CHAPTER # 1

INTRODUCTION
Rabbit has long been used as an important experimental Lab animal for the study of diseases and diagnosis. Virtually before its discovery as a laboratory model, rabbit was used as a source of food for human beings. However, it was not unto the second half of the twentieth century that its commercial importance as a source of animal protein was recognized (Checke, 1980). Commercially, rabbit farming is a multi potential venture for meat, wool & fur pelt (Jithendran, 1999). Rabbit meat is rich in proteins and low in calories and fat, which comprises of 60% unsaturated fatty acids (Checke, 1980). Thus, making it a healthy dietary supplement. The broiler rabbit farming has acquired a commercial status by virtue of its fast growth, high feed efficiency (Gracey, 1981; Mukundan et al.1986) & carcass characteristics (Kutinarayan & Nandakumar, 1989) and has been encouraged by FAO in developing countries.
Rabbit wool is of superior quality as compared to sheep wool & has better insulation properties. The average wool production of an angora rabbit varies from 800-1000 g. in a year while a broiler rabbit produces about 4 Kg. of meat. This is about three times higher than the production from a sheep besides superior quality of rabbit meat. Besides, rabbit dropping makes an excellent compost being rich in plant nutrients having considerable value as a fertilizer especially for crop fields, kitchen gardens and flowering plants. The manure is about 3 - 1.5 – 0.5 percent in N-P-K value.

In India, rabbit farming for fur and wool production is picking up as an important enterprise in hilly areas of the states like Himachal Pradesh, Jammu & Kashmir, Uttar Pradesh, Uttranchal, Sikkim and Arunachal Pradesh. The temperate and sub tropical areas in West Bengal, Assam, Manipur, Andhra-Pradesh, Tamil Nadu, Kerala and Karnataka are also taking up rabbitary for broiler meat production. Himachal Pradesh and Jammu & Kashmir are two leading states in rabbit production in the country (Arya, 1987).

At national level the central govt. has a programme for rabbit development and under 5-year plans has been extending financial assistance to states for the same. The central sheep & wool research institute (Indian council of agricultural research) Avikanagar (Rajasthan) and its two regional stations at Garsa (H.P.) and Mannavanur (T.N.) as also some state agricultural universities have contributed significantly towards this end and rabbit germplasm suitable for production under different agro-climatic conditions have been evaluated and developed for transfer to farmers. At state level, the J&K govt. has established, rabbit breeding farm under
department of sheep husbandry at wussan (Baramulla) for the said purpose. Later on other breeding farms were established at Rambirpur (Anantnag), Alusteing, Zukura, Lalmandi (Srinagar). Besides, many other small scale units were established by animal husbandry department in different parts of Kashmir.

The Central govt. Ministry of food processing industries and financial institutions like NABARD, other public sectors and scheduled banks as well as development departments and financial agencies of J&K govt. offer attractive schemes for those interested in rabbit farming. The govt. is playing the vital role in solving local problems and providing the technical information and package of practices pertaining to rabbit farming. Thus, rabbit production alleviates poverty and unemployment among local youth and women through establishment of small scale rabbit rearing units and contribute towards the self sufficiency in meat in J&K state.

Management of disease free rabbits has always been a priority both in rabbits as laboratory animal resource as well as commercial broiler rabbits used as meat source. Health cover forms an integral part for the successful development of rabbit industry. Disease is almost always the result of poor surroundings and environment coupled with pathogenic agents. The heightened stress owing to intensive system of rearing, higher population density, faster growth rate and prolific breeding makes them succumb to diseases & thereby causing financial losses to the farmers. Thus, the problems encountered due to various diseases, have been the main limiting factors for rabbit farming & coccidiosis is one of them. Even with highest bio security measures, coccidiosis continues to be an important disease inflicting severe losses in terms of high incidence of morbidity & mortality.
In order to obtain optimum returns, disease control strategies are of utmost importance. The knowledge of magnitudes & trend of rabbit mortality is of vital importance for instituting disease control strategies. There is paucity of information regarding systematic studies on coccidiosis in rabbits from Kashmir.

Keeping in view the importance of the rabbit farming & various factors limiting its productivity the present study was undertaken with the following objectives.

1. To study the prevalence of coccidiosis in rabbit of Kashmir valley both in govt. run and private farms.
2. To study the pathogenesis & pathology of coccidiosis infection in rabbits.
3. To study haematological & biochemical alterations due to coccidiosis in both experimentally as well as naturally infected rabbits.
4. To study the control of the disease by using drugs as Sulphaquinoxaline, Diclazuril & Maduramycin.
CHAPTER # 1.1

Biological Characters
1.2.1 LIFE CYCLE:

As is true with other species of the genus, *Eimeria* species associated with rabbit coccidiosis also have the characteristic intracellular and extracellular stages of asexual & sexual reproduction in their life cycle.

The parasite has a life cycle which lasts from 4 to 14 days. It starts after oral ingestion of food contaminated with oocysts. The wall of the oocysts is broken down in the stomach and spores are released. The presence of biliary and pancreatic enzymes in the duodenal portion of the intestine stimulates the spores. After entering the cells lining the intestinal wall, the spores start to divide asexually during one or more stages (schizogony) and merozoites are released to infest fresh cells of the intestinal mucosa. The final stage of schizogony leads to the formation of gametes, enabling sexual reproduction & oocysts are shed in the faeces.
Various species of *Eimeria* differ often in their location, organ and tissue specificities. Coccidiosis in rabbits has been classified in two distinct types:

