1. INTRODUCTION

1.1 Background

The Ostrich, or the 'camel bird' because of its similarities with dromedaries, was named in 1758 by Linnaeus as *Struthio camelus,* based on the Greek and Latin name Struthiocamelus (Bertram 1992). Ostrich (*Struthio camelus*) is the largest and heaviest living bird and is the only bird with just two toes and sole representatives of the order Struthioniformes (Alden et al. 1996). They are very good runners and scientifically called ratites because of the absence of the keel of the breast bone (Deeming 1999, Dingle and Shanawany 1999). The Ostrich has the largest eye of any land animal. Its eye is bigger than the world's smallest bird, the Bee Humming bird. Their eyes measures 2 inches (5 cm) across (animal corner 2013). When fully grown, an Ostrich has one of the most advanced immune systems known to mankind (animal corner 2013). Ostrich skeletons and fossils have been found dating back over 120 millions years which means Ostriches are true dinosaurs (animal corner 2013). Ostriches are attracted to small, shiny objects and peck curiously at them. Small head, bigger eyes, long neck and legs are the peculiar characteristics of Ostriches.

A male Ostrich is called a rooster, female as hen and baby Ostrich as chick. A group of Ostriches is called herd. Ostriches can grow to measure 1.7-2.8 meters (5.5-9.4 feet) in height and weight 130-150 kg. Despite being flightless Ostriches have small wings that are covered with fluffy feathers. The wings are too small to lift the ostriches heavy bodies off the ground and into the air but are used as rudders to change direction when it is running. Their massive leg muscles enable them to deliver a powerful kick which could seriously injure or even kill an attacker. However, Ostriches can only kick forwards (animal corner 2013). Ostriches contain their main musculature in the hips and thighs. The long legs enable them to run at speeds of over 65 km per hour (40 miles per hour). A male Ostrich has a black plumage with white wing tips, however, female and chicks have a brownish, more duller plumage which helps them camouflage. The Ostrich do not posses a gallbladder or crop but instead has a glandular stomach called proventriculus. The proventriculus leads to a muscular stomach called ventriculus which contains grit, rocks and other materials that helps break down food and allows it to pass into the small intestine. As in most birds, Ostrich posses a cloaca. It is a common site for excretion for both urinary tract and the digestive tract. Ostrich uses air sac system to reduce body heat by panting (animal corner 2013). Ostrich typically eat plants, roots and seeds but also eat insects, lizards or other creatures available in their sometimes harsh habitat.

Ostriches become sexually mature between two and four years of age although females mature around six months earlier than males. The life span of an Ostrich can be upto 75 years (animal corner 2013). During the breeding season around March/April, male Ostriches fight for harems of 2-7 females with which to mate with. They defend their territory by patrolling and displaying and by making loud booming calls. A female Ostrich can lay averaging about 60 eggs per year. Ostrich eggs are around 16 centimeters in length, weigh three pounds and are glossy and cream in colour. They are the largest bird eggs of all (animal corner 2013).

Ostriches produce red meat that is very similar in taste and texture to veal and beef (Du Preez 1991, Anonymous 1994). The demand for Ostrich meat in the international market has been due to its high protein and low cholesterol level (Shanawany 1996). Ostrich feathers are used to clean fine machinery and equipments as well as for aesthetics and in the fashion industry (Shanawany 1994). The medicinal importance of Ostrich in humans includes corneal transplantation of Ostrich eyes to enhance vision and use of its brain tissue to treat Alzheimer's disease (Shanawany 1994). Furthermore, the tendons of the Ostrich leg are used to replace torn tendons in human legs (Shanawany 1994).

Wild Ostriches are confined to the drier parts of Africa, generally from south of the Sahara to Cape Province, extending also to Southern Morocco, the Northern Sudan and Southern Egypt (Dingle and Shanawany 1999). The first successful artificial hatching took place in 1857 in Algeria (Smit 1963). The invention of the artificial incubator for Ostrich eggs by Arthur Douglass in 1869 provided a major stimulus for Ostrich farming (Smit 1963). Ostrich farming has been commercially practiced from 1860's at the Cape Colony of South Africa and has been breed successfully now in Canada, the United States, Australia, Spain, Italy, UK and many others European countries (Huchzermeyer 1994). Outside South Africa, only a few larger –scale operations exist in the USA, Australia and Europe (Deeming 1999). Most European countries have been developing ostrich farms since around 1990's based on stock imported from Africa and Israel and have reached the slaughter market (Deeming and Angel 1996).

1.2 Ostrich diseases

Most health problems in Ostriches occur during the first three months of life with mortality ranging between 30-40% which is commonly accepted as many as normal (Deeming 1999). Mortality and health problems diagnosed mainly in chicks and juveniles include starvation and malnutrition, intestinal obstruction, leg abnormalities and coliform infections. Other problems include improper handling and genetics (Lister 2003). Although there are several others factors that can affect Ostrich farming and production, infectious and non-infectious diseases and nutritional deficiencies are some of the major constraints to a viable Ostrich farming (Hallam 1992). Ostrich raised in captivity are susceptible to various gastrointestinal parasitic infections. The major gastro intestinal parasites reported in Ostriches are: *Cryptosporidium* spp. (Allwright and Wessels 1993, Bezuidenhout et al. 1993, Gajadhar 1993, Penrith et al. 1994, Jardine and Verwoerd 1997, Huchzermeyer 1999, Sotiraki et al. 2001, Ponce Gordo et al. 2002, Santos et al. 2005, Nemejc and Lukesova 2012), *Isospora* spp. (Yakimoff 1940, Jansson and Christensson 2000, Ponce Gordo et al. 2002), *Eimeria* sp. (Jensen 1992, wade 1992, Mushi et al. 1998, Sotiraki et al. 2001, Ponce Gordo et al. 2002, mushi et al. 2003, Ibrahim et al. 2006, Eslami et al. 2007, Mshelia et al. 2010, Nemejc and Lukesova 2012), *Balantidium* spp. (Hegner 1934, Jansson and Christensson 2000, Sotiraki et al. 2001, Ponce Gordo et al. 2002, Ederli and Oliveira 2008), *Entamoeba* spp. (Craig and Diamond 1996, Jansson and Christensson 2000, Martinez Diaz et al. 2000, pennycott and Patterson 2001, Sotiraki et al. 2001, Ponce Gordo et al. 2002), *Histomonas* sp. (Borst and Lambers 1985, Clipsham 1995, Deeming 1999, Jurajda 2002, Ponce Gordo et al. 2002), *Trichomonas* spp. (Jurajda 2002, Ponce Gordo et al. 2002), *Giardia* spp. (Ponce Gordo et al. 2002).

Philophthalmus gralli, a trematode (Greve and Harrison 1980, Dingle and Shanawany 1999, Cooper 2005, Kocan and Crawford 2007), *Houttuynia struthionis*, a cestode (Dingle and Shanawany 1999, Jurajda 2002, Ponce Gordo et al. 2002, Cooper 2005, Blood et al. 2007, Taylor 2007), *Libyostrongylus* spp. (Nel 1980, Barton and Seward 1993, Hoberg et al. 1995, Dingle and Shanawany 1999, Pennycott and Patterson 2001, Sotiraki et al. 2001, Ponce

Gordo et al. 2002, Mckenna 2005, Yaman and Durgut 2005, Bonadiman et al. 2006, Ibrahim et al. 2006, Blood et al. 2007, Taylor et al. 2007, Tisljar et al. 2007, Mshelia et al 2010, De Andra et al. 2011, Nemejc and Lukesova 2012), *Codiostomum struthionis* (Huchzermeyer 1994, Deeming 1999, Dingle and Shanawany 1999, Jansson and Christensson 2000, Sotiraki et al 2001, Huchzermeyer 2002, Jurajda 2002, Ponce Gordo et al. 2002, Blood et al. 2007, Taylor et al. 2007, Ederli et al. 2008, De Oliveira et al. 2009, Fagundes et al. 2012, Nemejc and Lukesova 2012), *Capillaria* sp. (Ponce Gordo et al. 2002, Ibrahim et al. 2006), *Heterakis dispar* (Eslami et al. 2007), *Ascaridia* (Yamaguti 1961, Ponce Gordo et al. 2002, Ibrahim et al. 2006).

The major ectoparasites reported in Ostriches are: *Struthiolipeurus struthionis* (Van Heerden et al. 1983, Jefferey 1996, Huchzermeyer 1998, Hoover et al. 1998, Jurajda 2002, Cooper 2005, Yamon and Durgut 2005, Cooper and EI Doumani 2006, Taylor et al. 2007), *Struthiolipeurus nandu, S. rheae* (Ponce Gordo et al. 2002, Yaman and Durgut 2005, Taylor et al. 2007, Almeida et al. 2008), *Gabucinia bicaudata* (Jefferey 1996, Huchzermeyer 1998, Deeming 1999, Jurajda 2002, Ponce Gordo et al. 2002, Cooper 2005, Cooper and EI Doumani 2006, Taylor et al. 2007), ticks (*Hyalomma* spp., *Ambylomma* spp., *Rhipicephalus* spp.) (Mertins and Schlater 1991).

The multifactorial diseases reported in Ostriches includes; Yolk-sac retention and infection, Enteritis,Gastricstasis, Impaction, Leg deformation, Respiratory disease (Avian pneumonias), Bacterial infections (Mycobacteriosis, Megabacteriosis, Anthrax, Fibrinopurulent tracheitis, Pneumonia, Pericarditis and Perihepatitis), Fungal infections (Dermatitis, Aspergillosis, Candidasis, Beak deformation, gastric stasis), Viral infections (New castle disease, Avian influenza, Crimean-Congo haemorrhagic fever, Eastern and Western equine encephalitis, Borna disease, Fowl pox, Chick fading syndrome, Wesselsborn disease), Spongiform encephalopathy (Deeming 1999). A sound management prevents infection whish is better than cure (Lister 2003). John and Thirunavukkarasu (2006) reported that nutrition and housing are particularly important in disease assessment and are thus important for optimal health management.

1.3 Ostrich farming in Nepal

Ostrich Nepal Pvt. Ltd. has been established in the year 2010 in Gangoliya VDC-1, Rupandehi, Nepal. It has started the farming with an initial investment of Rs 300 million in around 20 bighas (around 13.54 hectares) areas of land. At present there are 890 adult Ostriches along with 200 emus. The company based in Gangoliya of Rupandehi is planning to expand farming to Beljhungdi of Dang with additional investment of Rs 50 million. Ostrich Nepal has taken around 100 hectares of land owned by Mahendra Sanskrit university in Beljhundi on a 20 years lease (Republica 2013). Veterinary problems of Ostrich farming and production such as endoparasitism which can negatively affect production need to be investigated in the farm in order to enrich the farming system and overall economy of Nepal.

1.4 Objectives of the study

1.4.1 General objective:

- To determine the parasitic impediments of Ostrich farming in Gangoliya, Rupandehi.

1.4.2 Specific objectives:

- To determine the prevalence of gastrointestinal parasites of Ostriches.
- To find out the distribution of Ecto and Endo parasites of Ostriches.
- To find out the present status of Ostrich management system in the farm.

