*,(1995) estimated that the loss due to the WSD- related shrimp was US$17.6 million in India 1994.

Ahmed *et al.,* (2000) estimated the cost of sea lice to salmon aquaculture in eastern Canada and found the economic loss incurred due to the sea lice. They also found that about 17.30 % of the total cost involved in the sea lice control was expensed for the purchase of parasiticides and, purchase and maintenance of equipment.

Al-Rasheid*et al.,* (2000) reported that Trichodinid ectoparasites can cause serious threats, particularly under cultured conditions.

The protozoans, cestodes, nematodes, trematodes and crustacean parasites caused serious diseases on both cultured and wild fish species. These parasitic groups block fish growth and prevent feeding activity (Cengizler *et al.*, 2001)

Bergh *et al.,*(2001) reported that in economic terms, the most important losses have been suffered at the larval and juvenile stages of the Atlantic halibut *Hippoglossus hippoglossus.*

Fish health, growth, reproduction and behavior pattern can be affected by the different parasitic infections (Dunn, 2001).

Cengizler *et al*. (2001) observed protozoan parasites *Trichodina nigra* (Lom, 1961a) and crustaceans parasites *Argulus foliaceus*(L., 1758) during the skin examination of mirror carp (*Cyprinus carpio* L., 1758).

Maki *et al.,* (2001) reported that ciliated protozoan parasite *Ichthyophthirius multifiliis* infects fresh water fish causing an economically important disease referred to as 'Ich' or 'White spot'.

Hasan and Ahmed (2002) worked on some issues of finfish hatcheries and nurseries in some selected areas of Bangladesh. They found that 69% hatcheries and nurseries were affected by diseases though diseases were less prevalent in hatcheries than in nurseries. The major diseases in nurseries were white spot, tail and fin rot, EUS, sudden spawn mortality, gill rot, dropsy and malnutrition, while the major diseases in hatcheries were sudden spawn mortality and fish lice.

Supranee Chinabut (2002) reported that the economic loss due to the jaundice disease was US$ 4.3-21.3 million in Thailand. It was noticed that the rancid chicken offal was the cause of this disease.

Wei Q (2002) carried out the research on the Social and economic impacts of aquatic animal health problems in aquaculture in China and estimated that WSD-related shrimp losses ranged from US$400 million in and around 10% culture area was suffering from disease, with annual losses of fish production was around 15%.

Naich and Bilqees (2002) mentioned that commencement of symptoms or physiological changes in host may be related to an increase in the number of parasites. At that stage the non- pathogenic parasites become pathogenic. The high levels of density or intensity of *Ttichodina* sp., *Chilodonella* sp., *Costia necatrix*, *Gyrodactylus* sp., ,*Ichthyophthirius multifiliis* and sessile peritrichs can cause skin damage and affect cutaneous respiration.

Ostrow (2003) described *I. multifiliis*as one the most prevalent protozoan parasites of fish and is an important pathogen of ornamental and farm-raised food fish species when reared under intensive conditions.

Vera *et al*. (2003) reported the occurrence of *Trichodina acuta*, on the skin and gills.

Stewart *et al.* (2004) carried out the research on review of the impact of parasitic copepods on marine aquaculture and reported that indirect and direct losses due to sea lice salmonid aquaculture globally are estimated to be greater than US$ 100 million annually.

Faruk *et al.* (2004)studied the economic loss from the fish diseases on rural aquaculture of Bangladesh and estimated the average economic loss of Tk.20,615/ha/year (US$ 344).

Svobodova (2004) observed higher incidence of *Cryptobia branchialis* on skin and gills of early stages of tench fry. Ichthyobodosis is considered one of the most important protozoan diseases of tench fry. The agent *Ichthyobodo necator* (formerly Costia) is found on the skin and gills and massive infection cause nearly 100 % mortality of fry, mainly in the early stages.

Akter *et al.* (2007) examined five exotic carp species viz. *Hypophthalmichthys molitrix*, *Cyprinus carpio* var. specularis, *Cyprinus idellus*, *Cyprinus carpio* var. communis and *Puntius gonionotus* of Bangladesh were examined for parasitic diseases and they reported 3 protozoan (*Trichodina* sp., *Ichthyophthirius* sp. and *Chilodonella* sp.), 2 monogenean (*Gyrodactylus* sp., *Dactylogyrus* sp.), 2 trematoda (*Gorgotrema* sp., *Metadena* sp.), 4 cestoda (*Rhopalothyrax* sp., *Marsipometra* sp., *Lytocestus* sp. and *Senga* sp.), 2 nematoda (*Camallanus* sp., *Procamallanus* sp.), 3 crustacean (*Argulus* sp., *Alitropus* sp. and *Lamproglena* sp.) and 1 insect (Dipteran larvae) parasitic species. These parasites were isolated from body slime, gills and intestine of the infected fishes.

Levy *et al.*(2007) reported that the parasitic dinoflagellate caused a chronic infestation. Visible lesions began as a light golden dusting in oblique light and then progressed to more severe infestation intensity associated with dense white dusting of the skin.

Yamin (2007) reported a number of diseases in brood fish and spawn in different hatcheries of Mymensingh, Jessore and Bogra districts of Bangladesh. They reported that most prevalent disease of brood fish was argulosis (35%), followed by EUS (30%), gill rot (12%), dropsy (9%) and nutritional diseases (9%). The average prevalence of diseases in brood fishes was about 15-20% which varied hatchery to hatchery. The major disease problems of fish spawn as reported by the hatchery owners was fungal infection in fertilized eggs, white spot inside the yolk sac, loss of slime, spinal deformities, enlarge head and stomach, blindness and sudden spawn mortality due to unknown reason.

Majid *et al*. (2008) reported an outbreak of white spot disease ('Ich') caused by *I. multifiliis* in rainbow trout..

Abo-Esa (2008) performed parasitological investigation in one hundred naturally collected Nile catfish *Clarias gariepinus*. It revealed skin and gill infection with ectoparasitic protozoan *Trichodina* and *Epistylis* and monogenean *Gyrodactylus* spp. with average 20.15 % and 25 % respectively.

Teija *et al.* (2008) studied on the control of freshwater fish louse *Argulus coregoni*: and found that parasite juveniles and adults were highly sensitive to potassium permanganate treatments (0.01 g l–1), which lead to 100% mortality.

Khan (2009) investigated the role of parasites as the cause of disease outbreak and mass mortality on the basis of field and laboratory observations in wild and cultured fish and noted that ciliated protozoans, *Trichodina jadranica* (Ciliophora) and *Loma branchialis* (Microspora), were responsible for mass mortality of cultured fry and fingerling of Atlantic cod (*Gadus morhua*).

Jorgensen *et al.* (2009) observed in some rainbow trout farms white spot disease caused by *Ichthyophthirius multifiliis* associated with high fish mortality. He also recorded *Trichodina* sp., *Apisoma* sp.,*Ambiphrya* sp., *Epistylis* sp., *Chilodonella piscicola*, *Icthyobodo necator* and *Gyrodactylus derjavinoides.*

Osman (2009) reported white spots (Ichthyophthiriasis) as a prevalent ectoparasitic disease, mostly affecting cultured and aquarium fishes. The morbidity rate due to this disease may reach up to 100 % causing great economic losses in fish farms. Ichthyophthiriasis has also been known as sand grain, gravel or ich disease. This dangerous ectoparasite mainly attacks skin, fins, gills and buccal cavity and characterized by the presence of white spots all over the external body surface.