### 1.2.1.1 INTESTINAL COCCIDIOSIS:

The intestinal form of coccidiosis mainly affects young animals. Majority of the intestinal species develop in the small intestine except for *Eimeria piriformis* and *E. flavescens* which complete their development in the caecum and colon, respectively. In intestinal coccidiosis, the disturbances in water and electrolyte balance occur in the parasitized part of the intestine before the appearance of the macroscopic lesions and are essentially characterized by a loss of water and sodium. The loss of sodium is compensated by the exchange of potassium from the blood thereby leading to hypokalaemia and causing death of the animal (Lebas *et al.*, 1986). The coccidia which parasitize the ileum, caecum or colon cause pathogenic lesions which are more characteristic of the organs involved than of the parasite species (Peeters *et al.*, 1984; Coudert, 1989). Symptoms include rough coat, dullness, decreased appetite, poor feed conversion, anaemia, dehydration, loss of weight, growth retardation and profuse diarrhoea for 4 to 6 days post infection. If the loss of weight reaches 20% death follows within 24 hours. It is preceded by convulsion or paralysis. During necropsy, inflammation and oedema are found in the ileum and the jejunum portions of the intestine. It is sometimes accompanied by bleeding and mucosal ulcerations.
1.2.1.2 HEPATIC COCCIDIOSIS:

The liver form of coccidiosis affects rabbits of all ages and completes its life cycle in bile duct epithelium within liver. It is characterized by listlessness, thirst, wasting of the back and hind quarters with enlargement of the abdomen. An x-ray at this stage shows an enlarged liver and gall bladder. This form of coccidiosis runs either as a chronic course during several weeks or it ends in death within 10 days, preceded by coma and sometimes diarrhoea. The mucous membranes of animals may be icteric (Levine, 1985). At necropsy liver, gall bladder and bile duct are distended and enlarged. White nodules cover the surface of the liver. The protozoa can be found in the liver & biliary ducts. An impression smear of the liver reveals the presence of *Eimeria*. Secondary infection can lead to their presence in the nervous system. The disease is often accompanied by secondary bacterial infection, in particular by *Escherichia - coli*.

1.2.2. PREVALENCE:

Among the various coccidial parasites inhabiting the rabbit, the genus *Eimeria* constitutes the most important group and predominantly occurs all over the world producing clinical and sub-clinical diseases. The genus *Eimeria* belongs to phylum Apicomplexa and family Eimeriidae. More than 25 species of *Eimeria* have been reported to cause coccidiosis in rabbits world wide. However, only 11 species have been isolated and characterized without ambiguity (Coudert, 1989; Wang & Tsai, 1991). These species include *E. irresidua* (Kessel & Jankiewicz, 1931), *E. media*
(Kessel, 1929), *E. perforans* (Leuckart, 1897), *E. intestinalis* (Cheissin, 1948), *E. coecicola* (Cheissin, 1947), *E. piriformis* (Kotlan and pospesch, 1934), *E. exigua* (Yakimoff, 1934), *E. magna* (Perard, 1925), *E. flavescens* (Marotel and Guilhon, 1941) and *E. stiedai* (Lindemann, 1865) KissKalt and Hartmann, 1907. The other species described includes *E. elongata* (Marotel and Guilhon, 1941), *E. neoleporis* (Carvalho, 1942), *E. matsubayashii* (Tsunoda, 1952), *E. nagpurensis* (Gill and Ray, 1961) and *E. Vejdovsky* (Pakandl, 1988). In general, the prevalence of the disease recorded in European countries ranges from 21 to 60% & in India from 13 to 64% (Bhat *et al.* 1996).

### 1.2.3. SPECIATION OF COCCIDIA:

The identification and speciation of different species of *Eimeria* infecting rabbits are essential for detecting the acute and chronic infections. For differentiating species of *Eimeria* certain criteria are to be kept in view such as host specificity, habitat of the parasites, relation of the parasites to the host cells, pathogenicity of the parasites, cross immunity test, morphological studies of the oocysts, sporulation time at a given temperature and pre-patent period (Tyzzer, 1929). Pande *et al.* (1972) have additionally pointed out that the cross transmission and immunological studies also help in determining the validity of various species, which on oocystic character appear identical. Sporulation time is mainly influenced by population density of oocysts, oxygen tension and ambient temperature. The optimum temperature for sporulation of *Eimeria* has been reported to be
27°C with a maximum of 28°C (Coudert et al. 1995). Sporulation time influenced by temperature was studied by Hemaprasanth et al. 1998.

1.2.3.1 *Eimeria coecicola:*

The oocysts were reported to be sub cylindrical or elongate (Pellerdy, 1974); ovoid or cylindrical (Kheysin, 1972; Soulsby, 1982); oval, slightly ovoid (Gill and Ray, 1960); ellipsoid, often asymmetrical (Akram 1991; Hobbs, 1998). The oocysts measured 33 – 40 x 16 – 23 μm (Pellerdy, 1974); 27.5 – 33 x 14 – 19 μm (Gill and Ray, 1960); 25.3 – 39.9 x 14.6 – 21.3 μm (Kheysin, 1972); 32.13 x 18.45 μm (Akram, 1991) and 29.5 – 42 x 16 – 20 μm (Hobbs, 1998).

The oocyst wall was described as light yellow or light brown in colour. The smooth oocyst wall was thickened slightly at the end corresponding to the site of the micropyle and ends abruptly (Gill and Ray, 1960; Soulsby, 1982; Akram, 1991).

The micropyle was found distinct on the slightly narrow end and appeared convex. The oocystic residual body was prominent and round. It measured about 6 μm in diameter (Gill and Ray, 1960), 1.3 – 6.7 μm with an average of 3.7 – 5.3 μm in diameter (Kheysin, 1972).

The shape of the sporocysts was stated as ovoid or oval, measuring 17.1 x 8-9μm and had a stieda body (Pellerdy, 1974), 12 x 5.5 μm (Gill and Ray, 1960). The sporocystic residual body was round or oval in form and measured 2 – 4 μm in diameter (Gill and Ray, 1960; Kheysin, 1972). Sporocysts were ellipsoid or ovoid with granular sporocystic residuum. Their dimensions varied from 12-13 by 5.75 – 7.5 μm (Akram, 1991) and
The sporozoites were refractile globules of medium size placed at the broader end and nucleus was placed centrally (Gill and Ray, 1960). The sporulation time as recorded was 72 hours at room temperature (Kheysin, 1972; Soulsby, 1982), 50 – 75 hours (Pellerdy, 1974).