1.5 Significance of the study

Ostriches are prone to various parasitic diseases due to their coprophagic nature which directly hampers the Ostrich farming industry. Till date there is no any studies carried out regarding parasitic impediments and overall health status of Ostrich in the farm (Gangoliya - 1, Rupandehi). Hence this study will help to document overall health status of Ostrich particularly parasitic impediments to improve Ostrich farming system in Nepal.

2. LITERATURE REVIEW

2.1 Parasitic diseases of Ostriches

The Ostrich is the largest living species of birds and lays the largest eggs of any living birds. It is also the sole representatives of the order struthioniformes (Alden et al. 1996). Small head, bigger eyes, long neck and legs are the peculiar characteristics of Ostriches. The feathers of adult males are mostly black, with white primaries and a white tail. Females and chicks are grayish brown. Ostriches can tolerate a wide range of temperature. In much of their habitat, temperatures vary as much as 40° C (100° F) between night and day.

The invention of the artificial incubator for Ostrich eggs by Arthur Douglass in 1869 provided a major stimulus for Ostrich farming (Smit 1963). Its farming has been commercially started from "1860s" at the cape colony of South Africa. Before "1980s" Ostrich farming were practiced for its feathers only but after "1980s" they were farmed for their skins, meats, fats, feathers, and bones which have high value in international markets. Besides South Africa successful farming were done in USA, Australia and many other European countries. Their feathers were used to make hytek duster, carnimal dress, fashion dress, like wise skins were used to make high quality fashion wear, bags, belts, shoes. Its fats were used in cosmetic products like oil, cream, lotion. In Nepal 50-55 percent humidity and 90° to 99° F temperature is required for Ostrich farming.

Ostrich are susceptible to various diseases like coccidiasis, nematodiasis, respiratory diseases, bacterial, fungal and viral infections. The major ignorance part in this farming is its diseases. Although coccidiasis do not directly affect Ostriches but it can cause bloody diarrohea, weight loss, growth retardation, delay in egg laying which provides direct negative impact in the farming. Careless management practices, high bird density and confinement stress are the major threats in Ostrich farming (Dingle and Shanawany 1999).

As all other higher organisms Ostrich are also suffered from both ecto and endoparasites. The prevalence of internal parasites in hand raised ostriches is low in comparison with pasture raised or free roaming birds. Ostriches may be infested with their own specific parasites as well as with external and internal parasites of other birds, some parasites of ruminants and raccoons (Eslami et al. 2007). The economic impact of most of the ratite parasites are still unknown. Further detailed analysis are needed to determine not only the host-specific status of ratite parasites, but also the risk of infection for other animals and humans (Ponce Gordo et al. 2002). Many species can parasites Ostriches including nematodes, cestodes, trematodes, protozoans besides ectoparasites such as Ixodidae, Acarina which can acts as zoonosis vectors.

2.1.1 *Endoparasites or Internal parasites*:

Parasites of the digestive system (proventriculus, gizzard, small intestine and large intestine), as well as those of respiratory and circulatory system infest ratites. No parasites of the nervous system of veterinary importance were reported in them (Taylor et al. 2007). In Ostriches mainly protozoans and helminthes parasites have been reported.

a. *Protozoans parasites*:

A number of intestinal protozoans including *Hexamita*, *Giardia*, *Trichomonas*, *Cryptosporidium* (Deeming 1999, Chang Reissig et al. 2001, Ponce Gordo et al. 2002, Cooper 2005) and *Toxoplasma* have been isolated from Ostrich chicks. Often, they cause serious diarrhoea in ratites.

1. Coccidia:

There are at least two *Cryptosporidium* species infecting Ostriches have been reported (Sotiraki et al. 2001, Santos et al. 2005, Nemejc and Lukesova 2012). One with molecular, biological and morphological characteristics related to *C. baileyi* and another morphologically similar to *C. meleagridis* (Santos et al. 2005). *Cryptosporidia* complete their biological cycle on the surface of epithelial cells of the digestive and respiratory system of birds, mammals and reptiles (Ponce Gordo et al. 2002, Santos et al. 2005). *Cryptosporidium* species have been shown to infect the bursa, the rectum and the pancrease of Ostrich chicks. In South Africa coccidioses caused an outbreaks of cloacal prolapsed particularly in male Ostrich chicks, with severe losses (Allwright and Wessels 1993, Bezuidenhout et al. 1993) and enteritis (Huchzermeyer 1999). *Cryptosporidia* have also been reported in the faeces of imported Ostriches in Canada (Gajadhar 1993). In Europe, *Cryptosporidium* oocysts have been found in Ostriches from Greece (Sotiraki et al. 2001), Spain, Portugal, Netherlands, Belgium, Great Britain, France (Ponce Gordo et al. 2002).

Few reports have indicated the presence of *Isospora* and *Eimeria* in ratites. There is only one species described in this group of birds i,e *Isospora struthionis* from an Ostrich at a Russian Zoo (Yakimoff 1940). Other specimens have been designated as *Isospora* sp. (Jansson and Christensson 2000, Ponce Gordo et al. 2002) or *Eimeria* sp. (Sotiraki et al. 2001, Ponce Gordo et al. 2002). Both genera can be differentiated on the basis of the number of sporocysts. *Eimeria* oocysts have been reported in Ostriches from Nigeria (Ibrahim et al. 2006, Mshelia et al. 2010), Iran (Eslami et al. 2007), Czech Republic (Nemejc and Lukesova 2012), Botswana (Mushi et al. 1998, Mushi et al. 2003), North America (Jensen 1992, Wade 1992) and in different state of Europe (Ponce Gordo et al. 2002). According to Deeming (1999) no outbreaks of coccidiosis in farmed Ostriches have been documented.

2. Ciliates:

Balantidium struthionis (Hegner 1934, Ponce Gordo et al. 2002, Ederli and Oliveira 2008) is a ciliate and a normal inhabitants of Ostrich intestine, probably capable of becoming some what pathogenic under favourable conditions. Its cysts could also be mistaken for coccidial oocysts (Deeming 1999, Jurajda 2002). This species is considered as Ostrich specific (Sotiraki et al. 2001). A second unidentified *Balantidium* species, whose cysts are larger than those of *B. struthionis* has been described from rheas (Huchzermeyer 1999). In Sweden, Jansson and Christensson (2000) found a ciliate from Ostriches that they classified as *Balantidium* sp.

3. Amoebae:

Entamoeba cysts forming groups include non-pathogenic species, some of them described from birds: *E. gallinarum* of the eight –nucleate mature cysts group (or *E. coli* –like group), inhabits the caeca of Chicken, Turkey and Partridge (Levine 1985, Cordero de Campillo et al. 1994) and a non determined species of the one –nucleate mature cysts group (or *E. bovis* –like group) has been found in the caeca and large intestine of Ostriches (Craig and Diamond 1996, Martinez Diaz et al. 2000). This *E. bovis* –like amoeba has also been reported in

Rheas. *Entamoeba* sp. have been reported from Ostriches in Spain, Portugal, Belgium, France, Great Britain, The Netherlands (Ponce Gordo et al. 2002), Greece (Sotiraki et al. 2001), Scotland (Pennycott and Patterson 2001), Sweden (Jansson and Christensson 2000). The other type of amoebae found were *Endolimax* and *Iodamoeba* (Sotiraki et al. 2001, Ponce Gordo et al. 2002). These species were frequently found in the faecal samples of Ostriches and to a lesser extent Rheas. Both amoebae seem to be non –pathogenic for ratites.

4. Flagellates:

One of the most important flagellates species is *Histomonas meleagridis*, a parasites of Turkeys and other gallinaceous birds and cause inflammation of caeca and liver (typhlohepatitis). It can infect Ostriches in close contact with such birds and cause a similar diseases (Borst and Lambers 1985, Clipsham 1995, Deeming 1999, Jurajda 2002, Ponce Gordo et al. 2002). It is considered that its main transmission is through the eggs of the nematode *Heterakis gallinarum* (Levine 1985) and *Ascaridia dissimilis* has been also proposed (Norton et al. 1999).

A *Trichomonas* (flagellate) infection can be acquired by Ostriches via contact with Pigeons and Doves. It causes pseudomembraneous lesions in the upper digestive tract (Deeming 1999, Jurajda 2002). Morphologically compatible *Trichomonas gallinae* like trophozoites were found in the lower digestive tract of healthy Ostriches indicating that this species can live in more locations than previously considered (Ponce Gordo et al. 2002). Since Trichomonads do not form cysts (Levine 1985) their transmission should be by ingestion of live trophozoites in faeces.

References to *Hexamitids* in ratites were from Ostriches and rheas, where they were described as *Giardia* sp. (Clipsham 1995, Tully and Shane 1996, Huchzermeyer 1999). Two species of *Spironucleus* have been described from birds: *S. meleagridis* in Turkey and other poultry and *S. columbae* from pigeons. Both species are pathogenic to their hosts (Levine 1985). On the basis of morphology and in vivo movement, flagellates compatible with have *S. meleagridis* been found in several Ostriches (Ponce Gordo et al. 2002). The specific identification of the trophozoites and cysts of *Giardia* sp. found in Ostriches and Rheas is not possible until electronic microscopy studies are performed (Ponco Gordo et al. 2002).

Monocercomonas sp., *Chilomastix gallinarum* and *Pleuromonas* sp. were fairly common parasites of Ostriches that seems to be non pathogenic for them (Ponce Gordo et al. 2002). Trophozoites of *Retortamonas* sp. have been found in the intestinal contents of Ostriches and seems to be non-pathogenic (Martinez Diaz et al 2001, Ponce Gordo et al. 2002).

5. Others:

Under favourable circumstances, Ostriches are susceptible to infection with species of *Plasmodium* transmitted by Mosquitoes (Fantham and Porter 1943, Deeming 1999, Jurajda 2002, Cooper 2005). *Leucocytozoon struthionis*, a parasites of the circulatory system is transmitted by arthropods (black flies) and commonly infects Ostrich chicks in South Africa without causing clinical disease (Bennett et al. 1992, Huchzermeyer 1994, Deeming 1999, Cooper 2005, Taylor et al. 2007). Treatment and control has not been reported yet (Taylor et al. 2007).

b. Helminths:

1. Trematodes:

The only trematodes species described from Ostriches is *Philophthalmus gralli*, which was found in the nictitating membrane of Ostriches in Florida (Greve and Harrison 1980). It is extremely small, no longer than 2-3 mm (Dingle and Shanawany 1999, Cooper 2005). It was reported to cause severe eye irritation and discharge in captive Ostriches in Florida (Kocan and Crawford 2007). An unidentified trematode sp. was found by Ponce Gordo et al. (2002) in Europe.