Mark J Costello (2009) carried out the research on the global economic cost of sea lice to the salmonid farming industry and estimated the cost of sea lice control and reported that most of the loss estimates for sea lice infestation fall within the range of € 0.1-0.2/kg fish/year

Mhleggeru *et al.* (2010) reported two fish species of round goby *Apollonia melanostoma* and bighead goby *Neogobius kessleri* infected with two protozoans *Trichodina* sp. and *Ichthyophthirius multifiliis* and two monogeneans *Gyrodactylus* sp. and *Dactylogyrus* sp. These parasites were found on the skin and gills of fishes.

Aydogan *et al.* (2010) reported that black tetra (*Gymnocorym busternetzi*) in Turkey infected with *Ichthyophthirius multifiliis*. Microscopically, there were white spots of the different sizes on the skin of the head and back and increase amount of mucus on the skin and gills of fish.

Hossain *et al.* (2011) studied the environmental impact assessment of fish diseases, fish production and estimated the loss due to the different diseases.

The research conducted by Alam *et al.* (2012) on intensity of parasitic infestation in silver carp, (*Hypophthalmichthys molitrix*) revealed nine different parasite species (*Trichodina* *pediculatus*, *Dactylogyrus vastator*, *Ichthyophthirius multifilis*, *Gyrodactylus elegans*, *Lernaea* sp., *Apiosoma* sp.,*Myxobolus rohitae*, *Camallanus ophiocephali*, and *Pallisentis ophiocephali*) were recovered from the gill, skin, stomach, and intestine of host fish. The highest level of infection was observed for host skin, while lower levels were observed for host gill, stomach, and intestine. The results also revealed that the intensity of parasite infection in different organs of *H.molitrix* varied with the season.

Sahoo *et al.,* (2012) studied on the mixed infection of *Argulus japonicus* and *Argulus siamensis* (Branchiura and Argulidae) and estimated the economic loss US$ 1428 per hector per year which was incurred due to the infestation of *Argulus japonicus* and *Argulus siamensis.*

Mofasshalin *et al.*, (2012) worked on the parasites of three Indian major carps of Rajshahi, Bangladesh and revealed that 4 protozoan as *Trichodina* sp., *Ichthyopthirius* sp., *Apisoma* sp. And *Chilodonella* sp., 2 monogenean *Gyrodactylus* sp and *Dactylogyrus* sp.,2 crustacean *Argulus* sp. and *Lernea* sp. And 1 nematode sp.,*Camallanus* sp. They isolated these parasites from the body slime, gills, and intestine of the infected carp fish.

The research of Perveen *et al.,* (2013) on ectoparasites of indigenous and exotic fresh water carp fish (Cypriniformes: Cyprinidae) from Charbanda and Tarbela, Khyber Pakhtunkhwa, Pakistan revealed that the individual ectoparasitic infestation of 3 different species as *Lernaea cyprinacea*, (17.2%), *Argulus* (3.6%) and salmon fluke, *Gyrodactylus* sp.(0.3 %). They also found the highest overall prevalence (25.4%) and abundance (1.3%) in *Ctenopharyngodon idella*. The highest intensity (19.5 %) was found in *Cirrhinus mrigala.*

Bagum *et al.,* (2013) reported the fish diseases and economic losses due to the incidence of disease in rural freshwater aquaculture of Bangladesh and determined the different diseases as EUS (Epizootic Ulcerative Syndrome), fin gill rot, grayish white spot, parasites (external), gulping air and dropsy and, also computed the economic loss and control cost due to the diseases as BDT 24,870 and BDT 3,460 /ha per year respectively.

Viswanatha *et al.,* (2014), studied economic assessment of fish and Prawn health management in Andhra Pradesh and reported the geographical profile of fish farmers, aqua-inputs, fish and prawn diseases and, also determined the average financial loss including the health management as ₹ 8094 / acre in carp culture and ₹ 21,980 / in prawn culture in all the four district of Andhra Pradesh.

Samad *et al.,* (2014) worked on the status of bio-security and prevalent parasitic diseases in finfish hatcheries of Jessore, Bangladesh.

Munir *et al.,* (2015), conducted the research work to determine the parasitic diseases and loss due to infestation of parasites in three Indian major carp (*Labeo rohita*, *Catla catla* and *Cirrhinus mrigala*) from three districts of Bangladesh namely Mymensingh, Sylhet and Rajshahi during the period from July 2012 to June 2013. They determined the total of nine ectoparasite species as *Dactylogyrus* sp., *Gyrodactylus* sp., *Trichodina* sp., *Larnaea* sp., *Ichthyophthirius* sp., *Ichthyobodo* sp., *Chilodonella* sp., *Argulus* and *Apiosoma* sp. and three endoparasite species as *Cammalanus* sp., *Pallisentis* and *Eucreadium* sp. from the examined carp fish. They also estimated the total economic loss due to parasitic diseases which was found to be BDT 35,552.50 ha-1 yr-1.

3. MATERIALS AND METHODS

3.1 study area

The present study was conducted in Rupandehi district of Lumbini zone in Western Development Region (WDR). Rupandehi is located in south western part of Nepal boarding India in South, and Palpa, Nawalparasi and Kapilvastu districts in the North, East and West respectively. The district is divided into seven election constituencies area, 17 Ilaka, 48 VDCs, 5 Municipalities and 1 Sub-Metropolitan City.

About 1000 ha of the land area of the Rupandehi is occupied with water of which the natural wet land / lake share the 125 ha and aqua-ponds 875 ha. Further the community pond water surface area occupies 250 ha. and owner's pond water area625 ha. Similarly, irrigated rice field area occupies 47617.0 ha. Out of which the rivers share 2380 ha (5% low land area) and steams area 2460 ha.

The institutional development of the district is as follows.

Table 1: Institutional development of the fishery of Rupandehi

Description	Numbers
District fisheries professional association	1
Fisheries co-operative society	1
Aqua-pond farmers groups	57
Total aqua- ponds	3850
Female farmers groups	6 (105)
Male fisheries farmers group;	6 (105)
Integrated farmers group (male and female)	48 (1002)
Aqua –pond farmers	2150
Aqua-ponds	3850
Total fish yield	4500M.t

Fig 1: Map of Rupandehi showing the study areas

Study area –I(Fisheries Development Center, Bhairahawa)

Bhairawa Fishery Development Centre was established in 1961 which is located on the way to Bhairahawa at the distance of 18 Km south from the Butwal city and 4 km north from Bhairawa city. The station (Fishery Development Center, Bhairahawa) had a total area of 23 ha of which, 17.7ha area was occupied by water. There were four types of ponds, as follows:

Table 2: Different types, numbers and water surface area of ponds in Fisheries Development Center Bhairahawa.

Types of ponds	No. of ponds	Water surface area (ha.)
Brood stock	13	4.15
Rearing	13	0.86
Production	7	4.83
Not used	7	7.24
Others	8	0.62
Total	48	17.7

This station is supplying the fish seeds of all Indian major carps, Chinese carps, exotic carp and the common carps to the different parts of the country. The station was able to produce 642540hatchlings, 6575690 fry and 3090140 fingerlings of Chinese and Indian major carps. The sale of the station was 416300 hatchlings, 1608596 fry, 2594755 fingerlings 2-3" and 146385 fingerlings 3-5"as the summary breeding of the 2071-2072.