**1.2.3.2 Eimeria exigua:**

The oocysts were spherical or subspherical (Pellerdy, 1974; Akram, 1991), oval (Gill and Ray, 1960), rounded (Jain, 1988). The oocysts measured 14.5 x 12.7 μm (Soulsby, 1982), 17 – 22.5 x 8 – 14 μm with an average of 18.75 x 11.5 μm (Gill and Ray, 1960), 10-18 x 9-16 μm with an average of 14.5 x 12.7 μm (Pellerdy, 1974), 15-20 x 12-20 μm average being 18x16 μm (Jain, 1988), 12-19 x 11-15 with an average of 16 - 13 μm (Hobbs, 1998).

The oocyst wall was thin, smooth and of equal width throughout. Oocyst wall was devoid of micropyle. The oocystic residual body was absent (Gill and Ray, 1960). The oocyst wall was smooth, yellowish, 2 μm thick (Jain, 1988). The oocyst was colourless or light pink with smooth wall devoid of a micropyle (Akram, 1991).

The sporocysts were faintly visible, ovoidal in shape with blunt pointed anterior end and devoid of sporocystic residual body (Gill and Ray, 1960). The sporocysts were ovoid, measured an average of 10.5 x 6 μm and sporocystic residual body were round with an average size of 4x5 μm. Stieda body was present (Jain, 1988). Sporocysts measured about 6.25 – 10 x 4.25 - 6 μm and were ovoid (Akram, 1991); the sporocysts were 6-10 x
4.5-6 μm average being 8.5 x 5.1 (Hobbs, 1998). The sporozoites were described as refractile globules of medium size (Gill and Ray, 1960).

**1.2.3.3. *Eimeria intestinalis***:

The oocysts were broadly pyriform or ovoid (Kheysin, 1972); distinctly pear shaped (Pellerdy, 1974; Catchpole and Norton, 1979; Jain, 1988). Oocysts were pear shaped, greenish-brown and composed of two layers (Akram, 1991). Oocysts measured 25-30 x 17.3 - 20 μm with an average of 26.9 x 18.89 μm (Gill & Ray, 1960); 21.3 - 35.0 x 14.5 - 21.3 μm (Kheysin, 1972); 27 - 32 x 17 - 20 μm average being 27 x 18 μm (Pellerdy, 1974); 23.5 x 18.5 μm (Jain, 1988); 30.0 - 31.2 x 15.0 - 20.0 μm (Sanyal and Srivastava, 1986); 28 - 32 x 16.5 - 20 μm with an average of 30 x 18.25 μm (Meitei, 1988); 31.23 - 19.13 (Akram, 1991); 26-34 x 16-20 with average of 29.1 x 18.2 (Hobbs, 1998).

The oocyst wall was smooth, yellowish or light brown in colour (Kheysin, 1972; Pellerdy, 1974). The attenuation in thickness of the wall began either at or slightly above the micropyle. However, in some oocysts, the wall when reaching the micropyle suddenly increased in thickness (Gill & Ray, 1960). The oocysts residuum was distinctly present, rounded in shape and measured 5 - 8 μm in diameter (Gill & Ray, 1960); 2.5 - 9.9 μm with a mean of 4.9 - 7.5 μm (Kheysin, 1972); round to oval measured an average of 5x5 μm (Jain, 1988). Oocyst residuum was present and polar granule was absent (Akram, 1991). A distinct micropyle was present at the narrow pole (Kheysin, 1972; Pellerdy, 1974; Jain, 1988; Akram, 1991).
The sporocysts were ovoidal with their anterior end bluntly pointed. The residuum body was rounded or oval, measured 15 – 23 μm in diameter (Gill & Ray, 1960). According to Kheysin (1972), sporocysts appeared ovoid, measured 10 x 15 μm and had a residual body of 1.25 – 6.25 μm in diameter; an ovoidal sporocyst with a rounded sporocystic residual body measured an average of 4 x 4.5 μm (Jain, 1988). Sporocysts were ovoid with bluntly pointed anterior end and sporozoites with a big refractile globule. The oocystic and sporocystic residual bodies were round or oval (Meitei, 1988). The sporocysts were ovoidal to elongate, 9.5 – 15 by 6.25 – 9 μm with small residuum and stieda body (Akram, 1991).

The sporozoites with a refractile globule of big or medium sized and a centrally placed nucleus (Gill & Ray, 1960). The sporulation time as recorded by Kheysin (1972) was 72 hours, 24 to 48 hours at room temperature (Pellerdy, 1974; Soulsby, 1982; Sanyal & Srivastava, 1986) and 36-72 hrs. (Meitei, 1988)

1.2.3.4 *Eimeria irresidua:*

The oocysts were ellipsoidal slightly broadened at one end and light or dark brown (Kheysin, 1972) ovoidal, usually blunt at the micropylar end, light yellow to yellowish brown (Gill & Ray, 1960); egg shape with rounded end (Jain, 1988), ellipsoidal to ovoid, slightly broadened at one end (Meitei, 1988); ellipsoidal & sometimes ovoidal, with curvature at each pole (Akram, 1991). The oocysts measured 25 – 37.5 x 17.5 – 24.75 μm (Gill & Ray, 1960); 25.3 – 47.8 μm x 15.9 – 27.9 μm with a mean of 35.1 – 40.8 x 20.2 – 23.8 μm (Kheysin, 1972); 31 – 34 x 22-27 μm with an average of
38.3 x 25.6 μm (Pellerdy, 1974); 28-35 x 16-22 μm (Sanyal & Srivastava, 1986); 31 x 21 μm (Jain, 1988); 31 – 36 x 18 – 23 with an average of 33.5 x 20.5 μm (Meitei, 1988); 35.33 – 24.04 μm (Akram, 1991) & 35 – 45 x 21 – 27 with an average of 39.1 – 24.3 (Hobbs, 1998)