2. Cestodes:

Houttuynia struthionis is a tapeworm that belongs to the family Davaineidae. It is a parasite of the small intestine and major endoparasite of the Ostrich and Rhea. It causes unthriftiness and diarrhoea mainly in Ostrich chicks (Jurajda 2002, Ponce Gordo et al. 2002, Blood et al. 2007). Frequent occurrence of this tapeworm was reported in chicks and pasture raised Ostriches in South Africa (Dingle and Shanawany 1999, Jurajda 2002). The tapeworm has also been spread to Europe with Ostriches imported from Africa and it was diagnosed sporadically in the USA, too (Jurajda 2002, Cooper 2005). Ostrich chicks are the most susceptible and show signs of infestation very slowly: gradual loss of condition, lethargy and anaemia, loss of appetite, sometimes accompanied by mild diarrhoea (Dingle and Shanawany 1999, Taylor et al. 2007). Diagnosis can be made by observing mature tapeworm segments looking like white grains of rice in the faeces, observing eggs in the faeces and by floatation laboratory techniques (Dingle and Shanawany 1999, Cooper 2005). The anoplocephalid cestode *Monoecocestus rheiphilus* was identified in Rhea americana (Uhart et al. 2006).

3. ***Nematodes*:**

The nematode *Libyostrongylus* (wireworm) is one of the most important pathogens for Ostriches, producing a disease known as 'vrootmag' or 'rotten stomach' which can cause high mortalities among juvenile Ostriches (Nel 1980, Foggin 1992, Dingle and Shanawany 1999, Mushi et al. 2003, Mustapha 2003, Lordman and Bronneberg 2004) and occasionally also to adults (Jansson and christensson 2000). In 2000, Jansson and Christensson reported the first finding of *L. douglassii* in Emus (*Dromaius novaehollandiae*). It belongs to a genus of nematodes in the family Trichostrongylidae (Yaman and Durgut 2005, Blood et al. 2007, Taylor et al. 2007). Wireworms are very small, round, wire-like, yellowish redworms of about 3mm long, male being 4-6mm and female 5-6mm long (Taylor et al. 2007). Mature worms and late larval stages lives in the openings of the deep proventricular glands and under the koilin layer of proventriculus and gizzard (Deeming 1999). Clinical signs of infection includes anorexia, weight loss and anaemia (Blood et al. 2007, Tisljar et al. 2007, Bonadiman et al. 20060. Three species of *Libyostrongylus* have been reported in Ostriches: *L. douglassii*, *L. magnus* and *L. dentatus.* Of these, only *L. douglassii* and *L. dentatus* have been reported outside Africa (Hoberg et al. 1995) and they can be differentiated exclusively on the basis of adult morphology (Hoberg et al. 1995). *L. douglassii* has been reported in Ostriches from Portugal, Spain, Belgium, Netherlands (Ponce Gordo et al. 2002), Australia (Barton and Seward 1993), Sweden (Jansson and Christensson 2000), Greece (Sotiraki et al. 2001), Czech Republic (Nemejc and Lukesova 2012), Croatia (Tisljar et al. 2007), Brazil (Bonadiman et al. 2006, De Andra de et al. 2011), Nigeria (Ibrahim et al. 2006, Mshelia et al. 2010), Iran (Eslami et al. 2007), New Zealand (Mckenna 2005). In Ukarine *L. magnus* was reported in Ostriches originating from Ethiopia and *L. dentatus* in USA originating from Tanzania (Huchzermeyer 2002).

Codiostomum struthionis is a slightly larger roundworm that inhabits in the large intestine and caeca of the Ostriches and it interferes with water absorption (Huchzermeyer 1994, Deeming 1999, Dingle and Shanawany 1999, Jurajda 2002, Blood et al. 2007, Ederli et al. 2008). *Codiostomum* is about 1-1.5cm long and white (Dingle and Shanawany 1999, Taylor et al. 2007). These nematodes feeds on the caecal mucus (Ederli et al. 2008). It's lifecycle has not been yet determined but it is believed to be simple and direct (Taylor et al. 2007, Ederli et al. 2008). It's eggs closely resemble to those of the *Libyostrongylus* (Deeming 1999, Ponce Gordo et al. 2002). It is relatively harmless (Huchzermeyer 1994) but heavy infestations are likely to be dangerous (Jurajda 2002, Blood et al. 2007). Treatment and control are the same as for *Libyostrongylus* spp. (Taylor et al. 2007). Besides Spain and Great Britain (Ponce Gordo et al. 2002), the data published indicate the presence of *C. struthionis* in Sweden (Jansson and Christensson 2000), Greece (Sotiraki et al. 2001), Brazil (de Oliveira et al. 2009, Fagundes et al. 2012), Equator (Dzoma and Dorrestein 1998), South Africa (Huchzermeyer 2002, Warmser 1930), Czech Republic (Nemejc and Lukesova 2012).

Capillaria sp. a nematode was recorded in the faecal samples of both captive and free-living Ostriches in North east Nigeria (Ibrahim et al. 2006) and also in different states of Europe (Ponce Gordo et al. 2002). Ova of *Capillaria* were found in greater Rheas faeces (Uhart et al. 2006). Eggs of *Capillaria* sp. were also found in lesser Rheas (Chang Reissing et al. 2001). *Capillaria parvum spinosa* has been described from Rheas in Europe (Yamaguti 1961) and Jansson and Christensson (2000) found *Capillaria* sp. eggs in Emu samples. *Heterakis dispar*, a nematode common in poultry was recorded in the alimentary canal of Ostriches on a farm in Iran (Eslami et al. 2007). It was the first report in Ostriches. *Baylisascaris* is a nematode which is transimitted to Ostriches in the USA by Skunks or Raccoons through faecal materials in which the eggs remain viable in the soil for years (Cooper 2005). It is a neurotropic parasite that cause CNS lesions and signs (Cooper 2005). *Struthiofilaria megalocephala* that affect body cavity of an Ostrich and *Paronchocerca struthionis*, a filariad nematode is a parasite of the respiratory system recovered from the lungs of an Ostrich in West Africa (Jurajda 2002). *Dicheilonema spicularum* is a filariad nematode parasiting in the subperitoneal connective tissue (Jurajda 2002).

Ascaridia struthionis has been reported from Ostriches in Italy (Yamaguti 1961), *Ascaridia* sp. in North Eastern Nigeria (Ibrahim et al. 2006), in different state of Europe (Ponce Gordo et al. 2002). *Deletrocephalus dimidiatus* is a strongylid nematode parasite of the small intestine of greater and lesser Rheas (taylor et al. 2007). The lifecycle is thought to be direct with birds ingesting infective larvae while foraging (Taylor et al. 2007). It is wide spread in South America, North America and Europe (Taylor et al. 2007).

2.1.2 *Ectoparasites or External parasites*:

Several species of ectoparasites affect ratites of all ages, both ratite specific and non –specific parasite species. Birds infested with ectoparasites generally exhibit irritation and react by scratching. Lice and Mites can be found by examining the skin and feathers, especially around the vent, legs, wings and neck (Dingle and Shanawany 1999). Feather lice (*Struthiolipeurus struthionis*) do not suck blood but feeds on the feathers, resulting in skin damage, pruritius and excessive feathers preening and losses in Ostriches. The lice and eggs can be seen in feathers close to the skin (Van Heerden et al. 1983, Jefferey 1996, Hoover et al. 1998, Huchzermeyer 1998, Jurajda 2002, Cooper 2005, Yaman and Durgut 2005, Cooper and EI Doumani 2006, Taylor et al. 2007). They are narrow bodied lice with large heads (Taylor et al. 2007). It is difficult to spot them as they can easily vanish under feathers. *Struthiolipeurus* eggs are deposited on feather barbs on both sides along the shaft (Van Heerden et al. 1983, Deeming 1999). A variety of other lice may also be found on Ostrich including *Struthiolipeurus nandu*, *S. rheae* (Ponce Gordo et al. 2002, Yaman and Durgut 2005, Taylor et al. 2007, Almeida et al. 2008), *Struthiolipeurus stresemanni* (Yaman and Durgut 2005,Taylor et al. 2007). In Rheas, infections were caused by *S. rheae* or *S. nandu* but not by both species at the same time (Ponce Gordo et al. 2002).

Ostrich quill mites or shaft mites or feather mites (*Gabucinia bicaudata*) live in the vein in the ventral groove of the feather shaft and feeds on blood and gelatinous contents of the feather sheath. They can be visualized as small, reddish, dust like elongated particles in the feather vein (Jefferey 1996, Huchzermeyer 1998, Deeming 1999, Jurajda 2002, Ponce Gordo et al. 2002, Cooper 2005, Cooper and EI Doumani 2006, Taylor et al. 2007). Other mites reported in Ostriches were *Gabucinia sculpturata* (Taylor et al. 2007), *Dermoglyphus pachycnemis* (Ponce Gordo et al. 2002), *Struthiopterolichus bicaudatus* (Almeida et al.

2008). The Hippoboscid fly (*Struthiobosca struthionis*) spends most of it's time on the host, only flying directly across to another Ostrich and irritates it's host by sucking blood (Ormerod 1900, Mertins and Schlater 1991, Huchzermeyer 1998, Jurajda 2002). A number of ticks of various species (*Hyalomma* spp., *Ambylomma* spp., *Rhipicephalus* spp.) were reported in Ostriches, their main significance being disease vectors (Mertins and Schlater 1991, Huchzermeyer 1994, 1998, Jefferey 1996, Deeming 1999). High infestation is associated with areas of high rainfall and dense vegetation (Dingle and Shanawany 1999, Cooper 2005). The ticks are found under the chin (Deeming 1999). Mosquitoes and blackflies (*Simulim* spp.) regularly feed on Ostriches and in addition to causing irritation and stress they can also transmit a number of infectious diseases (Beavers 1990, Huchzermeyer 1994, 1998). *Riphicephalus* sp. has been reported from Ostriches in Portuguse farms (Cortes et al. 1999). Some species of family of Cullicoides acts as a vectors of *Plasmodium struthionis* and *Leucocytozoon struthionis* and mechanical transmitters of Fowlpox virus or filariosis in Ostriches (Deeming 1999, Mushi et al. 1999). Infestations by lice, flies, mites and ticks can be treated by regular and through spraying with synthetic pyrethroids or by dosing or injecting with Ivermectin (Huchzermeyer 1998). Preparations containing Lindane should not be used as this is highly toxic to Ostriches (Jansen et al. 1992).

So in general till date a total of 17 species of Protozoan, two species of Trematodes, two species of Cestodes and nine species of nematodes has been reported as endoparasites in Ostriches. As ectoparasites four species of Lice, four species of mites and 10 species of Ixodid ticks has been reported in Ostriches. Bacterial, Fungal and Viral infections are the most notable impact in Ostriches besides protozoan and nematode parasites. It leads direct losses in the farming. Regarding to above literature review lots of research has to be done in Ostriches inorder to enhance the Ostrich farming system.