Table 3: Breeding summary 2071-2072

Particulars	Production	Sale
Hatch	642540	416630
Fry	6575690	1608596
Fingerlings	3090140	2741140
Fingerlings 2-3"		2594755
Fingerlings 3-5"		146385
Total	10308370	4766366

Fig 2: Study area I, Fishery Development Center, Bhairahawa

Study area –II (Mandal Hatchery, Patthardada)

Mandal Hatchery, located at Tillottama-17, Patthardada is one of the private sector hatcheries farm in Rupandehi. It is located 9 km far from the district head-quarters, Bhairahawa and about 5 km north-west far from the Fisheries Development center, Bhairahawa. It occupied the total area of five hector including total 23 ponds(Nursery-16 and broods-7). It was one of the famous and well managed hatcheries farm of the Nepal which supplied the fish seeds specially the fry and fingerlings of the Indian major carps, Chinese carps along with the exotic common carps to the different parts of the countries. The different information about this farm was collected through Mr. Rameshwar Mandal, an owner of the farm.

Fig 3: Study area II, Mandal Hatchery, Pattharthadada

Study area-III (DayanagarVDC)

Dayanagar VDC is located in the south-west of Rupandehi District. It has Harnaiya, Sitapur and Mainaihiya at the east, Suryapura and Bishnupura in the west, Amawa and Manmateria in the north, and Kamahariya in the south. It was located 14.6 km. far from the district head-quarters, Bhairahawa.It occupies the 200 ha of land with 500 ponds. It also has the total households 1769 and total population of 10214. The place Chhapia is famous for aquaculture is also a part of this VDC. The ponds of this VDC were visited and the required information was collected through the pond farmers of this area during the study period. Most of the people of this area were found having the aquaculture practice instead of growing paddy due to the easy, safe and good turnover of the cash.

Fig 4: Study area III, Dayanagar VDC

Study area –IV (Manmateria VDC)

Manmateria VDC, is the place in the Rupandehi which is located at the western part of the Rupandehi was the IV selected study area of the research.. It is located 102 m. above the sea level and 21 km. of the north –west of the district head-quarters, Bhairahawa. It is seven km. far from the Dayanagar VDC. It is bordered by Amawain east, Suryapura in the west, Manpakadi and Sauraha Pharsatikar VDC in north and Dayanagar VDC in the south.

Fig 5: Study area IV, Manmateria VDC.

3.2 Data collection

3.2.1 Survey of aquaculture zones

Data was collected through the questionnaire interview and Participatory Rural Appraisal (PRA) with fish farmers. The data were collected from February to July 2016 AD. For the interview simple random sampling method was followed. A set of preliminary questionnaire was prepared for questionnaire interview. Attempts were made to make the language unambiguous, brief, polite and non-technical far as possible. Primarily the questionnaire was prepared in English and then translated to Nepali (local dialect) for effective results of the survey and for better understanding of the local inhabitants of Rupandehi. The survey questionnaire consisted of four major categories, i.e. (i) socio-economic profile of farmers, (ii) information on aquaculture, (iii) pond and health management practices and (iv) problems and priority issues. A total of 136 farmers having the different farm sizes were interviewed. Prior to field survey, background information on the number, location and distribution of the fish farms and aquaculture activities were collected. After collecting the primary data, focus group discussion with farmers and cross-check interviews with key informants were carried to justify the previously collected data. The relevant information regarding management and outbreak status of parasites was collected by visit to the individual farms.

3.2.2 Measurement of pH, Dissolved Oxygen and temperature

The measurement of pH and DO was carried out by using the pH and DO meter.

3.2.3 Detection and identification of ectoparasites:

Selection of host Fishes: Two species of Indian major carp Rohu (*Labeo rohita*) and Naini (*Cirrhinus mrigala*) were selected as host specimen for the present study. Eight species of each host fishes were collected randomly per month and a total number of 96 species were examined during the study period from February to July 2016 AD in different ponds of Rupandehi.

Collection of Specimen: The live fishes were collected directly from the different fish ponds of study area.

3.3 Collection of parasites

3.3.1 Observation of ectoparasites

The ectoparasites on the external surface of the host fish were observed with the help of the magnifying glass and the parasites present on the skin, scales and fins were recorded. Further, the other physical abnormalities like, ulcers, raised scales, reddened fins, cyst and injuries resulting from physio-chemical agents were also noted. Parasites were collected with the help of the fine brush and preserved in individual vials and placed for the identification. The gills were removed from the branchial cavity and kept in a petridish with saline solution. Later, the gills were separated to dislodge the live monogeneans which then were observed under the microscope.

3.4 Estimation of prevalence, abundance and mean density:

Prevalence, abundance and mean density were determined by following the keys of (Margalef*et al.*, 1982) as follows:

$$\text{a. Prevalence} = \frac{\text{Number of infested host}}{\text{Total number of host examined}} \times 100$$

$$\text{b. Abundance} = \frac{\text{Number of infested host}}{\text{Total number of host examined}}$$

$$\text{c. Mean density} = \frac{\text{Number of parasites}}{\text{Total number of infected host}}$$

3.5 Estimation of loss due to parasitic infestation:

The loss due to parasites was determined by considering on account of fish mortality occurred, expected loss in fish growth in terms of the total biomass production and the expenditure towards the drugs/ chemicals being utilized for the prophylaxis and control of this disease.

The loss was calculated according to the following formula;

Total loss = {(Loss due to reduction in growth + Loss due to mortality) × Rate per kg }+ Cost of treatment

Where, loss due to reduction in growth (per kg) = average growth per day × number of fish affected × total period of infestation from all the outbreaks in a year (in days).

Loss due to mortality (per kg) = average weight of fish × mortality (in number)

The average loss due to reduction in growth per day was determined on basis account of stocking density and average fish yield of the farm per hector per year.

The loss in growth increment per day during the infection was computed as follows;

1, 2, and 3 g loss in growth per day at stocking densities from 12000 and above, 9000-12000 and 9000 and less number per hector of water of carps cultured ponds respectively. This was based on field survey data, discussion with fish pond-farmers, on the basis of their own experiences, previous studies as well as specific growth rate relationship there on (Jena *et al*., 2001, 2002, 2008).

3.6 Analysis of data

The data was analyzed using the tabular and descriptive statistical techniques. The summary tables were prepared on the basis of objectives of the study. The technique of the analysis included the classification of the tables into meaningful result by arithmetic mean, percentages and ratios.

4. RESULTS

4.1 Month-wise pH recorded in different study area in Rupandehi, 2016

The pH recorded in the ponds of different study area was found to be varied from February to July. The maximum pH (8.7) was recorded in the study area II in February month and minimum (8.3) was at the study area III and IV in May and June month.

Table 4: Month-wise record of the pH at different study area in Rupandehi, 2016

Months	Study areas				Max	Min
	I	II	III	IV		
February	8.5	8.7	8.5	8.7	8.2	7.8
March	8.3	8.6	8.6	8.6	8.3	8.1
April	8.4	8.5	8.4	8.6	8.5	8.1
May	8.8	8.6	8.3	8.4	8.6	8.2
June	8.6	8.4	8.4	8.3	8.7	8.3
July	8.8	8.7	8.5	8.6	8.6	8.5
Average	8.2	8.4	8.3	8.2	8.4	8.1

4.2 Month–wise dissolved oxygen (DO) in different study area in Rupandehi,2016

The dissolved oxygen content was ranged from 7.1 mg/l to 8.9 mg /l. The DO was found minimum (7.1mg/l) at the study area II and IV during the July month and maximum (8.9 mg/l) at the study area I (FDC Bhairahawa) during the February month.