The oocyst wall was smooth, light yellow and side walls were usually parallel (Kheysin, 1972). The oocyst wall had gradual increase in thickness towards the micropyle end forming moderately distinct shoulder or only slightly prominent shoulder or it was of the same thickness throughout forming no shoulder at all at the micropyle. The oocystic residual body was absent (Gill & Ray, 1960) but Norton et al. (1977, 1979) showed the presence in minute oocystic residual body. The oocyst was double walled wherein outer layer was yellowish and inner layer greenish with no oocystic residuum (Jain, 1988). Oocyst wall was smooth, yellow and composed of two layers, 1.25 – 1.5 μm in thickness, oocyst residuum and polar granule were absent (Akram, 1991).

The micropyle was distinctly wide either with a concave gap or with a distinct round hole in the wall (Gill & Ray, 1960). Micropyle was well developed (Jain, 1988). At one end there was prominent micropyle of 3.75 – 8.75 μm, with a mean value of 6 μm (Akram, 1991). A distinct micropyle was present at one end of oocyst (Meitei, 1988).

The sporocysts were ovoid measured 13.3 – 19.1 x 6.2 – 9.3 μm and had a large residual body, which was 4 – 9.3 μm in diameter or slightly elongate (Kheysin, 1972). The anterior end of the sporocysts was moderately pointed or slightly blunt in a few oocysts with an average size of 18 x 9 μm. The sporocystic residual body was either oval or spherical and measured 5 – 8 μm or small having a diameter of 3 μm (Gill & Ray, 1960);
long sporocystic residual body, measured 6 - 14 µm x 3.5 - 7 µm with an average of 12.5 x 4 µm (Jain, 1988)

The sporocysts were ovoid and sporozoites were having a large refractile globule. The sporocystic residual body was oval and massive with out oocystic residual body (Meitei, 1988). The sporocysts were elongated ovoidal with a small stieda body and a large residuum. The sporocysts measured 12 - 17.5 by 7.5 - 10 µm with a mean of 13.75 by 8.25 µm, the sporozoites were arranged head to tail with two large refractile globules. (Akram, 1991). The sporocyst measured 16 - 21 x 9 - 11 with an average of 18.7 - 9.7 µm and sporocystic residuum present (Hobbs et al. 1998). The sporulation time was 72 - 96 hours (Kheysin, 1972); 50 hours at room temperature (Pellerdy, 1974; Soulsby, 1982); 48 hours (Sanyal and Srivastava, 1986) and 50-72 hrs (Meitei, 1988).

1.2.3.5 *Eimeria magna*:

The oocysts were described as ovoidal or ellipsoidal (Pellerdy, 1974; Gill and Ray, 1960); broadly ovoidal (Kheysin, 1972; Soulsby, 1982); ovoid with truncated anterior and rounded posterior end (Jain, 1988). Oocysts were ovoidal, sometimes ellipsoidal, frequently brownish or yellowish orange with a well formed micropyle at the end (Akram, 1991). The oocysts measured 27 - 41 x 17 - 29 µm (Cheissin, 1947); 31.5 - 40.25 x 18 - 25.5 µm with an average of 37.66 x 23.28 µm (Gill and Ray, 1960); 26.6 - 41.3 x 17.3 - 29.3 µm with a mean of 32.9 - 37.2 x 21.5 - 25.5 µm (Kheysin, 1972) 31 - 40 x 22 - 26 µm (Pellerdy, 1974); 31.5 - 40 x 18 - 23 µm (Jain, 1988); 34.05 - 2.16 (Akram., et al. 1991) 30 - 42 x 18 - 26 (Hobbs, 1998).
The oocyst wall was stated to be thin, evenly thick throughout or it suddenly increased in thickness towards the micropyle, forming distinct hillock (Gill & Ray, 1960). The outer wall was detached. The distinct collar like protrusion was absent during sporulation (Soulsby, 1982). The micropyle was well developed with a collar of about 8 μ (Jain, 1988; Meitei, 1988). Around the well developed micropyle a collar like protrusion was distinctly visible (Akram, 1991). The micropyle was found wide and distinct which was surrounded by a collar like protrusion at the narrow end (catchpole and Norton, 1979) with the measurement of 5 – 7.5 μm (Gill and Ray, 1960).

A large oocyst residuum was present measuring 7.5 – 12.5 μm in diameter (Gill and Ray, 1960); 3.9 – 12 μm with a mean of 6.7 – 9.7 μm (Kheysin, 1972); large irregular or comma shaped oocyst residuum with a mean of 8.5 x 10 μm (Jain, 1988). Oocysts were present with large residuum (18.75 – 10.5 μm) and the polar granule was absent (Akram, 1991). The oocyst residuum was present (Hobbs, 1998).

The sporocysts were ovoid, measured 15.25 –18 x 7 – 8.75 μm in size with the sporocystic residual body which was found rounded or oval, 13-8.5 μm in the largest sporocyst (Gill and Ray, 1960); 15 x 7.8 μm sporocyst, had a residual body measuring 3.9 – 4.9 μm (Kheysin, 1972). Sporocyst was having a small stieda body (Pellerdy, 1974). The sporocysts were ovoid or pear shaped with an elongated residual body (Jain, 1988). The sporocysts were ovoid, with out stieda body and varied from 13 – 16 by 6.25 – 8.7 μm (Akram, 1991); 14 – 18 x 7 – 10 μm with an average of 15.3 – 8.5 μm (Hobbs, 1998).
The sporozoites bore a large refractile globule about 4 μm in diameter at the broader end and nucleus placed in the centre (Gill and Ray, 1960). The sporozoites were arranged head to tail around a coarsely granular sporocystic residuum (Pellerdy, 1974). The sporulation time as recorded by Pellerdy, (1974) and Soulsby, (1982) varied from 48 – 72 hours at room temperature whereas Kheysin (1972) mentioned the sporulation time as 72 – 120 hours and 48 hours as recorded by Sanyal and Srivastava (1986). The sporozoites were arranged head to tail, with two large refractile globules. (Akram, 1991).