3. MATERIALS AND METHODS

3.1 Glasswares:

I. Slides
II. Cover slips
III. Test tubes
IV. Measuring cylinders
V. Glass rods
VI. Stands
VII. Beakers

3.2 Chemicals required:

I. Potassium dichromate (2.5%)
II. Normal saline
III. Lugol's Iodine solution
IV. Saturated NaCl solution
V. Saturated ZnSO4 solution
VI. Saturated Sucrose solution

3.3 Equipments:

I. Electric balance
II. Incubator
III. Refrigerator
IV. Centrifuging machine
V. Electric microscope
VI. Stagemicrometer
VII. Oculomicrometer

3.4 Study area:

Ostrich Nepal pvt. Ltd., Gangolyia-1 Rupandehi, Nepal (The only one Ostrich farm in Nepal). Gangolyia is situated three km. east from Madhaulia, Siddhartha highway. It has tropical climate. Summer is warm with monsoon while winter is cool, dry and humid. The average temperature ranges from 25° C to 37° C.

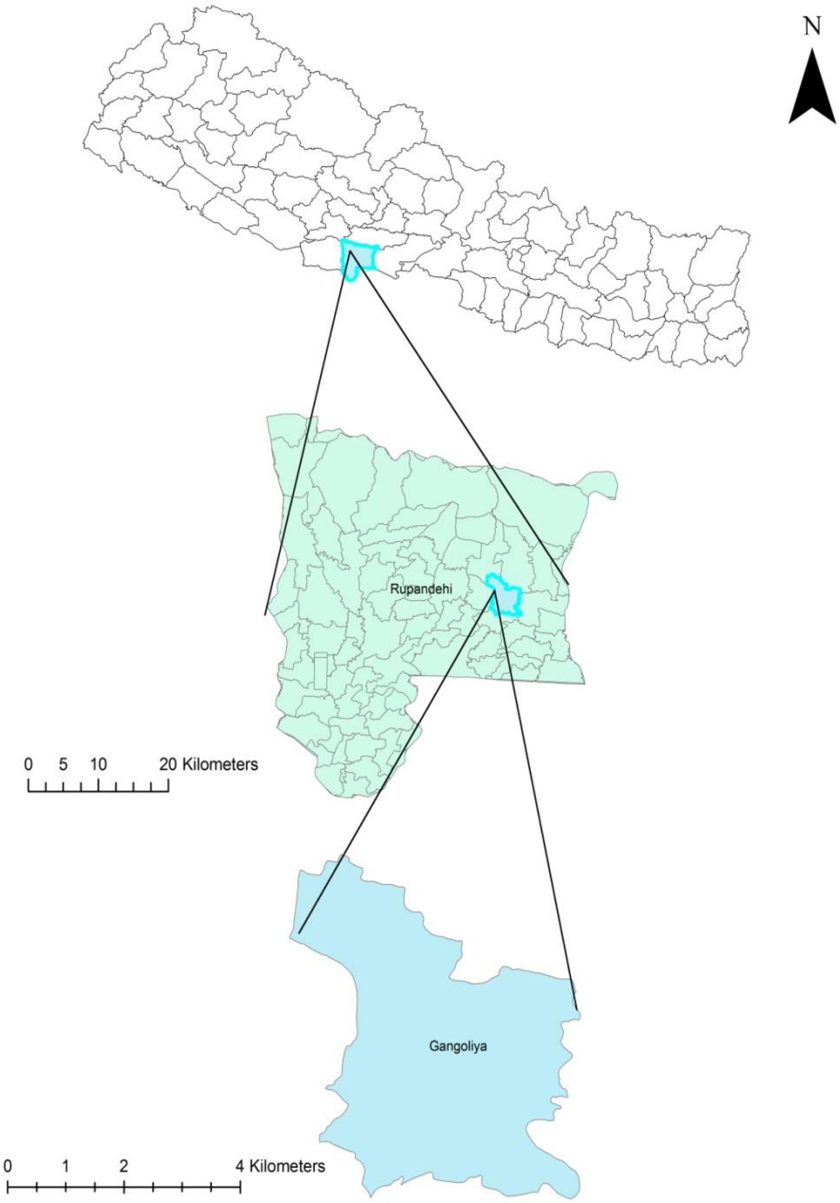

Figure 1: Study Area

3.5 Study design:

A cross-sectional study was designed to assess the parasitic impedimence among farmed Ostriches. The study was divided into three consequtive parts.

3.5.1 *First phase*:

Faecal sample collection and examination for protozoan trophozoites and cysts and for helminthes eggs and larvae.

3.5.2 *Second phase*:

Necropsy examination of Ostriches slaughter for meats for Ectoparasites and adult helminthes parasites.

3.5.3 *Third phase*:

Management system in the farm through questionnaire survey, observational study and secondary information collection.

3.6 First phase: Faecal sample collection, preservation and examination

3.6.1 *Faecal sample collection*:

Fresh faecal samples of the Ostriches were collected in wide mouthed, clean, leak-proof sterile vials. Morning samples were collected in order to get good results. A total of 92 faecal samples were collected during the study period (one year period). All the faecal samples were collected randomly in the early hours of the morning using clean polythene bags (Photo 1) and later transferred into sterile vials with 2.5% potassium dichromate to preserve the eggs. All the samples collected were labeled properly.

3.6.2 *Preservation*:

Preservation of faecal samples helps in maintaining morphology of Protozoan parasites and preventing further development of some Helminthic eggs and larvae. Since the preservatives kill the parasites, therefore characteristic motility of trophozoites cannot be seen. The collected samples were preserved in 2.5% potassium dichromate solution (5gm potassium dichromate powdered dissolved in 200ml of distilled water) (Photo 2).

Photo 1: Sample collection

Photo 2: Sample preservation

3.6.3 *Microscopic examination*:

Intestinal protozoa, eggs and larvae of helminthes can be detected and identified by microscopic examination of the faecal samples. It includes saline wet mount, Iodine wet mount and concentration method (Photo 3, 4).

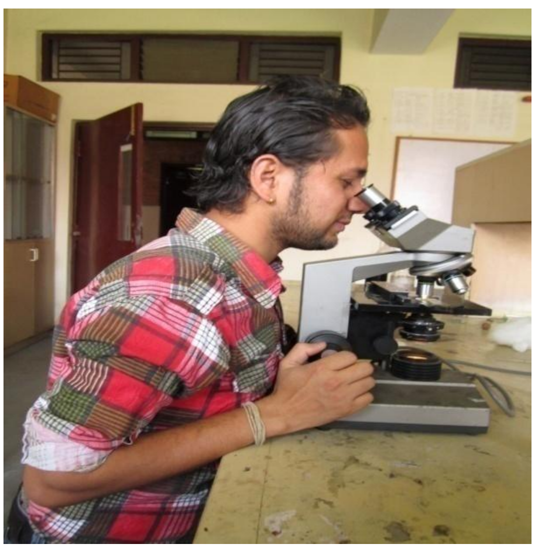

Photo 3: Sample examination

Photo 4: Sample examination

1. ***Saline wet mount***:

Saline wet mount was made by mixing a small quantity (about 2mg) of faeces in a drop of saline placed on a clean glass slide. Any gross fibers or particles were removed and cover with a coverslip. The smear was then examined under electric microscope (10x power). When a parasite–like object comes into view, it was more closely examined and identified under high power (40x power). Photo snapped of each parasites were taken for further identification.

2. ***Iodine wet mount***:

Faecal samples were emulsified in a drop of five times diluted solution of Lugol's Iodine on a clean glass slide covered with a clean coverslip and examined under microscope as above. For the preparation of Lugol's iodine, 10gm of potassium iodide was dissolved in 100ml of distilled water and 5gm of Iodine crystals were then added slowely. The solution was then diluted 5 times. Then, the solution was filtered and kept in a stoppered bottle of amber colour. Since the stain deteriorates quickly, hence it should be prepared every two weeks.

3. ***Concentration methods***:

Eggs, cysts and trophozoites are often in such low number in faecal materials, that they are difficult to be detected in direct smears or mounts. Therefore concentration procedures were performed which includes floatation and sedimentation methods (Soulsby 1965).

a. ***Floatation method***:

Floatation involves suspending the specimen in a medium of greater density than that of the helminthic eggs and protozoans cysts. The eggs and cysts float to the top and were collected by placing a cover slip on the surface of the meniscus at the top of the tube. Then it was transferred into the slide and examined under light microscope. Any suspected were photo snapped further identification. Following floatation techniques were used:

- Saturated salt floatation technique
- Zinc sulphate floatation technique
- Saturated sucrose floatation technique

b. ***Sedimentation techniques***:

Concentration of intestinal parasites by sedimentation techniques, using either gravity or centrifugation leads to a good recovery of cysts of protozoa and eggs of helminthes cysts. Eggs and cysts of parasites were settled and concentrated at the bottom because they have greater density than the suspending medium. The residue were examined using saline wet mount and Iodine wet mount. The recovered parasites were photo snapped for further identification.

3.7 Second phase: Necropsy examination

(a) ***For Helminths parasites*:**

At slaughterhouse, the lungs, liver and carcass of birds were visually inspected for the presence of macroscopic parasites/parasite structures. The digestive tract was opened and the oesophagus, proventriculus, gizzard, small intestine and caeca were visually inspected for helminthes.

(b) ***For Ectoparasites*:**

A detailed search for ectoparasites was performed at slaughterhouse. Special attention was taken when looking at the nasal and auricular cavities, the skin folds of wings and legs, leg scales, feathers barbs, feathers shaft.

3.8 Third phase: Management system

Overall management system was carried out by using following methodology:

a. ***Questionnaire survey***:

A pretested, semi structured questionnaire was used as an instrument for collecting data. Sets of questionnaires were conducted among employee of the farm and to the director of the farm.

b. ***Observational study***:

Observational study was basically focused on:

I. Environmental conditions, hygiene and sanitation in an around the farm as well as waste management system.

II. Feeding observation.

III. Facilities provided for Ostriches in the farm.

3.9 Data analysis

Since the study was mainly focused in identification of Ecto and Endo parasites the data analysis was done by using Microsoft excel 2007.

4. RESULTS

4.1 Gastrointestinal parasites of Ostriches by Faecal Examination:

During the study period a total of 92 faecal samples from four (cages) of Ostrich were examined by faecal floatation and sedimentation methods. The results presented here include the contribution of both the methods. Out of 92 faecal samples examined the overall prevalence of gastrointestinal parasites was found to be 86.96% (Fig. 2).