Table 5: Month-wise record of the DO at different study area in Rupandehi, 2016

Months	Study areas				Max	Min
	I	II	III	IV		
February	8.9	8.7	8.8	8.6	8.9	8.6
March	8.8	8.3	8.1	8.7	8.8	8.1
April	8.7	7.9	8.1	8.3	8.7	7.9
May	8.1	7.4	7.7	7.8	8.6	7.4
June	7.9	7.3	7.5	7.6	7.9	7.3
July	7.6	7.1	7.2	7.1	7.6	7.1
Average	8.33	7.78	7.9	8.01	8.41	7.73

4.3 Month-wise temperature recorded in different ponds in study area of Rupandehi

The average temperature recorded in different selected ponds of Rupandehi was found to be ranging from 21.6°C from February to 29.3°C in July. The average temperature recorded was found maximum (27.76°C) in Manmateria area followed by Dayanagar VDC (27.66°C), Fisheries Development Center Bhairahawa (27.35°C) and Mandal Hatchery (26.5°C)

Table 6: Month-wise record of the temperature at different study area in Rupandehi, 2016

Months	FDC Bhairahawa (°C)	Mandal Hatchery (°C)	Dayanagar VDC (°C)	Manmateria VDC (°C)	Average Temperature (°C)
February	21.1	21.5	21.3	22.5	21.6
March	24.3	23.5	24.5	24.2	24.12
April	25.8	26.1	26.5	25.4	25.5
May	32.2	30	33.1	32.8	32.3
June	31.5	29.8	32.3	31.5	31.1
July	29.2	31.2	29.3	30.2	29.3
Average	27.35	26.5	27.66	27.76	27.32

4.4 Status of fish diseases recorded in different selected area of Rupandehi

According to respondent farmers, the most prevalent diseases were Argulosis (37.66%), Red spot (14.28%), Fungal disease (10.38%), Unknown A (9.09%), Gill-rot (7.79%), Dropsy (6.49%), Unknown B (6.49%), Pisciculosis (5.19%) and Lerniasis (2.59%) in two species of Indian major carps, *Cirrhinus mrigala* (Naini) and *Labeo rohita* (Rohu). The occurrence of Argulosis was common in each study area.

Table 7: Status of fish disease in different study area of Rupandehi

Disease	**Species**	**No. of ponds**				**Overall**	
		FDC Bhairahawa	Mandal hatchery	Dayanagar VDC	Manmateria VDC	Total	Per cent
Argulosiss	*Labeo rohita Cirrhinus mrigala*	1	4	17	7	29	37.66
Red spot	*Labeo rohita Cirrhinus mrigala*	-	2	7	2	11	14.28
Unknown A	*Labeo rohita Cirrhinus mrigala*	-	1	4	2	7	9.09
Gill rot	*Labeo rohita*	-	2	1	3	6	7.79
Dropsy	*Labeo*	-	1	2	`2	5	6.49

	rohita Cirrhinus mrigala						
Unknown B	*Labeo rohita*	-	-	4	1	5	6.49
Pisciculosis	*Cirrhinus mrigala*	-	-	3	1	4	5.19
Learniasis	*Labeo Rohita Cirrhinus mrigala*	-	-	1	1	2	2.59
Gill fluke	-	-	-	-	-	-	unavailable
Total		1	10	46	20	77	100

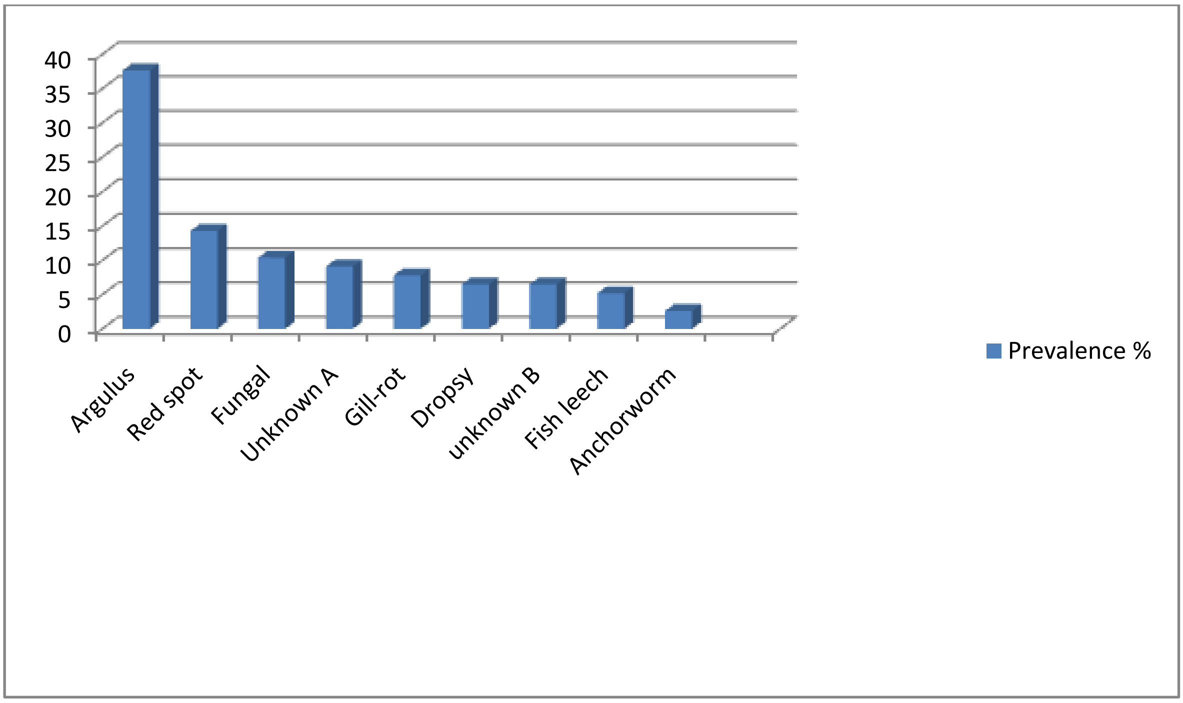

Fig 9: Prevalence of parasites and disease in different ponds of Rupandehi

4.5 Month–wise estimation of prevalence, abundance and mean intensity of parasites in different ponds of Rupandehi, 2016

The prevalence of the parasitic infestation was fluctuated from February to July month during the study period. The highest prevalence (100%**),** abundance (9.12) and mean density (8.87) was found in *Cirrhinus mrigala* during the month of May and the lowest value of prevalence (12.5 %), abundance (0.12) and mean density (1) was recorded during the month of July.