1.2.3.6 *Eimeria media:*

The oocysts were ovoid or ellipsoidal (Kheysin, 1972; Soulsby, 1982); ovoidal (Pellerdy, 1972; Gill and Ray, 1960; Jain, 1988; Sanyal and Srivastava; 1986, Akram, 1991, Hobbs, 1998). The oocysts measured 25 – 37 x 16 – 20 μm with a mean of 30.5 x 18 μm (Gill and Ray, 1960); 19 – 33 x 13 – 21 μm (Levine, 1961); 18.6 – 33.3 x 13.3 – 21.3 μm with an average of 26.2 – 30.2 x 16.7 – 17.5 μm (Kheysin, 1972); 27 – 36 x 15 – 22 μm and average being 31.2 x 18.5 μm (Pellerdy, 1974); 22.0 – 34.0 x 12.0 – 24.0 μm (Sanyal and Srivastava, 1986); 26 – 31 x 17.5 – 20 μm (Jain, 1988); 27.71 – 18.22 (Akram 1991), 23 – 34 x 14 – 20 with an average of 29.1 – 17.2 μm (Hobbs, 1998).

The oocyst wall was smooth, light yellow or pinkish to orange in colour and uniformly thick except towards the micropyle where it became thinner. The oocysts narrowed slightly at the micropylar end (Gill and Ray,
1960; Pellerdy, 1974). The oocyst wall was smooth, light yellowish and composed of two layers of 0.9 – 1.1 μm, (Akram, 1991).

The micropyle was distinctly present, prominent, convex and shallow pyramidal shaped (Catchpole and Norton, 1979). Micropyle was 5.75 – 7 μm (Akram, 1991). The oocystic residual body was 4 – 5 μm in diameter (Gill and Ray, 1960) 2.7 – 7.9 μm (Kheysin, 1972); coarsely granular oocysts residuum measured 5.2 μm in diameter (Pellerdy, 1974). Oocyst residuum was 5.75 – 6.25 μm in diameter and polar granule was absent. (Akram, 1991).

The sporocysts were ovoidal measured 6.6 – 14.7 x 5 – 7 μm and had a residual body 1 – 3 or 2.7 μm in diameter (Kheysin, 1972), coarsely granular sporocystic residuum was placed centrally in oval sporocysts (Pellerdy, 1974); round or oval or scattered sporocystic residuum was also present (Gill and Ray, 1960). The sporocysts were ovoid, measured an average of 11 x 6.5 μm with round or ovoid sporocystic residual body (Jain, 1988).

The sporocysts were elongate ovoidal (13 – 14 by 7.0- 8.25 μm) with a small residuum and one clear globule at the larger end of the sporozoites (Akram, 1991); 11 – 16 x 6 – 9 with an average of 13.9 x 7.1 (Hobbs, 1998). The sporulation time was 52 hours at room temperature (Pellerdy, 1974); 48 hours (Soulsby, 1982); 48 – 72 hours (Kheysin, 1972; Jain, 1988; Sanyal and Srivastava, 1986).
1.2.3.7. *Eimeria perforans*:

The oocysts were ovoid to ellipsoidal in shape at both the ends equally rounded and one end was slightly attenuated than the other (Gill and Ray, 1960); ovoid subspherical or cylindrical (kheysin, 1972) and more ellipsoidal than ovoid (Pellerdy, 1974) subspherical to elongate ellipsoidal (Catchpole and Norton, 1979); pear shaped to ellipsoidal (Jain, 1988). Oocysts were spherical to ellipsoidal in shape (Meitei, 1988); oocysts were often ellipsoidal sometimes ovoid (Akram, 1991; Hobbs, 1998).

The oocysts measured 15 – 29 x 11 – 17 μm average being 22.7 x 14.2 μm (Kessel and Jankicwiez, 1931) 15 – 22 x 12 – 16 μm (Kotlan, 1961); 24 – 30 x 14 – 20 μm average being 26 x 16 μm (Levine, 1961) 24 – 30 x 14 – 20 μm average being 25.5 x 15.5 μm (Bouvier, 1967); 18 – 29 x 18 – 21 μm with the mean of 19 – 12.8 μm (Martinez *et al.*, 1969); 17 – 32 x 12.5 – 19.5 μm average being 20.25 x 15 μm (Gill and Ray, 1960); 13.3 – 30.6 x 10.6 – 17.3 μm (kheysin, 1972); 15 – 29 x 11 – 17 μm with an average of 22.7 x 14.2 μm (Soulsby, 1982); 12.0 – 28.6 μm x 11.7 – 16.0 μm (Sanyal and Srivastava, 1986); 18.5- 22.5 μm x 13 – 18 μm (Jain, 1988); 23 – 30 μm x 16 – 19 μm average being 26.5 x 17.5 μm (Meitei, 1988) 22.12 x 14.84 μm (Akram, 1991) 17.38 x 11.5 – 17 μm (Hobbs, 1998).