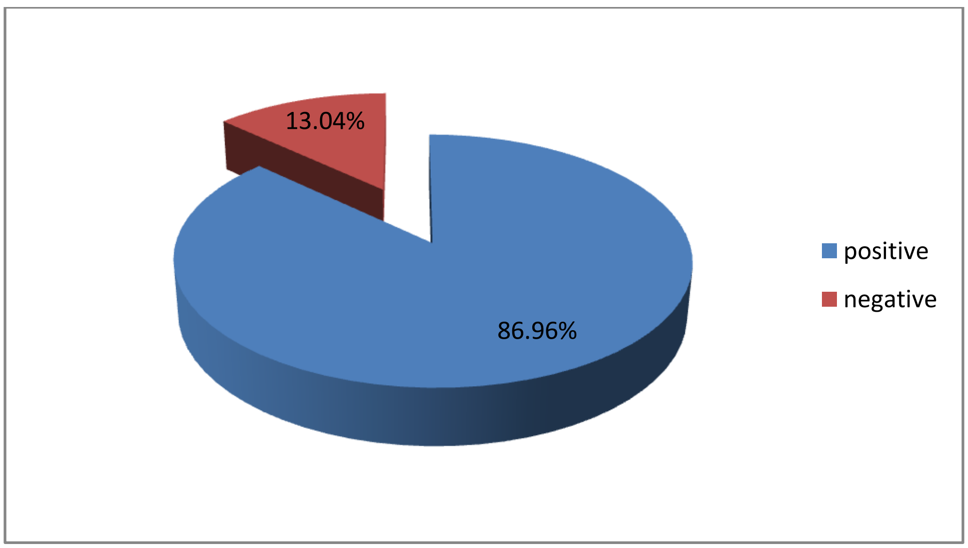

Figure 2: Overall prevalence of endoparasites

Among the total endoparasitic eggs, cysts and trophozoites identified, five species of protozoans parasites, one species of unidentified cestode and four species of nematodes have been recorded. *Entamoeba* (57.6%), *Ascaridia* (43.48%) and *Serratospiculum* like (36.96%) were the highest prevalent parasites infecting farmed Ostriches of Nepal. During the process major parasitic trophozoites, cysts and eggs were recovered from Lugol's Iodine stain. Most interestingly by faecal floatation methods (saturated NaCl) one species of louse and two species of microscopic acarina mites were isolated (Table 1).

Table 1. Prevalence of different endoparasites and ectoparasites in Ostriches:

1	**Endoparasites**	**Frequency(percentage) (n=92)**
A	**Protozoans**	
	a. Entamoeba	**53(57.6%)**
	b. Eimeria	**7(7.61%)**
	c. Isospora	**3(3.26%)**
	d. Balantidium	**5(5.43%)**
	e. Histomonas	**1(1.09%)**
B	**Cestodes**	**4(4.35%)**
C	**Nematodes**	
	a. Ascaridia	**40(43.48%)**
	b. Libyostrongylus	**13(14.13%)**
	***c. Serratospiculum* like**	**34(36.96%)**
	d. Codiostomum	**6(6.52%)**
2	**Ectoparasites**	
A	**Louse**	
	a. Goniocotes	**1(1.09%)**
B	**Mites**	
	a. Gabucinia	**2(2.17%)**
	b. Dermoglyphus	**1(1.09%)**

Among the gastrointestinal protozoans parasites identified *Entamoeba* (57.6%) showed the highest prevalence followed by *Eimeria* (7.61%), *Balantidium* (5.43%), *Isospora* (3.26%) and *Histomonas* (1.09%) in Ostriches farmed at Gangoylia VDC-1 Rupandehi. All these protozoan parasites were recovered from Lugol's Iodine mount, while *Eimeria* and *Entamoeba* were also encountered in normal saline mount. Moreover, *Entamoeba* was also recovered from Saturated NaCl floatation technique. Many species of coccidian parasites like *Eimeria* and *Isospora* are highly pathogenic to the Ostrich causing bloody diarrhoea. The present study highlights the existence of these parasites among the Ostriches, although the species level of these parasites couldn't be identified. Two species of flagellated-*Balantidium* and *Histomonas* were identified during faecal examination (Fig. 3) (Photo 5-9).

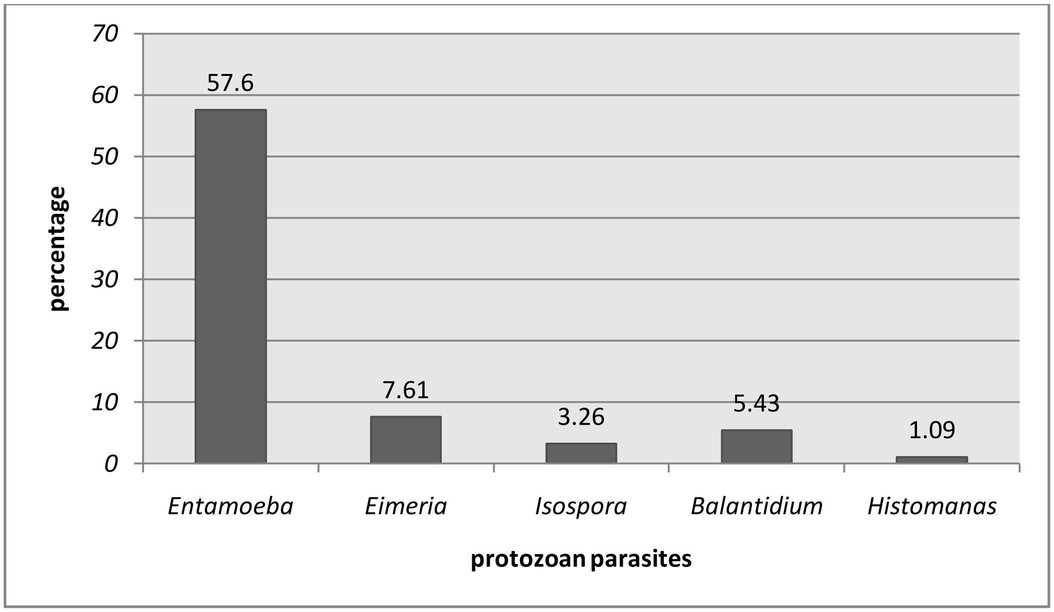

Figure 3: Prevalence of different protozoan parasites

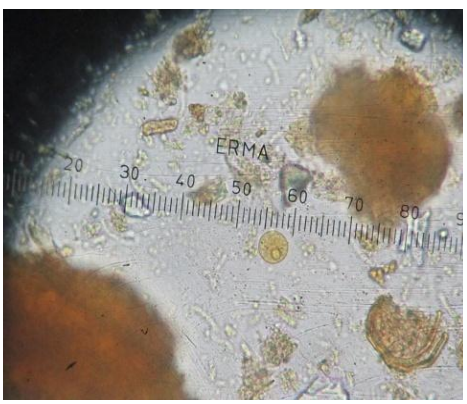

Photo 5: *Entamoeba* (cyst) under 10×40

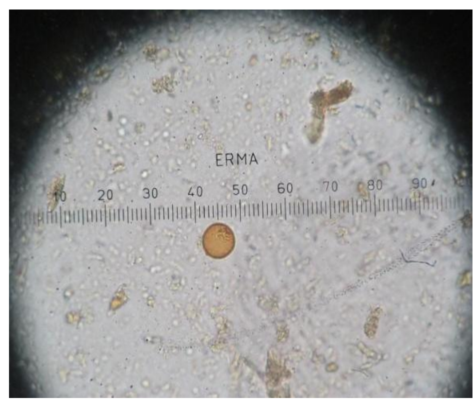

Photo 6: *Eimeria* (oocyst) under 10×40

Photo 7: *Isospora* (oocyst) 10×40

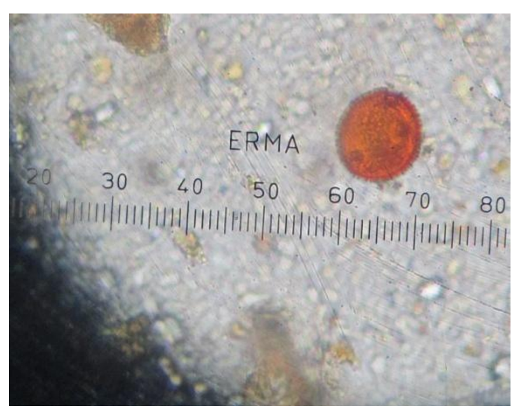

Photo 8: *Balantidium* (trophozoite) 10×40

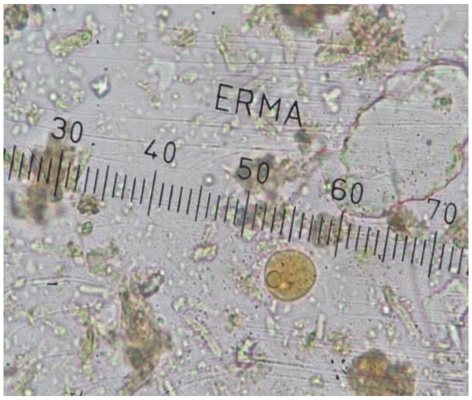

Photo 9: *Histomonas* (cyst) under 10×40

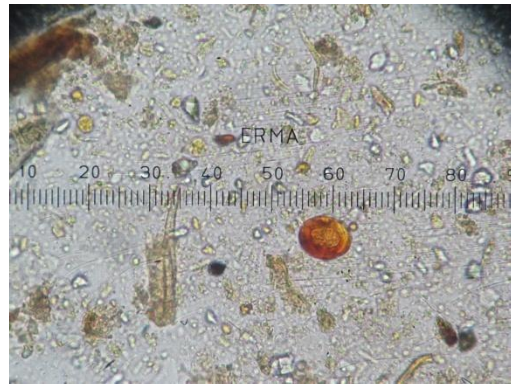

Photo 10: Cestode (egg) under 10×40

A total of four different nematodes parasites were recovered. Among them *Ascaridia* (43.48%) was the prevalent nematodes parasites in Ostriches followed by *Serratospiculum* like (36.96%), *Libyostrongylus* (14.13%) and *Codiostomum* (6.52%). All these nematode parasites were recovered from Lugol's Iodine mount and normal saline mount, while *Ascaridia* was also found from Saturated NaCl floatation technique. A characteristic nematode egg of size 28×15µm was also found to be distributed in many faecal samples. Morphologically it is different from other parasitic eggs but similar to the *Serratospiculum* parasites of lungs of aves mainly the Falcons (Fig. 4) (Photo 11-14).

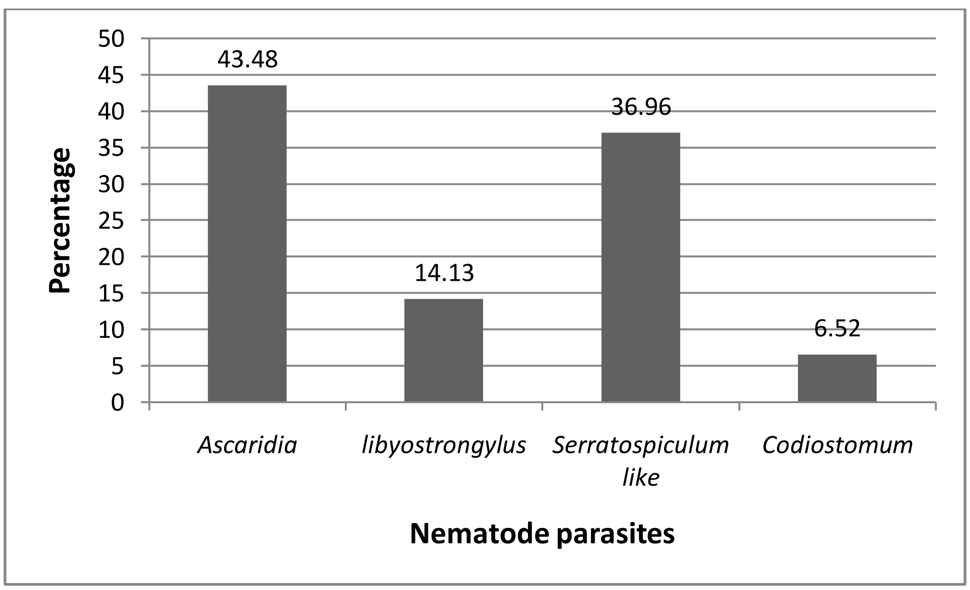

Figure 4: Prevalence of different nematode parasites.