Table 8: Month–wise estimation of prevalence, abundance and mean intensity of parasites in different ponds of Rupandehi

Months	Fish species	No of fishes investigated	Parasites	Site of infection	No of infected fish	Prevalence (%)	Abundance	Mean density
February	*L. rohita*	8	*Argulus*	Skin	**2**	**25**	**1.62**	**6.5**
			-	-				
	C. mrigala	8	*Argulus*	skin	**3**	**37.5**	**2.37**	**6.33**
			-	-	**-**			
March	*L. rohita*	8	*Argulus*	Skin	**3**	**37.5**	**2.87**	**7.66**
			-	**-**	**-**			
	C. mrigala	8	*Argulus*	Skin	**4**	**62.5**	**3**	**4.8**
			Lernaea	Skin	**1**			
April	*L. rohita*	8	*Argulus*	Skin	**4**	**50**	**3.87**	**7.75**
			-	**-**	**-**			
	C. mrigala	8	*Argulus*	Skin	**6**	**75**	**4.62**	**6.16**
			-	**-**	**-**			
May	*L. rohita*	8	*Argulus*	Skin	**7**	**100**	**8.37**	**8.38**
			Lernea	Skin	**1**			
	C. mrigala	8	*Argulus*	Skin	**8**	**100**	**9.12**	**8.87**
			Lernaea	-	**-**			
			-	-	**-**			
June	*L. rohita*	8	*Argulus*	Skin	**3**	**37.5**	**2.62**	**7**
			-	-	**-**			
	C. mrigala	8	*Argulus*	Skin	**2**	**25**	**1.37**	**5.5**
			-	-	**-**			
July	*L. rohita*	8	-	-	**-**			
			Piscicola	Skin	**1**	**12.5**	**0.12**	**1**
	C. mrigala	8	*Lernaea*	Skin	**1**	**12.5**	**0.5**	**4**
			-	**-**	**-**			
			-	**-**	**-**			

4.6 Chemotherapeutics used for the parasites and disease control

The result showed that different sorts of chemotherapeutics were used by pond farmers to control the parasitic infestation and disease in their farms. It was reported that application of lime was the highest followed by, salt, potash alum (Phitkiri), antibiotics and pesticides. It was found that maximum no of farmers (34.55 %) used the lime and salt together followed by lime only (19.85%), potash alum (13.97%) and lime, salt and potash together (8.8.2%). The use of the pesticides was found very less and only 2.94 % of the farmers used the pesticides.

Table 9: Chemotherapeutics used for fish disease control in different ponds of Rupandehi

Therapeutics used	No of farmers	Overall (% farmers)
Lime only	27	19.85
Salt only	15	11.02
Potash alum (phitkiri)	19	13.97
Lime and salt together	47	34.55
Lime, salt and potash	12	8.82
Antibiotics and vitamin	12	8.82
Pesticides	4	2.94
Total	136	100

4.7 Dosage and cost on pesticides used in different ponds of Rupandehi

The survey showed that different types of pesticides were used in different study area of Rupandehi. Cleaner, lysetik, O_2max, salcoprim, Toximar were found to be used in the different parts of the study area. Cleaner, salcoprim and Toximar were found as the pesticides of common practice. The toximar was used as the cheapest pesticides among all but its dose was more. Similarly, the salcoprim was found expensive but its dose was least. The lysetik was the pesticides used for the control of the *Argulus* in FDC Bhairahawa and Dayanagar VDC which was costly with NRS 2592.00/ kg

Table 10: Dosages and cost on pesticides used in different ponds of Rupandehi

Pesticides/hector	FDC Bhairahawa		Mandal Hatchery		Dayanagar VDC		Manmateria VDC	
	Dosage	Cost	Dosage	Cost	Dosage	Cost	Dosage	Cost
	(L/kg)	(Rs/L/kg)	(L/kg)	(Rs/L/kg)	(L/kg)	(Rs/L/kg)	(L/kg)	(Rs/L/kg)
Bromex								
Cleaner	-		0.03	1700	0.03	1700	0.03	1700
Copper sulphate	-				-		-	
Diptrex								
Lysetik	0.03	2592	-	-	0.03	2592	-	-
Malathion	0.25							
Malachite green								
O_2 Max	-	-	-	-	2	1350	2	1350
Potassiumpermanganate	-	-	-	-	1.5	1200	1.5	1200
Salcoprim	-	-	-	-	0.01	1900	0.01	1900
Toximar	-		30	76	30	76	30	76

4.8 Estimation of loss due to the parasites in different selected area of Rupandehi, 2016

In Fisheries Development Center the cost of treatment was estimated NRs 3,780.00 and loss in value due to the reduced growth was estimated NRs 38,400.00. The average total loss was NRs 42,180.00

Table 11: Economic loss due to the parasitic disease in FDC Rupandehi

Factors	Fish weight loss Kg/ ha/yr	Market price of carps(NRs/Kg)	Cost of treatment (NRs)	Loss invalue (NRs)
Mortality carp fish/ha/yr	-	-	-	-
Reduced growth /ha/yr	192	200.00	-	38,400.00
Chemicals/drugs Manpower used	-	-	3,780.00	3,780.00
Total average loss due to parasitic diseases (NRs)				42,180.00

The average total loss estimated in Mandal hatchery was found NRs 47,970.00 including the cost of treatment NRs 7,200.00 and loss in value due to the reduced growth NRs 40,770.00

Table 12: Economic loss due to parasitic diseases in Mandal Hatchery Rupandehi

Factors	**Fish weight loss Kg/ha/yr**	**Market price of carps (NRS/Kg)**	**Cost of treatment (NRS)**	**Loss in value (NRS)**
Mortality carp fish/ha/yr	-	-	-	-
Reduced growth /ha/yr	163.08	250.00	-	40,770.00
Chemicals/drugs /manpower	-	-	7,200.00	7,200.00
Total average loss due to parasitic diseases (NRs)				47,970.00

The average total loss estimated in Dayanagar was found to be NRs 59,380.00, the loss due to the mortality was NRs 3,740.00,cost of treatment was NRs 4,160.00 and loss due to reduced growth was NRs 51,480.00.

Table 13: Economic loss due to the parasitic disease inDayanagar VDC

Factors	Fish weight loss Kg/ha/yr	Market price of carps (NRS/Kg)	Cost of treatment (NRS)	Loss in value (NRS)
Mortality carp fish/ha/yr	17	220.00	-	3,740.00
Reduced growth /ha/yr	234	220.00	-	51,480.00
Chemicals/drugs /manpower	-	-	4,160.00	4,160.00
Total average loss due to parasitic diseases (NRs)				59,380.00

The economic loss in Manmateriya was found to be NRs 43450.00, the loss due to the mortality was NRs 3,080.00, loss due to treatment was NRs 4,730.00 and the loss due to the reduced growth was NRs 35,640.00

Table 14: Economic loss due to the parasitic disease in Manmateria VDC

Factors	Fish weight loss Kg/ha/yr	Market price of carps (NRS/Kg)	Cost of treatment (NRS)	Loss in value (NRS)
Mortality carp fish/ha/yr	14	220	-	3,080.00
Reduced growth /ha/yr	162	220	-	35,640.00
Chemicals/drugs /manpower			4730.00	4,730.00
Total average loss due to parasitic diseases (NRs)				43,450.00

4.9 Total average loss estimated in Rupandehi District, 2016

The total average loss in value of Rupandehi was estimated as NRs 48,245.00/ha/yr. The maximum loss NRs 59,380.00 was found in Dayanagar VDC and minimum loss NRs 42,180.00 was estimated in FDC Bhairahawa. The average loss due to treatment was NRs 3,410.00 and the maximum (NRs 3,740.00) in Dayanagar. The average loss due to the treatment was NRs 4,967.5. It was maximum (NRs 7,200.00) in Mandal Hatchery. The average loss in value due to the reduced growth was NRs 41,572.5 which was maximum (NRS 51,480.00) in Dayanagar VDC.