The oocyst wall was thin and of the same thickness throughout with smooth surface (Gill and Ray, 1960). The oocysts wall was double and light in colour (Jain, 1988; Meitei, 1988). Oocyst wall was smooth colorless and composed of two layers with a thickness of 0.9 – 1.25 μm (Akram, 1991). The micropyle was present in the larger oocysts but sometimes not
visible in smaller oocysts (Kheysin, 1972). Micropyle was absent (Gill and Ray, 1960; Jain, 1988). Micropyle absent but rarely could be seen a fine structure similar to micropyle (Akram, 1991).

The oocystic residual body was spherical or oval and measured 2 – 4 μm in diameter (Gill and Ray, 1960). The oocyst residuum measured 3.2 μm and often polar granules were present, (Pellerdy, 1974; Martinez et al., 1969) observed a pleomorphism of the oocyst residuum. The oocysts residual body was round, measured an average 6 x 6 μm (Jain, 1988). Oocystic residuum was present without a polar granule in the oocysts (Akram, 1991); small oocystic residuum was present (Hobbs, 1998).

The shape of the sporocysts was ovoid to oval which measured an average of 7.75 x 3.75 μm (Gill and Ray, 1960) and 8 – 9 x 4.5 μm (Kheysin, 1972). The long sporocysts had a stieda body and residuum (Pellerdy, 1974). The sporocystic residual body was indistinctly present and appeared spherical (Gill and Ray, 1960). The sporocysts were elongated with round small residual body (Jain, 1988); sporocysts were ovoid (Meitei, 1988). The sporocysts were ellipsoidal; 8.75 – 11.5 by 4.5 – 6 μm (mean 9.6 – 5.2 μm). sporocyst residuum and stieda body were present (Akram, 1991). 8–14 ×5-7with a few granules of sporocystic residuum. (Hobbs, 1998).

The sporozoites were refractile globule of medium sized placed at the blunt extremity with a centrally placed nucleus (Gill and Ray, 1960) sporozoites were elongate (Akram, 1991). Sporozoites had medium sized refractile globule (Meitei, et al., 1988).The sporulation time was observed to be 48 hours at room temperature (Gill and Ray, 1960; Jain, 1986), 24 – 48 hours (Kheysin, 1972), 30 – 56 hours (Pellerdy, 1974; Soulsby, 1982). 48 hours (Sanyal and Srivastava, 1986).
1.2.3.8. *Eimeria piriformis:*

The shape of the oocysts was pyriform often asymmetrical, measured 26 – 32 x 17 – 21 μm with an average of 29 x 18 μm (Pellerdy 1974); 26 – 32.5 x 14.6 – 19.6 μm with a mean of 29.6 – 31.7 x 17.7 – 18.8 μm (Kheysin, 1972); 26.0 – 31.2 x 16.9 – 18.2 μm (Sanyal and Srivastava, 1986); 25.5 x 18.5 μm (Jain, 1988); oocysts were pear shaped with an average of 30.32 – 20.11 μm (Akram, 1991). 24 – 36 x 18 – 21 μm (Hobbs, 1998). The oocyst wall was smooth, double coloured, yellowish brown and no oocystic residuum was formed (Pellerdy, 1974). The oocyst wall was light yellowish, smooth and composed of two layers (Akram, 1991).

A prominent micropyle was visible at the tapering or narrow end of the oocysts (Pellerdy, 1974; Soulsby, 1982). A micropyle with 5.75 – 7 μm was present, oocysts residuum was present with 5.75 – 6.25 μm in diameter, polar granule was absent (Akram, 1991).

The sporocysts were ovoid measured 10.5 x 6 μm (Kheysin, 1972), 14 – 16 μm in diameter with granular sporocyst residuum, 3 – 5 μm in diameter (Pellerdy, 1974); 2.5 – 5.5 μm in diameter (Kheysin, 1972). The sporocysts were pear to ovoid measured 22 x 18 μm with round sporocystic residual body (Jain, 1988).

The sporocysts were ovoid 11-25x12-8 μm with granular residuum and stieda body. The sporozoites were with a clear globule at the larger end (Akram, 1991) 11 – 14 x 7 – 9 μm with average of 12.7 x 7.8 μm (Hobbs, 1998). The sporulation time as recorded by Kheysin, (1972) was 72 – 96 hours at room temperature and 24 – 48 hours (pellerdy, 1974); 40 hours (Sanyal and Srivastava, 1986).
The oocysts were ovoidal or ellipsoidal (Gill and Ray, 1960; Soulsby, 1982) narrowly oval, flattened slightly at the micropylar end sometimes asymmetrical (Pellerdy, 1974). The oocysts were ovoidal (Meitei, 1988) ellipsoidal to oval (Hobbs, 1998); oocysts were elongate ovoidal (Akram, 1991). The oocysts measured 26 – 40 x 16 – 24 μm with a mean of 35 – 75 x 21 μm (Gill and Ray, 1960) 28 – 40 x 16 – 25 μm mean being 37 x 21 μm (Pellerdy, 1974), 30 – 40 x 16 – 25 μm (Kheysin, 1972); 28 – 40 x 16 – 25 μm (Soulsby, 1982); 35 – 40 x 20 - 25 μm (Meitei, 1988); 31.52 – 20 μm (Akram, 1991), 34 – 40 x 18 – 22 with mean of 36.2 – 20.6 (Hobbs, 1998).

The oocyst wall was uniformly thick throughout but slightly thin towards the micropyle (Gill and Ray, 1960). Oocyst wall was bilayered salmon- coloured, outer layer was smooth and thin (Pellerdy, 1974). The oocyst wall and micropyle was thin (Meitei, 1988). The wall was smooth and composed of two clear layers (Akram, 1991).

The micropyle was thin, convex and continuous with contour colour of the wall (Gill and Ray, 1960). A residual body was found after sporulation, consisting of several light refracting granule situated between the sporocysts (Kheysin, 1972) and oocyst residuum was absent (Gill and Ray, 1960). Kotlan and Pellerdy, (1936) described the presence of a small oocyst residuum but did not confirmed while a minute oocystic residual body was observed by Norton et al. (1977,1979). Micropyle was present and oocyst residuum was visible after sporulation (Meitei, 1988). The micropyle was indistinguishable but when visible it was about 4 – 5 μm wide. Oocyst
residuum was present more frequently with a diameter of 4 μm but some
times absent. The polar granule was present (Akram, 1991).