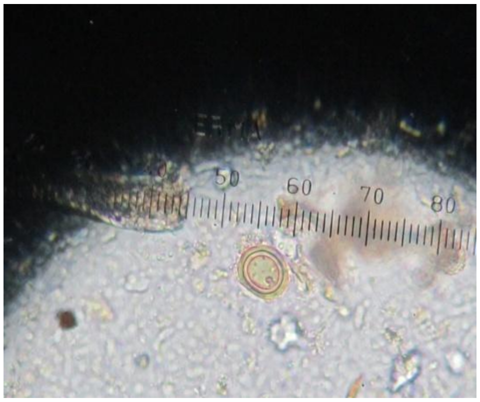

Photo 11: *Ascaridia* (fertilize egg) 10×40

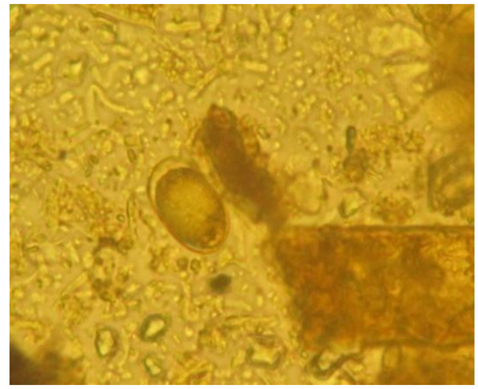

Photo 12: *Libyostrongylus* (egg) 10×40

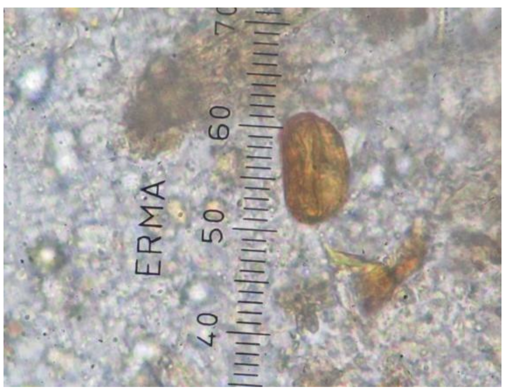

Photo 13: *Serratospiculum* like (egg) 10×40

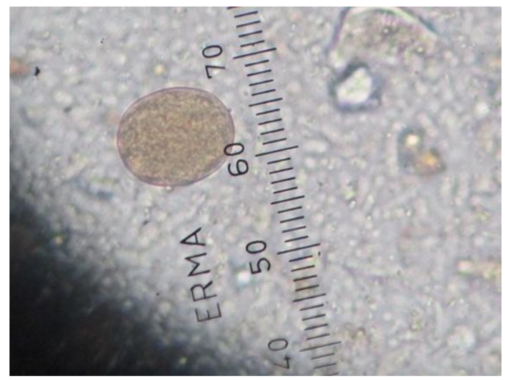

Photo 14: *Codiostomum* (egg) 10×40

Nematodes parasites (69.56%) were highly prevalent among three endoparasites encountered among 92 faecal samples of Ostriches followed by Protozoan parasites (65.22%) and Cestodes (4.35%). The graph showed that there was not much significant difference between the prevalence rate of Protozoan and nematode parasites as compared to cestode (Fig. 5).

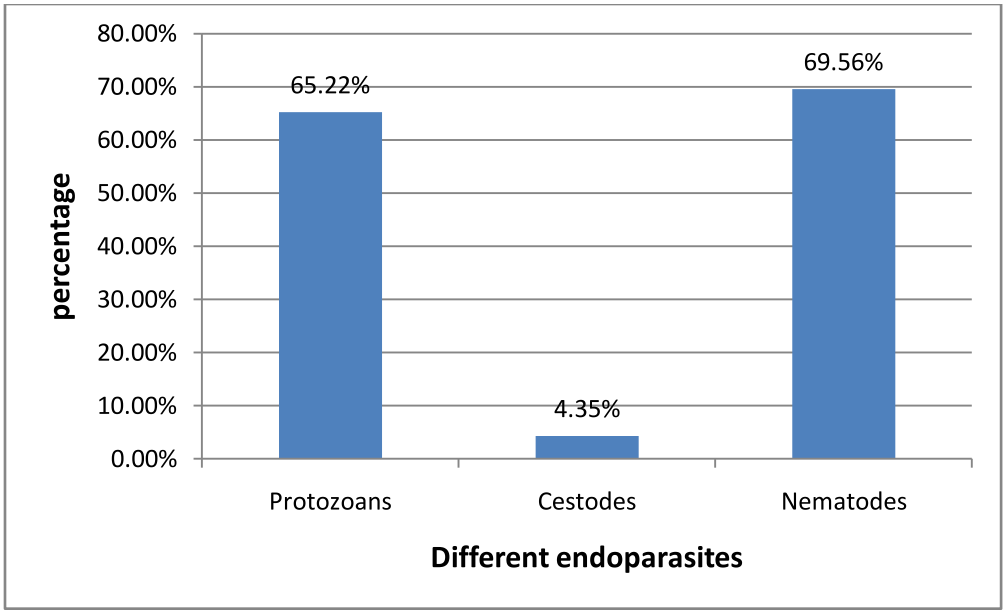

Figure 5: prevalence of different endoparasites in Ostrich

4.2 Ecto and Endoparasites of Ostriches by necropsy examination:

4.2.1 *Ectoparasites of Ostrich*:

A total of 10 Ostriches slaughtered for meat at slaughter house in the farm were examined thoroughly for ectoparasites. Head, neck, body, wings and tail were screened with great care. None of the macroscopic ectoparasites were recovered. But during the faecal examination one species of lice and two species of mites have been isolated by saturated NaCl floatation techniques in the lab. Of the 92 samples examined, these three ectoparasites were encountered from only three samples. *Gabucinia* (2.17%) showed the highest prevalence among three ectoparasites (Fig. 6) (Photo 15-18).

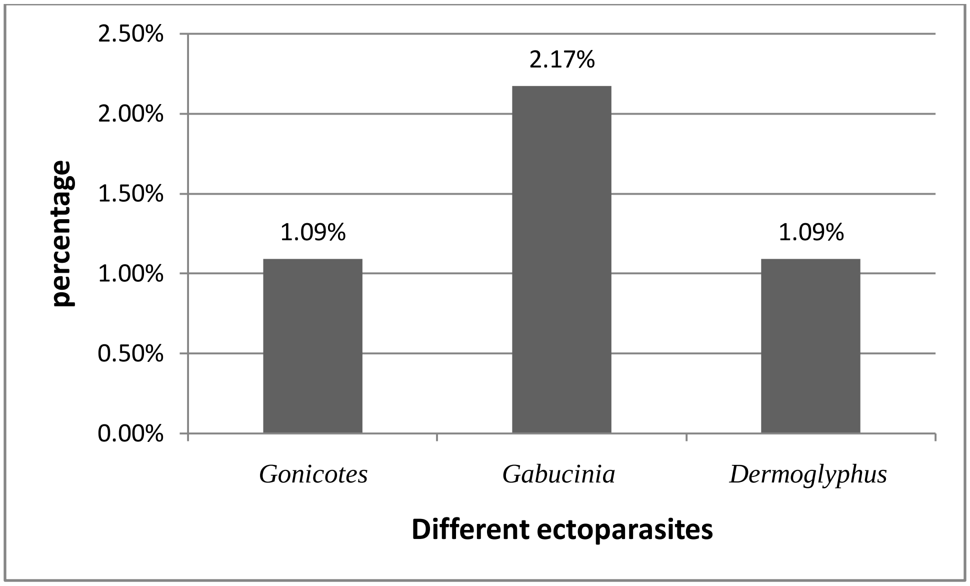

Figure 6: prevalence of different ectoparasites

Photo 15: *Gonicotes* under 10×10

Photo 16: *Gabucinia* (male) under 10×40

Photo 17: *Gabucinia* (female) under 10×40

Photo 18: *Dermoglyphus* (male) under 10×40

4.2.2 *Endoparasites during necropsy examination*:

Lungs, liver, oesophagus, proventriculus, gizzard, small intestine and caeca of 10 Ostriches were thoroughly examined for endoparasites which were slaughtered for meat at slaughter house. All the parts were dissected in saline water and visually inspected for the presence of parasites. Examination was mainly focused for macroscopic trematode, cestode and nematode parasites. But none of them were found to be infected with endoparasites.

4.3 Management practices of Ostrich farming in Gangoliya-1 Rupandehi:

4.3.1 *Management system in the farm*:

At present there are 890 adult Ostriches along with 200 Emus. Ostrich has been managed at 20 bighas (around 13.54 hectares) area of land in four cages including farm office and housing. Ostriches have been managed in four cages with cage height above five feet. The Ostriches in the farm were kept for commercial purposes but it is not highly commercialized yet. Both Ostriches and Emus were provided with premix based compounded foods once a day. Woven wires and poles were used as fencing materials with heights above five feet. The farm provides only one single sources of water. No any antibiotics, vaccines and other medication were provided to Ostriches unless severe cases. Colony configuration of breeding was practiced in the farm as a means of Reproductive practices. All employee in the farm were educated about Ostriches and Emus. The visitors in the farm were first sprayed with virgon before entering in the farm (Table 2).

Table 2. Overall management practices in the farm.

	Items	Frequency(percentage)
1	**Production purpose**	
	➢ **Commercial**	**5(100%)**
2	**Livestock types**	
	➢ **Other livestock species in the farm(emu)**	**1(20%)**
3	**Facilities**	
	➢ **Woven wire and poles as fencing materials**	**5(100%)**
	➢ **Fencing above five foots**	**5(100%)**
	➢ **Low grasses as floor materials for chicks**	**0**

4	**Feeds and feeding practices**	
	➢ **Local on farm feed compounding**	**5(100%)**
	➢ **Premix based compounded feed**	**5(100%)**
	➢ **Provision of grit**	**5(100%)**
	➢ **Single water sources(underground)**	**5(100%)**
	➢ **Once daily feeding practice**	**5(100%)**
	➢ **Use of sole grass feed**	**5(100%)**
	➢ **Use of cereal bran**	**5(100%)**
5	**Health practices**	
	➢ **Use of antibiotics, vaccine**	**0**
	➢ **Regular check up**	**5(100%)**
	➢ **Leg band**	**2(40%)**
	➢ **Other means of disease identification**	**0**
6	**Reproductive practices**	
	➢ **Colony configuration of breeding group**	**5(100%)**
7	**Biosecurity**	
	➢ **Prevention of disease spread between groups**	**5(100%)**
	➢ **Basic sanitation**	**0**
	➢ **Farm divided into disease control units**	**0**
	➢ **Educating employee**	**5(100%)**
	➢ **Spraying of visitors**	**5(100%)**

4.3.2 Feeds and extra vitamins supplement for Ostriches:

Ostriches are mainly herbivorous. In the wild state, they mainly feed on seeds, grains, shrubs, grass, fruits and flowers; occasionally they also feed on insects such as locusts, worms, rodents, frogs, lizards and field mice available in their harsh habitat. In the captive state they were provided with premix based compounded foods which includes grasses, wheat, maize, soyameals, vitamins and minerals and others (Table 3).