Table 15: Total average loss due to infestation of parasites in Rupandehi, 2016

Selected area	Loss in value due to mortality (NRs)	Loss in value due to treatment (NRs)	Loss in value due to reduced growth(NRs)	Total average loss in value (NRs)
FDC Bhairahawa	-	3,780.00	3,8400.00	42,180.00
Mandal hatchery	-	7,200.00	40,770.00	47,970.00
Dayanagar VDC	3,740.00	4,160.00	51,480.00	59,380.00
Manmateria VDC	3,080.00	4,730.00	35,640.00	43,450.00
Total	6,820.00	19,870.00	1,66,290.00	1,92,980.00
Total average loss	3,410.00	4,967.5	4,1572.5	**48,245.00**

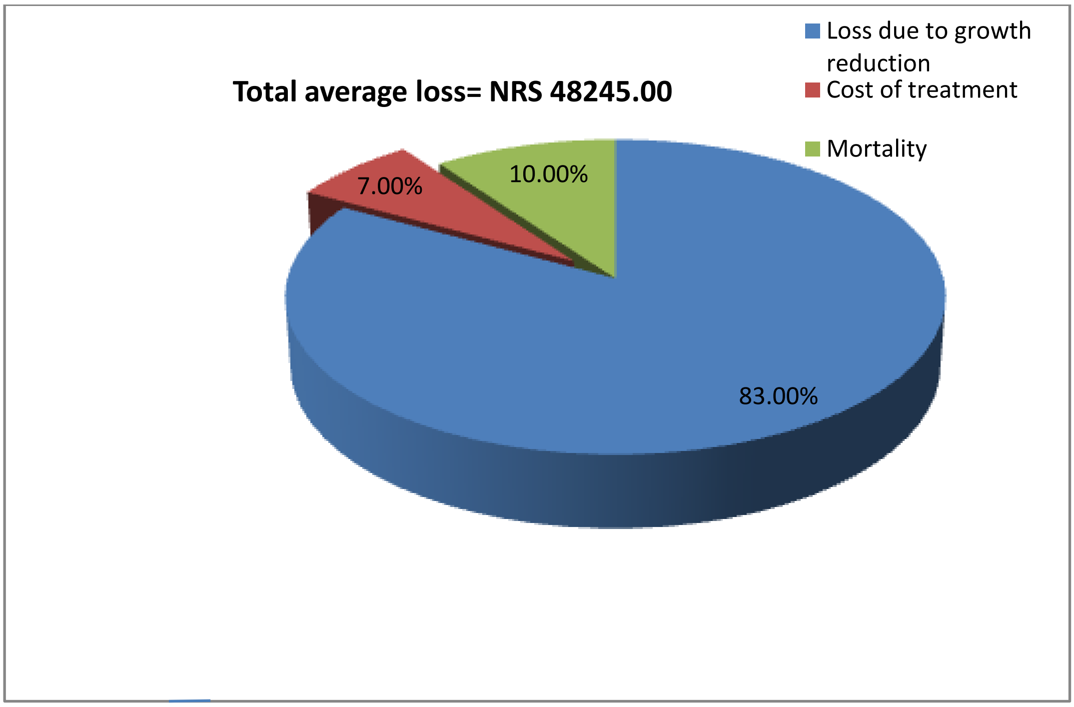

Fig 10: Estimation of los due to infestation of parasitic disease carp culture in Rupandehi, 2016

5. DISCUSSION

Parasitic infestation and disease pose the serious problem to the aquaculture pond farmers. Parasites are economically important elements that their infestation may pose the outbreak of the diseases in the carp ponds. They are liable for the heavy economic loss to the farmers' level and also to the nation's economic progress as a whole. The parasitic infestation may contribute the significant fish losses through the direct effects such as dermal ulceration, osmotic imbalance, physiological stress, immune suppression and other secondary infection. Aquaculture pond farmers are also found to be facing the challenges of substantial losses due to the indirect effects of fish louse infestation. The later is liable for the reduced fish growth, reduced feed conversion ratio (FCR) and market down grading (Mustafa *et al.*, 2001). Due to the direct and indirect infestation effect of the parasites *(Argulus*) the farmers are compelled to face the heavy losses in their pond farms which form the sole factor for the pessimistic result of the aquaculture industry.

The present study shows that the majority of the aquaculture pond farmers were educated up to secondary level education and yet they were found using the traditional system of culture practice. They were unknown to identify the parasites and the diseases that attack the fish in their ponds. But a very few of them were able to identify some ectoparasites like *Argulus*,*Lernaea* and fish leech and mentioned about the symptoms of the diseases which they could view externally.

The pond farmers used the basic method of pond preparation for the fish culture. The use of the cow dung or buffalo dung was found to be used by almost all pond farmers. In addition to the use of urea and DAP was also prevailed in the study area which showed that pond farmers were having the intension of the good fish production from their industry. The information collected from pond farmers of this area revealed that majority of them adopted the complete artificially prepared balanced diet and fulfilled all the needs and the requirement for the aquaculture practices. The research also showed that the culture system and the quality of feed and their feeding system was similar among the different study area of the district.

The aquaculture pond system practice in Rupandehi holds the different scale farmer level. Farmer's category on the basis of the pond area showed that people adopted their profession of the fish farming even as the small scale that meant for the less than 0.2 hector to the large scale more than 0.4 hector. This reflected their motive towards the aquaculture pond system instead of agriculture practice. Most of the rural people who had their piece of agricultural land now found to be turned to the fish farming. High economic income through low investment in the scenario of the both physical and economical aspects might be the pulling factors towards this profession. The average age of the pond farmers ranging from the 22-65 years indicated that there was the positive penetration towards aquaculture profession. High experience about this profession reflected that pond farmers were well trained and skillful to handle aquaculture system in the study area.

The scenario of the water quality parameter like pH, dissolved oxygen and temperature recorded during the study period in the different ponds of Rupandehi was found in normal range which indicated that the ponds were quite supportive for the aquaculture practice. The pH value of most of ponds in cultured area was ranging from 6.5- 9 optimum for the aquaculture pond farming and thus was considered best for the fish production. But some ponds of the study area where the pH was found lower than normal range which resulted the unexpected carp production of the study area. The study under such ponds showed that fish suffered by some parasites like *Argulus, Lernasea.*and *Piscicola.*

The DO is regarded as the important basis for the aquaculture practice since its range dropping below the normal range may influence directly to fish fauna of the ponds and it might lead to the mass mortality of the fish in aquaculture ponds. The dissolved oxygen concentration was found to be in the normal range in most of the pond of the study area which declared that these ponds were productive and well managed for the fish production. The pond farmers reported that during the cloudy days, the pond farmers faced the great challenges since the DO level used to fall below the normal range and fish used to move towards the surface to gulp the air which resulted the abnormal condition of fish due to the insufficient DO. The farmers reported that it was the great problem for them to face such situation in their ponds. Sometimes, the mass mortalities occurred was also reported due the decreased level DO level in ponds.

Different sorts of chemotherapeutics applied to control the parasites and diseases were reported by aquaculture pond farmers. The use of lime and salt together (34.55 %) was practiced by most of the aquaculture farmers followed by lime only (19.85 %) potash alum (13.97 %) , salt only (11.02 %), This result agrees with the Bagum (2013) which reported that liming and salting together was the most common practice for controlling the fish disease. Faruk *et al.* (2012) reported that mostly lime was applied in treating brood and health management. Lime is very effective in maintaining pH, water color, and turbidity, increase the rate of decomposition and to treat diseased fish. Sultana (2004) also observed that lime was very effective and widely used common chemical in Bangladesh.