The sporocysts were oval to ovoid, measured 17 x 9 μm (Gill and
Ray, 1960); 18 – 10 μm in diameter with a stieda body and a granular
residuum (Pellerdy, 1974). The sporocysts were elongate ovoidal, 12.5 –
15.5 by 6.25 – 10 μm with a fine residuum and stieda body (Akram, 1991),
14-17 x 7.5 – 9 with sporocystic residuum present (Hobbs, 1998). The
sporulation time was 72 – 96 hours (Kheysin, 1972); 72 hours at room
temperature and 58 hours at 22°C (Soulsby, 1982) 48 – 72 hours (Pellerdy,
1974) and 72 hours Meitei, 1988.

1.2.3.10 Eimeria elongata:

The oocysts were ellipsoidal or elongate and greyish in colour
(Soulsby, 1982), ovoidal (Pellerdy, 1974). The oocysts measured 31 – 43 x
22 - 27 μm average being 38.3 x 25.5 μm (Pellerdy, 1974); 36.0 – 41 x 15.0
– 24.0 μm average being 39.2 x 18.2 μm (Sanyal and Srivastava, 1986). The
oocyst wall was smooth, light yellow with a concave micropyle which was
not thickened around it. The micropylar end of the oocysts was somewhat
narrower than the other. No oocyst residuum was present (Gill and Ray,
1960).

The sporocysts were elongate with a granular sporocystic residual
body (Pellerdy, 1974). The sporulation time was 98 hrs., as reported by
Soulsby (1982), 96 hours according to Pellerdy (1974), it was 48-50 hours
as recorded by Sanyal and Srivastava, 1986.
1.2.3.11. *Eimeria matsubayashii*:

The oocysts were broadly ovoidal (Kheysin, 1972; Pellerdy, 1974); ovoidal or ellipsoidal (Gill and Ray, 1960). Oocysts were broadly ovoid with yellowish brown in colour. (Akram, 1991). The oocysts measured 23.5 - 29.5 x 14.9 - 19.25 μm with an average of 26.25 x 15.5 μm (Gill and Ray, 1960); 24.9 x 18.2 μm (Kheysin, 1972); 22 - 29 x 16 - 22 μm with an average of 25 x 18 μm (Pellerdy, 1974); 30.41 - 21.09 (Akram, 1991).

The oocyst wall was smooth, light yellow in colour. The walls were having the same thickness throughout except about the micropyle where its thickness increased. The oocystic residual body was prominent, rounded, about 4 μm in diameter (Gill and Ray, 1960); 6.2 μm in diameter (Pellerdy, 1974). The oocyst wall was yellowish brown in colour. The wall was smooth and had a micropyle around which it was a little thicker. Oocystic residuum was present but without polar granule. (Akram, 1991). The micropyle was distinct, 2 - 4 μm wide (Gill and Ray 1960); Diameter of the micropyle was 5.95 μm (Akram, 1991).

The sporocysts were ovoid, about 7 x 6 μm in size with round sporocystic residual body (Gill and Ray, 1960). The sporocysts were ovoid (14 - 15 by 7 - 7.5 μm) with a stieda body and granular residuum. The sporozoites had a clear globule at the larger end (Akram, 1991). The sporozoites were placed terminally at the blunt end having refractile globule and nucleus at the centre (Gill and Ray, 1960). The sporulation time as recorded by Pellerdy, (1974) was 32 - 40 hours at 28°C.
1.2.3.12. *Eimeria flavescens*:

The oocysts were ovoidal, tan in colour. The oocysts measured about $27 - 37 \times 20 - 23 \, \mu m$ with an average of $32.1 - 21.4 \, \mu m$. Oocystic residuum was absent. The sporocysts varied from $12 - 17 \times 8 - 9$ average being $14.6 \times 8.4$, sporocystic residuum was present (Hobbs, 1998).

1.2.3.13. *Eimeria nagpurensis*:

The oocysts were barrel shaped, longitudinally parallel (Gill and Ray, 1960; Soulsby, 1982). The oocysts measured $20.25 - 26.5 \times 10 - 15 \, \mu m$ with an average of $23 \times 13 \, \mu m$ (Gill and Ray, 1960; Kheysin, 1972; Pellerdy, 1974); $20 - 27 \, \mu m$ by $10 - 15 \, \mu m$ (Soulsby, 1982); $20.8 - 22.1 \times 12.9 - 13.0 \, \mu m$ with average being $21.3 \times 13.0$ (Sanyal & Srivastava, 1986). The oocysts wall was smooth, thin walled, prominent and of even thickness throughout. The oocysts were devoid of micropyle and oocystic residuum body (Gill and Ray, 1960). Oocysts were thin walled, without micropyle and residuum (Soulsby, 1982).

The sporocysts resembled an oat grain in shape. The anterior extremity was sharply pointed, measuring an average of $15 \times 5 \, \mu m$. The sporocystic residual body was distinct, granular lying in the centre of sporocysts (Gill and Ray, 1960; Soulsby, 1982).

The sporozoites were elongate rather, long measured a mean of $12.5 \times 2 \, \mu m$. Refractile globule of small size was prominent which measured $1.75 \, \mu m$ in diameter and was placed normally at the terminal end of the blunt
extremity. The nucleus was placed centrally and sporulation time was 48 – 72 hours at room temperature (Sanyal and Srivastava, 1986).