Table 3. Composition of feeds given to Ostriches in the farm.

Composition of feeds	Percentage
Grass (Lucerne or Clover)	50%
Wheat	12%
Maize	18%
Soyameal	17%
Vitamins and minerals	1%
Others(oil, NaCl, refined sugarcane juice)	2%

Extra vitamins and minerals were provided to Ostriches along with the foods. A deficiency of vitamin E and/or selenium causes the degeneration of the muscles, also referred to as 'white muscle disease'. The lack of calcium or phosphorus in the ration can lead to the development of soft bones leading to frequent and multiple fractures. Ostriches fed on grain rations without vitamin supplements can develop vitamins B deficiencies, mainly affecting the skin of head. So vitamins and minerals were added in order to overcome the nutrient deficiencies in Ostriches (Table 4).

Table 4. Extra vitamins and minerals supplied along with the feeds.

Each 1.5kg contains:

Vitamin A(miu)	Vitamin A 1000	12
Vitamin D3 (miu)	Vitamin D3 500	3.6
Vitamin E (g)	Vitamin E-50 (50%)	150
Thiamine (B1) (g)	Thiamine Mononitrate (98%)	1.8
Riboflavin (B2) (g)	Riboflavin (80%)	4.8
Niacin (B3) (g)	Niacin (99.5%)	12
Pantothenic Acid (B5) (g)	D-CALPAN (98%)	4.2
Pyridoxine (B6) (g)	Pyridoxine HCl (99%)	1.2
Folic Acid (B9) (g)	Folic Acid 100 (97%)	0.9
Cyanoc (B12) (g)	Vitamin B12 10000 (1%)	0.01
Biotin (H2) (g)	Biotin HP (10%)	0.12
Menodione (k) (g)	Menodione (31.2%)	0.18

Cobalt (g)	**Cobalt Sulphate 21%**	**0.06**
Iodine (g)	**Potassium Iodide 68%**	**0.21**
Iron (g)	**Ferrous Sulphate 30%**	**7**
Manganese (g)	**Manganous Oxide 51%**	**24**
Copper (g)	**Copper Sulphate 25%**	**1.2**
Selenium (g)	**Selenium 2%**	**0.06**
Zinc (g)	**Zinc Sulphate Mono 35%**	**18**
Magnesium (g)	**Magnesium Oxide 56%**	**12**
Choline Chloride (g)	**Choline Chloride 60%**	**100**
Lysine (g)	**Lysine Mono HCl**	**300**
Methionine (g)	**DL Methionine**	**225**
Anti-oxidant (g)	**Eurotiox-32**	**25**
Vitamin C		**100 gms**

Source; Pro Bio-Tech Industries (P) Ltd.

5. DISCUSSION

The Ostrich (*Struthio camelus* – meaning ‘camel-like’) is the world’s largest flightless bird which is native to the Savannas and grasslands of South Africa. It is the only living species in the family: struthionidae and a member of the order struthioniformes. Ostriches have long, bare necks, a flat, broad beak with a rounded tip and large eyes. They have long, powerful, bare legs and strong feet with two sharp claws on each foot which are used for defense. Male have black feathers with white tails and female are grayish-brown.

The inventions of the artificial incubator for Ostrich eggs by Arthur Douglass in 1869 provided a major stimulus for Ostrich farming (Smit 1963). Its farming has been commercially started from “1860s” at the Cape colony of South Africa. Before “1980s” Ostrich farming were done for its feathers only but after “1980s” they were farmed for their skins, meats, fats, feathers and bones which have high value in international markets. Ostrich farming has been commercially practiced from Africa, Israel, Zimbabwe, Kenya, Tanzania, North America, Canada, UK, N. Europe, Australia, China, Japan, N. Korea, Malaysia, Indonesia, Thailand, Philippines, Pakistan, Iran and Gulf countries. Ostriches can tolerate a wide range of temperature from -50° C to +50° C. In Nepal 50-55% humidity and 90-99° F temperature is required for Ostrich farming. Ostrich Nepal Pvt. Ltd. has been established in the year 2010 in Gangoliya VDC-1 Rupandehi with an initial investment of Rs. 300 million in an around 20 bighas (around 13.54 hectors) area of land. At present there are 890 adult Ostriches, around 1000 chicks and 200 Emus in the farm.

Ostrich are susceptible to various kinds of diseases like Coccodiasis, Enteritis, Gastric stasis, Avian pneumonias, Mycobacteroisis, Megabacteriosis, Anthrax, Perihepatitis, Aspergillosis, New castle diseases, Avian influenza, Crimean-Congo haemorragic fever, Borna disease, Fowl pox, Wessels born disease (Deeming 1999). The lack of Calcium or Phosphorus in the feeds can lead to the development of soft bones leading to frequent and multiple fractures (Cooper and Gimbi 1994). Degeneration of the muscles, also known as ‘white muscle disease’ is mainly due to the deficiency of Vitamin E and/ or Selenium with resulting inability to stand up and to walk (Van heerden et al. 1983). Vitamin B deficiencies can be seen in those Ostriches which are fed on grain rations without vitamin supplement affecting the skin of the head (Foggin 1992). Till date there is no any studies carried out regarding the gastrointestinal parasites of ostriches in the farm. This is the first study in Nepal.

Generally birds can be affected with both ecto and endoparasites. The major endoparasites reported in wild birds are *Cheilospirura gymnorhinis, Syngamus trachea, Trichomonas, Haemoproteus, Toxoplasma gondi, Australobilharzia* spp. (silver gulls), *Mausontrema eudyptulae* (Penguins), *Capillaria* spp., *Contracaecum* spp. (Piscivorous birds), *Dispharynx nasuta, Echinuria uncinata* (water fowl), *Serratospiculum* (birds of prey, falcons), *Oxysprirura* spp., *Angiostrongylus cantonensis* (Yellow- tailed black cockatoos), *Spironucleus, Giardia* spp., *Cryptosporidia* spp., *Caryospora* spp., *Leucocytozoon, Plasmodium, Atoxoplasma, Babesia, Isospora, Eimeria* (Rose 2005). The major ectoparasites in birds are *Ixodes holocyclus, Ornithodorus, Cnemidocoptes* sp., *Hippoboscid* flies, *Sternostoma tracheacolum* (mite).

According to available literature the major endoparasites reported in Ostriches are *Cryptosporidium, Isospora, Balantidium, Entamoeba, Endolimax, Iodamoeba, Histomonas, Trichomonas, Giardia, Spironucleus, Monocercomonas, Chilomastix, Pleuromonas Retortamonas, Plasmodium, Leucocytozoon, Philophthalmus, Houttuynia, Libyostrongylus, Codiostomum, Capillaria, Heterakis, Ascaridia* and *Dicheilonema*. The major ectoparasites are *Amblyomma, Haemaphysalis, Hyalomma, Rhipicephalus, Struthioliperus, Gabucinia and Deremoglyphus.*

The overall prevalence of endoparasites (86.96%) in the present study was lowered as compared to the prevalence rates of 100%, 92.85% and 88% obtained by the previous studies (Bonadiman et al. 2006, Fagundes et al. 2012 and Ibrahim et al. 2006) respectivelly. But it was higher than 78.8% obtained by Sotiraki et al. (2001). The higher prevalence rates may be due to the fact that they took their samples from younger Ostriches (<1 year). According to Tully and Shane (1996) age is an important determinant of the occurrence of infections, as young animals usually show a higher predisposition to infection with some helminthes. From the economic and sanitary points of view, coccidian parasites are the most important group among protozoa. Two species of *Cryptosporidium* have been reported infecting Ostriches (Sotiraki et al. 2001, Santos et al. 2005, Nemejc and Lukesova 2012). It has been reported from South Africa, Canada, Greece, Spain and from others. Ostriches raised at Gangoliya VDC-1 Rupandehi were negative for this parasite. Few reports have indicated the presence of *Isosproa* and *Eimeria* in ratites. There is only one species described in this group of birds i,e *Isospora struthionis* from an Ostrich at a Russian zoo (Yakimoff 1940). Both genera can be differentiated on the basis of the number of sporocysts. *Eimeria* oocysts have been reported in Ostriches from Nigeria (Ibrahim et al. 2006, Mshelia et al. 2010), Iran (Eslami et al. 2007), Czech Republic (Nemejc and Lukesova 2012), Botswana (Mushi et al. 1998, 2003), North America (Jensen 1992, Wade 1992) and in different state of Europe (Ponce Gordo et al. 2002). In the present study 7.61% of *Eimeria* and 3.26% of *Isospora* were isolated from the faecal examination of Ostriches. The prevalence rate of present study of *Eimeria* was less than the prevalence rate (43.8%) as obtained by Mshelia et al. (2010). But the prevalence of both *Eimeria* and *Isospora* were higher than as obtained by Ponce Gordo et al. (2002) (< 1). Due to coccidiosis infected birds generally exhibit loss of appetite, weakness, ruffled feathers, bloody diarrhoea but these symptoms are usually minimal in Ostriches and infection can only be properly diagnosed by post-mortem examination (Dingle and Shanawany 1999). The use of coccidiostats in ostriches rations is waste full and possibly dangerous as some of the Ionophore coccidiostats are toxic for Ostriches (Jensen 1992).

Balantidium struthionis as Ostrich specific is a ciliate and normal inhabitants of Ostrich intestine, probably capable of becoming some what pathogenic under favourable conditions with intestinal lesions (Huchzermeyer 1999). Its cysts could also be mistaken for coccidial oocysts (Deeming 1999). The prevalence rate (80%) obtained by Ponce Gordo et al. (2002) was much higher than the present study (5.43%). This prevalence rate was also less than as obtained by Ederli and oliveira (2008) (60%). *Entamoeba* sp. have been reported from Ostriches in Spain, Portugal, Belgium France Great Britain (Ponce Gordo et al. 2002), Greece (Sotiraki et al. 2001), Scotland (Pennycott and Patterson 2001) and Sweden (Jansson and Christensson 2000). The prevalence rate (57.6%) of *Entamoeba* in Ostriches of Gangolyia was less than the prevalence rate (90%) obtained by Ponce Gordo et al. (2002). The size of *Entamoeba* (13-18µm) obtained in the present study corresponds to the size of *E. coli* (10-33µm), *E. histolytica* (10-15µm) and *E. muris* (9-20µm). Further analysis and comparisons with *E. coli, E. histolytica* and *E. muris* are required before a specific identification can be proposed. The other amoebae found in faecal samples of Ostriches were

Endolimax and *Idamoeba* (Ponce Gordo et al. 2002) which were negative to the present study.