The pond farmers also faced the challenges of fish health management (25%) as the prime constraint of pond management since pond farmers were unable to recognize the disease due to the lack of knowledge on fish disease, lack of any idea on treatment of disease, no any advisory services from the concern authority and lack of training facility in terms of fish disease treatment. So it seemed that pond farmers still were unable perfectly to declare the type of disease problem and parasitic infestation prevailed in their own pond. The pond farmers of the study area were on pure traditional long run of aquaculture practice. The farmers reported the problem created by the Siberian predating bird which used to attack the fish by entering inside the water. Some loss was also caused due to such bird in aquaculture ponds in this district. Lack of proper marketing and good preserving facility caused the farmers to face the problem in fishery profession. The overlapping of Indian fish in the local market was also giving the torture to the economic success of the local aquaculture pond farmers in this area.

The species wise prevalence of the parasitic infestation and disease accounted more ponds with the *Argulus* infestations. The parasitic infestation was found to prevail in accordance with the temperature. The increase in the temperature was favorable for the multiplication of the parasites and was found maximum in the May month. It was noticed that there was the positive correlation between the temperature and the parasitic multiplication. The correlation coefficient (r) between the temperature and the prevalence was found to be 0.653 and probable error 0.157which clearly defined that there was the strong positive correlation between the temperature and prevalence of the parasites. So the temperature of the water body (pond) showed the direct influence on parasitic multiplication. According to increase in temperature the parasitic prevalence, abundance and mean density was also found to be affected.

In this research the multiplication of the parasites was noticed maximum during the May month as the temperature reaches maximum. The prevalence, abundance and mean density all were maximum in this month. This result agrees more or less with Bichi and Bizi (2002) who noted that infection was peak in the rainy season in August, low in dry season in April. Seasonal variation in water quality has an effect on the abundance of pathogens and their ability to survive on a host. Appropriate water quality and proper stocking density should be maintained to minimize the risk of parasitic disease.

In the present study it was found that higher number of ectoparasites like *Argulus* and the *Lernea* were found on the skin of the fish. This research agrees with Delwer *et al.* (2010) who reported that the highest number of parasites was recorded on the skin and lowest number of parasites was found in the intestine of the examined carp fishes. They also reported that carps fishes are mostly infested by the skin parasites, which indicate the food prevalence and distribution pattern of parasites itself.

The results revealed that there was the highest parasitic prevalence in the Indian major carps *Cirrhinus mrigala* and *Labeo rohita* of the study area during the month of May. The Indian major carps were more susceptible to the parasitic (*Argulus*) prevalence. The parasitic infestation was found to be causing the more economic loss in this area. The economic loss due to the infestation of the parasites *(Argulus*) was estimated as NRs 48,245.00/ ha/yr which shared the loss due to the mortality was 3,410.00, cost of treatment NRs 4,967.5, loss in value due to the reduced weight NRs 41,572.50 /ha /yr. Furthermore the result showed that the loss due to mortality was 7%, the cost of treatment was 10% and loss due to the reduced weight shared 83 %. This result agrees more or less with the research of Monir *et al* (2015) who estimated loss of BDT 35,552.50 (US$ 444) ha-1 yr-1 in the aquaculture ponds in Bangladesh. They also reported that overall loss due to parasitic diseases were found 11% for carps mortality, 11% for chemicals or drugs cost and 78% for reduction of carps growth was taking place due to the the parasitic diseases during the study period.

Economic losses from the diseases are likely to increase as aquaculture expands and intensifies. The estimated economic loss due to the parasitic disease varied from farm to farm based on the intensity of infection, duration of infestation, stocking density and the management practice adopted by farmers. Mohan (1999) reported that ectoparasites like protozoans, monogenetic trematodes and fish lice are some of the very important pathogens that may have the notable impact on the yield in the carp hatcheries and seed production centers in India. Ahmed (2004) reported that the freshwater louse, *Argulus* caused mortality, growth and economic losses to the carp farms and hatcheries. They also reported that 7.6% loss of net profit in carp hatcheries and nurseries was occurred due to diseases. Nazneen (2014) estimated the loss due to the incidence of the diseases as BDT 24,870.00 and the disease controlling cost 3,460 /ha/yr.

The present result also agrees with the loss estimated due to Argulosis by Sahoo *et al.* (2013) which accounted ₹ 29524.40 (US$ 615) /ha /yr. Further, the loss was estimated to be ₹ 9.84 (0.146) /Kg carp production. Costello (2009) reported the similar sort of result that attributed the loss estimate for sea lice infestations fall within the range of € 0.1- 0.2 per kg fish produced annually. This further showed that out of the total estimated loss, 82% was due to reduced growth rate (reduction in production of biomass than expected), 8% due to mortality (direct reduction in biomass) and 10% was in the form of cost of drugs used for control of *Argulus* spp. Infestations.

Hasan and Ahmed (2002) stated that the economic loss due to disease was about 7.6% of the profit. These findings are more or less similar to this research. Mostly the carp farms and the hatcheries of the study area in this district were found to be suffered by the *Argulus* which was the chief parasite of each carp farms and hatcheries of this place and caused the significant economic loss to the pond farmers. The greatest financial loss due to the parasitic infestation could be attributed to the reduced growth rate which was possibly due to the poor food conversation ratio (FCR) in the infected fish. Sinnot (1998) reported that sea lice infested fishes were 5-15% lesser in weight due to reduced fish growth and suggested that 5% more feed was required to compensate the reduced FCR.

Economic loss due to Argulosis was estimated to be ₹ 67102.00 (US$ 1428) by Sahoo *et al* (2012)/ha/yr. taking into account factor like mortality, reduced growth rate, and costs associated with drug application. .Viswanatha, Bhatta and Shankar (2014) estimated the total financial loss ₹6202/acre in carp culture and ₹ 18,844/acre in prawn culture. On including health management costs, the average total loss was computed to be of ₹ 8094/acre in carp culture and₹ 21,980/acre in prawn culture in all the four districts of Andhra Pradesh. It was stated that 19% of the ponds were infected with *Argulus* and gill flukes in Indian major carps. The present research is also more or less similar with the above research since most of pond in the study area were infected by *Argulus* and it was the key ectoparasite responsible for the huge economic loss of the aquaculture industry in study area.

6. CONCLUSION

During the study, the different sorts of parasites and diseases were found in the study area. The most prevalent diseases recorded were Argulosis (37.66 %) followed by Red spot (14.28 %), Fungal disease (10.38 %), Unknown A (9.09%), Gill- rot (7.79%), unknown B (6.49 %), Dropsy (6.49%) Pisciculosis (5.19%) and Lerniasis (2.59 %). The total economic loss due to the infestation of parasites has been estimated as NRs 48245.00/ ha/yr. The study has revealed that the overall loss due to parasitic diseases was calculated to be 7% for mortality, 10% for treatment cost and 83% for reduction of growth of fishes in the study area. Thus, it is important to consider the parasitic infestations of the fishes an important aspect from the policy perspective when it comes to mitigating losses due to diseases in cultured fishes. This involves investment in research on fish parasites and development and implementation of efficient curative and effective preventive measures.

Rupandehi has the high potential for the aquaculture industry and the aqua- pond farmers are still traditional for the culture practice. The high priority must be given to improve the on growing technique and the training must be given to aqua-pond farmers in order to identify the common problems of their ponds regarding the parasitic diseases and their control, and its preventive measures. The government support and subsidy is needed to the farmers which might play the supportive role to improve their production and which may even be able to prevent from the huge economic losses.

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8. QUESTIONNAIRES

ANNEX- 1

1**. PERSONAL INFORMATION**

a. Name of Farmer…………………………………………………...Age………………

b. Address ………………………………………………………………………………..

c. Education………………………………………………………………………………

2. GENERAL INFORMATION

a. When did you first start fish farming? ………………………

b. Do you get any training for farming? Yes /No ☐ ☐
   If yes, from where: GOs NGOs Others

c. Land ownership Owned Leased
   If leased, lease money……………………………………/ ha. / Yr

d. Total area of farm…………………………………………

3. PRE STOCKING POND MANAGEMENT

a. Do you prepare your pond before start of culture? Y/N

b. Do you dry your pond? Y/N

c. Do you remove pond mud? Y/N

d. Do you remove the undesirable species? Y/N

e. Do you repair pond embankment? Y/N

f. Do you remove aquatic weeds?Y/N

g. Do you apply lime during pond preparation? Y/N
   If yes, dose………. ...kg/hector.

h. Do you apply fertilizer during pond preparation? Y/N
   If yes,
   Fertilizer Dose (kg/hector)
   Cow manure …………………………………………………
   Poultry manure ……………………………………………
   Urea. ………………………………………………………..
   TSP………………………………………………………...
   Others……………………………………………………

4. CULTURE STRATEGY

a. Type of culture: Monoculture ☐ Polyculture ☐

b. What is stocking density of fish into the pond ?.............

5. BIO-SECURITY ISSUES

Sources of water supply:

(i) Rain water (ii) Ground water (iii) Others ………………

a. Do you treat your water before use? Y / N
   If yes, what chemicals do you use?

b. Do you use different water source? Y / N
c. Do you disinfect the water distribution channel/tank?Y / N
   If yes, how often ……………………………………………………………………
d. Do you change water into the pond? Y / N
   If yes, how often ……………………………………………………………………
e. Do you measure water quality into the pond?
   If yes, what parameters do you measure?
   Temperature ☐ DO ☐ pH ☐ Ammonia ☐
   Others………………………………………………..
f. How often do you measure water quality?
Daily ☐ Weekly ☐ Bi-weekly ☐ Monthly ☐ Others…. ☐
g. Where do you discharge the water?
No discharge ☐ Near-by agricultural Land/canal ☐ Other ponds. ☐

Feeds /feeding/ waste management

a. Is there any storage facility of feed? Y / N
   If yes, duration of storage ………………. day /…………………week
b. Do you maintain proper storage condition?Y/N
   Temperature ☐ Light ☐ Humidity ☐ Moisture ☐
c. Do you check the feed/feed ingredients either contaminated or not? Y / N
d. Do you clean or disinfect your feed store room? Y / N
   If yes, how often…………………………………………………………………...
e. What kind of feed do you prefer and feed to your fish?
   Commercial pelleted fed ☐ Rice bran ☐
   Fish meal Wheat bran ☐
   Homemade feed ☐ Soyabean meal ☐
   Mustard oilcake ☐ None ☐
f. Do you control monitor the disease condition in your farm? Y / N
   If yes, how often Daily ☐ Weekly ☐ Biweekly ☐ Monthly ☐
g. Do you dispose disease pest/predator in your farm? Y / N
h. Do you use antibiotics/medicine in your farm? Y / N
   If yes, mention the name of antibiotics/medicine?
   i. Antibiotics…………………….
   ii. Dose…………………………..
i. Do you have any scope to enter wild fish to your farm from outside? Y/N
j. Is there any scope of entering pollutants/wastage to your farm from various sources? Y / N
   If yes, what are the sources? ☐
   Agricultural Industrial Household ☐ Others ☐
k. Is the farm surrounded by a boundary to control entry of wild animals? Y / N
l. Is there any sanitary latrine? Y / N
m. Is there any safe place to keep empty packet/pot? Y / N
n. Is there any Limitation on the movement of visitors? Y / N
o. Record keeping? Y / N

p. Do you take any preventive measures? Yes ☐ No ☐

If yes, what are those measures?

Pond drying ☐ Liming ☐ Weeding of pond ☐ Addition of water ☐

Others…………………………☐

6. Disease and Fish Health Management Issues

a. What types of disease do you find in your farm?

Name of Fish	Age/size of affected fish	Name of diseases with clinical signs	% of diseased fish	Pattern of death	Frequency

b. Have you ever observed any parasite on the fish skin? Y/N

c. What is the major disease occurring month/season of your fish?

d. Do you confirm disease outbreak by a laboratory? Y/N

e. Do you report to any government office about any disease outbreak inyour farm Y/N

f. Disease treatment:

Name of disease	Treatment used	Usually	Always	Never	Dose
	Lime				
	Salt				
	Potash alum				
	Formalin				
	Malachite green				
	Dipterex				
	$CuSO_4$				
	Vitamins				
	Antibiotics				

g. What problem do you face in control and treatment of fish diseases?

h. Do you get any assistance from GO/NGO/any government agencies for control and treatment of fish diseases? Y/N

If yes, types of assistance ……………………………………………

7. Production……………………………………..Ton /ha/year.

9. PHOTOPLATES

Photo: 1.

Photo: 2.

Photo 1, 2: Taking data with fishery officer Mr. Mahesh Chandra Gupta at Fishery Development Center Bhairahawa.

Photo: 3. Removing the parasites from the fish body in Mandal Hatchery

Photo: 4. Parasites in petridish

Photo: 5. Removing the Parasites from the infected fishfrom the fish body

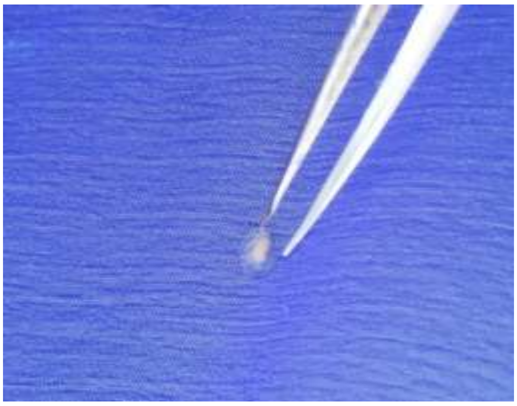

Photo: 6. Showing the Argulus removed

Photo: 7. Counting the Argulus removed from the infected fish.

Photo: 8. Mr. Rameshwar Mandal giving the data about his farm as per questionnaire.

Photo: 9.RameshwarMandal calculating the loss value of his farm

Photo: 10. Measuring the water temperature on parasite infested pond.

Photo: 11. Measuring Dissolved Oxygen on parasite infested pond.

Photo. 12. Observing the fish parasite and status of fish in pond of Dayanagar.

Photo: 13. Netting from parasite infested ponds

Photo: 14. Observing the parasites

Photo: 15. Fish with unknown disease A

Photo: 16. Pond farmers, fisherman and researcher .

Photo: 17. Collecting data from Punya prashadChaudharyManmateria at his farm office.

Photo: 18.Collecting data from pond farmer.