Although the present findings have been apparently in healthy Ostriches, some flagellates are known to be pathogenic. One of the most important flagellate species is *Histomonas*. In the present study, this organism was found only in one faecal sample as cystic form. It is considered that its main transmission is through the eggs of the nematode *Heterakis gallinarum* (Levine 1985) and *Ascaridia dissimilis* has been also proposed (Norton et al. 1999). However, the present study haven't found *Heterakis* in any samples but genus *Ascaridia* has been isolated in many samples. Other flagellates described from ratities(Ostrich) are *Trichomonads* and *Hexamitids* but no specific diagnosis was given (Tully and Shane 1996, Huchzermeyer 1999) and non of these flagellates were encountered in the present studuy.

The only trematode species described from Ostriches is *Philophthalmus gralli*, which was found in the nictitating membrane of Ostriches in Floridia (Greve and Harrison 1980). It was reported to cause severe eye irritation and discharge in captive Ostriches in Florida (Kocan and Crawford 2007). The present study was negative for this parasite. *Houttuynia struthionis*, a cestode is a common parasite of the small intestine and major endoparasite of Ostrich and Rhea (Jurajda 2003, Blood et al. 2007). Ostrich chicks are the most susceptible and show signs of infestation very slowly: Gradual loss of condition, lethargy and anaemia, loss of appetite, sometimes accompanied by mild diarrhoea (Dingle and Shanawany 1999, Taylor et al. 2007). One unidentified cestode cysts (23µm) was isolated with prevalence rate 4.35% in the faecal sample examined in the present study.

All the species of nematodes were recorded from the faeces of farmed Ostriches. *Libyostrongylus* (wire worm) is one of the most important pathogenic nematode for Ostriches, producing a disease known as "rotten stomach" which can cause high mortalities among Juvenile Ostriches (Nel 1980, Foggin 1992, Lordman and Bronneberg 2004) and occasionally also to adults (Jansson and Christensson 2000). Its eggs are very similar to those of *Codiostomum struthionis*, a non pathogenic round worm. *Libyostrongylus* with prevalence rate 14.13% was isolated in the present study with average size 25-30×13-18µm. In the present study no adult worms were recovered and the identification of the nematode genus has been established using the criteria indicated by Barton and Seward (1993). The prevalence of *Libyostrongylus* in the present study was less than the prevalence rate of previous studies (Sotiraki et al. 2001 (43.45%), Ponce Gordo et al. 2002 (20%), Eslami et al. 2005 (40%), Ibrahim et al. 2006 (100%) and De Andrade et al. 2011 (61-97%)). The life cycle of this parasite is typically strongyle (Taylor et al. 2007). The eggs are excreated with the faeces of the host and under optimal conditions the infective larvae develops within 60 hours. However, eggs containing these infective larvae can resist desiccation for up to 3 years. After such a larvae has been ingested by a new host it takes 33 days to reach maturity (Soulsby 1984). *Codiostomum struthionis* is a slightly larger roundworm that inhabits in the large intestine and caeca of the Ostriches (Deeming 1999, Dingle and Shanawany 1999). It is about 1-1.5cm long and white (Dingle and Shanawany 1999). These nematodes feed on Caecal mucus. Its life cycle has not been yet determined but it is belived to be simple and direct (Taylor et al. 2007). The prevalence rate of *Codiostomum* in the present study was found to be 6.52%. This prevalence rate was higher than as obtained by Ponce Gordo et al. 2002 (less than 1) but less than as obtained by Fagundes et al. (2012)(56%). Morphologically, the infective larvae of *C. struthionis* are similar to be *L. dentatus*; however, the tail of *Libyostrongylus* larvae ends in a lump-shaped button while *C. struthionis* larvae present the acute end of the tail (Barton and Seward 1993, Ponce Gordo et al. 2002, Ederli et al. 2008b).

Ascaridia struthionis has been reported from Ostriches in Italy (Yamaguti 1961). *Ascaridia* sp. in North Eastern Nigeria (Ibrahim et al. 2006) and in different states of Europe (Ponce Gordo et al. 2002) with prevalence rate less than 1%. The prevalence rate was higher in the present study (43.48%) as compared to others findings (Ibrahim et al. 2006 and Ponce Gordo et al. 2002). A characteristic nematode egg of size 25×15µm was also found to be distributed in many faecal samples of the present study. Morphologically it was different from other parasitic eggs but similar to the *Serratospiculum* parasities of lungs of aves mainly the falcons. So it was identified as *Serratospiculum* like with prevalence rate 36.96%. The other types of nematodes so far reported in Ostriches were *Capillaria* (Ibrahim et al. 2006), *Heterakis dispar* (Eslami et al. 2007), *Baylisascaris* (Cooper 2005), *Struthiofilaria, Megalocephala, Paronchocerca struthionis, Dicheilonema spicularum* (Jurajda 2002). The latter three are all filariad nematodes.

Several species of ectoparasites affect ratites of all ages, both ratite specific and non- specific parasite species. Lice and Mites can be found by examining the skin and feathers, especially around the vent, legs, wings and neck (Dingle and Shanawany 1999). Non of the ectoparasites were recovered externally from 10 Ostriches slaughtered for meat at slaughter house. But most interestingly they were observed in the faecal samples. In the present study one species of Louse (*Gonicotes*) and two species of acari mites (*Gabucinia* and *Dermoglyphus*) were encountered. The prevalence rate of these three ectoparasites were found to be 1.09%, 2.17% and 1.09% respectively. These two ectoparasites (*Gabucinia* and *Dermoglyphus*) were named according to Ponce Gordo et al. (2002). Although usually harmeless, both lice and acari can cause intense pruritus and feather loss (Hoover et al 1988, Huchzermeyer 1999). *Gabucinia* live in the vein in the ventral groove of the feather shafts and feeds on the blood and gelatinous contents of the feather sheath. They can be visualized as small reddish, dust like elongated particles in the feather vein (Jefferey 1996, Huchzermeyer 1998, Jurajda 2002). As compared to the present study mites were also seen in the faecal samples examined by Mshelia et al. (2010). In the present study, male and female of *Gabucinia* with size 107µm and 117µm respectively were recovered. Only male of *Dermoglyphus* with size 163µm was isolated. The unique lice (*Gonicotes*) was recovered during examined. Non of the previous record of this lice was found in Ostriches. This is the first reported in Ostriches. But detailed study was not done regarding its pair of legs, body segments, mouthparts due to some technical error.

At present there are 890 adult Ostriches along with 200 Emus. Ostrich has been managed at 20 bighas land in four cages including farm office and housing with an initial investment of Rs. 300 million. Four cages in the farm were managed with cage height above five feet. The result reveals a commercial production of Ostriches by 100% with the farm engaged in production of other livestock species (Emus). But it is not highly commercialized yet. Ostriches in the farm were provided with premix based compounded foods which includes grass (Lucerne or Clover) 50%, wheat (12%), maize (18%), soyameal (17%), vitamins and minerals (1%) and others which includes oil, NaCl, refined sugarcane juice (2%). The farm provides only one single source of water (underground). No any antibiotics, vaccines and other medication were provided to Ostriches unless severe cases. On the reproductive practices, only colony configuration (100%) was practiced. Extra vitamins and minerals were supplied along with the feeds in order to overcome the nutrients deficiencies in Ostriches. The prominent biosecurity measures include prevention of disease spreed between groups (100%), employee enlightenment (100%) and spraying of visitors (100%). Ostrich management practices in three states of Northern Nigeria was far better than the management practices of gangolyia VDC-1 Rupandehi.

6. CONCLUSION AND RECOMMENDATIONS

The overall prevalence of endoparasites of Ostriches of Gangoliya was found to be 86.96% with high prevalence of *Entamoeba* (57.6%). Although the species encountered was higher in protozoa than nematode, the overall nematodes prevalence was slightly higher than protozoa. High prevalence of endoparsites in Ostriches of Gangoylia, Rupandehi could be due to lack of reliable history of strategic antihelminthic medication. This prevalence rate showed that Ostriches in Nepal are highly susceptible to endoparasites which if not looked properly could lead to losses in Ostrich industry. The specific identification of both protozoa and nematode has not been possible due to: their characteristics (morphology or host location) do not fulfill with the species described in other avian hosts and there are not enough data for comparisons until further analysis are performed (i.e. for *Serratospiculum, Gonocotes*). Most of the protozoan and nematodes parasites were recovered from Lugol's Iodine stain reflects the efficacy of Iodine stain to those parasites.

The presence of ectoparasites in the faecal samples suggested that these parasites were not seen externally in the body of Ostriches. This makes very difficult in the species identification. The presence of ectoparasites only in saturated NaCl floatation technique is due to the fact that its density is less than that of saturated NaCl solution. Since none of the ecto and endoparasites were recovered externally from the slaughtered Ostriches but were encountered in faecal samples showed that the Ostriches were in the initial phase of infections. The management practices adobted in Ostrich farming was not much satisfactory. This can lead to the high prevalence of endoparasites. The presence of leg band Ostriches in the farm is probably due to the deficiency of vitamins and minerals. Therefore effective deworming programme and management strategy should be conducted in order to upgrade the health status and hence to maximize the benefit from Ostrich farming. The common recommendations that should be adopted in the farm in order to enrich the economy are:

- Deworming must be done on regular basis in every three months interval for effective control of endoparasites.

- Routine faecal examination should be done to determine wheather the deworming programme is effective or not.
- Droppings should be removed from farm areas regularly.
- Effective management practices should be launched regarding feeds and sanitation.
- Overcrowding of Ostriches should be checked in the different cages.
- Effective medication should be given to Ostriches in the farm.
- Government should provide full support in such farming to enrich its Gross National Product (GNP).

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APPENDIX 1

QUESTIONNAIRES

Central Department of Zoology, Tribhuvan University

Kirtipur, Kathmandu

"Parasitic Impediments of Ostriches (*Struthio camelus* Linnaeus 1758) Farming at Gangoliya VDC-1, Rupandehi"

<u>Questionnaires to Employee</u>

1. Do you know about Ostriches?

   a. Yes……… b. No………..

2. Do you ever saw these birds?

   a. Yes……. b. No………….

3. What time did you give foods to them?

4. Do you provide water 24 hours to them?

   a. Yes……. b. No……………..

5. Can you tell me the composition of foods given to Ostriches?

6. What medicine did you use when they are injured?

7. How many adult Ostriches and Emus are there at present?

8. Did you know the cage height of these 5 sub divided farm?

9. Do you have knowledge about parasites? If Yes

10. Do you know about Ostrich diseases?

Questionnaires to Director

1. Could you explain the main purpose of this farming?

2. What are the facilities that you provide to Ostrich in the farm?

3. What are the feeding practices adopted in your farm?

4. Did you provide any antibiotics vaccine to the Ostriches? If not then why?

5. What type of breeding practices did you practice in the farm?

6. Could you explain about the biosecurity measures that are practiced in the farm?

7. Could you explain about the composition of feeds given to Ostriches in the farm?

8. Do you have knowledge about parasites in Ostriches?

9. What do you think about leg band Ostriches in the farm?