1.2.3.14. *Eimeria neoleporis*:

The oocysts were elongate ellipsoidal (Gill and Ray, 1960) sub cylindrical or elongated cylindrical (Pellerdy, 1974); nearly cylindrical (Kheysin, 1972); Sub cylindrical to ellipsoidal (Soulsby, 1982). The oocysts measured 30 – 45 x 16 – 22 μm average being 37.5 x 19 μm (Gill and Ray, 1960); 32.8 – 44.3 x 16.7 – 22.8 μm with a mean of 38.8 x 19.8 μm (Kheysin, 1972; Pellerdy, 1974).

The oocyst wall was smooth, yellowish slightly thickened at the end corresponding to the site of the micropyle (Pellerdy, 1974). The oocystic residual body was absent (Gill and Ray, 1960), few granules representing oocyst residuum without polar body were seen (Pellerdy, 1974). The prominent micropyle was located at the slightly narrow end of the oocysts (Kheysin, 1972).

The sporocysts were ellipsoidal measured 17.1 x 8 μm (Kheysin 1972); ovoid measured 17.1 x 8 – 9 μm and had a stieda body (Pellerdy, 1974) weekly ovoid to more or less oval measuring 16.5 x 8 μm in size (Gill and Ray, 1960). Sporocystic residual body was spherical with an average diameter of 5 – 8 μm (Gill and Ray, 1960). The sporozoites were refractile globule of medium or small size with a centrally placed nucleus (Gill and Ray, 1960). The sporulation time was 48 – 72 hours (Kheysin, 1972; Soulsby, 1982); 50 – 75 hours (Pellerdy, 1974).
1.2.4. PRE-PATENT PERIOD:

It is essential to know the prepatent period of coccidial infection in rabbits as it helps in determining the different species of the genus *Eimeria*. Kheyisn (1947) reported a pre-patent period of 8 – 9 days, while Cheissin (1940) mentioned 6-7 days. Meitei (1988) also recorded 8-9 days for *E. magna*. Rutherford (1943) and Cheissin (1946) reported 9-10 days and 7-8 days respectively, as the pre-patent period of *E. irresidua*. Prepatent period of *E. media* and *E. piriformis* was 6 – 7 days and 9 – 10 days, respectively (Pellerdy, 1974), while Meitei (1988) reported 6 – 7 days for *E. media*. *E. perforans* had a pre-patent period of 5 – 6 days according to Levine (1961) and 6 days as recorded by Cheissin (1947) while Meitei (1988) also recorded 6 days for *E. perforans*.

The pre-patent period of 11-14 days (Carvalho, 1944) and 12 days (Pellerdy, 1974) have been reported in case of *E. neoleporis* infection in rabbits. The pre-patent period *E. intestinalis* has been described as 10 days (Kheyisn, 1947). 10 – 11 days by Meitei (1988), where as 9 – 10 days pre-patent period was noted for *E. coecicola* (Kheyisn, 1947; Meitei, 1988). Kotlan and Pellerdy (1936, 1949) reported the pre-patent period of 16 days and 17 days in case of *E. stiedai & 14 days according to Soulsby, 1982*).

1.2.5 PATHOGENIC POTENTIALS:

*E. intestinalis* is recognized as the most pathogenic coccidial species parasitizing rabbits (Catchpole and Norton, 1979; Coudert, 1979; Zundel,
1979; Peeters et al. 1981; Coudert et al. 1993). In general, depending upon pathobiological effects, *Eimeria* species causing intestinal coccidiosis in rabbits have been divided into three groups (Lebas et al. 1986; Bhat and Jithendran, 1995). viz.

1. Non pathogenic to slightly pathogenic e.g *E. media*, *E. exigua*, *E. perforans*, *E. coecicola*.
2. Moderately pathogenic e.g, *E. irresidua*, *E. magna*, *E. piriformis* and
3. Very pathogenic e.g *E. intestinalis*, *E. flavescens*.

The only species responsible for hepatic coccidiosis has been classified as moderately pathogenic. However Hung et al. (1984) reported *E. stiedai* to be the most pathogenic but pathogenicity was closely related to load and host age. Fortineau and Stachurski (1985) reported that *E. intestinalis* and *E. flavescens* were most pathogenic causing mortality at low parasitic burden while as *E. irresidua*, *E. magna* and *E. piriformis* caused mortality at higher intensities of infection. *E. media* and *E. perforans* caused clinical disease without any mortality and *E. coecicola* was found to be non-pathogenic. The clinical severity of the disease and mortality was highest during the patent phase which in all the intestinal types lasts for 5 – 35 days and in *E. stiedai* for 21 – 30 days (Bhat et al. 1996). However, the overall pathological effects on the host are determined by various hosts and environmental factors besides the nature of infection viz, single or mixed infection, managemental practices, geoclimatic conditions, immune status of the host, concurrent infections with other type of pathogens like mycotoxicosis etc. Single infection as well as mixed infections with a number of species associated with intestinal coccidiosis or concurrent hepatic and intestinal coccidiosis has been reported (Sugar, 1978; Catchpole and Norton, 1979;
Zundel, 1979; Ogunbiyi and Uche, 1981; Sanyal and Srivastava, 1986; Jain, 1988; Meitei, 1988; Gurpratab & Khahra 1997). Sugar (1978) reported concurrent occurrence of hepatic and intestinal coccidiosis in 6 of 50 rabbits and could identify *Eimeria stiedai, E. magna, E. media, E. irresidua* and *E. perforans*. Zanger (1987) reported that most of the rabbits infected with coccidia revealed a concurrent infection with 2–5 species and monospecies infection could be found in only 4.1% cases.

The managemental practices, geoclimatic conditions as well as concurrent infection have been found to influence type and frequency of *Eimeria* species affecting rabbits. Zundel (1979) reported that most of the coccidian infected cases in France were found to harbour two or three different species although one species was always observed to be predominating. The authors have reported that the frequency of different species varied with the rearing method i.e cage or litter system, the presence of *E. coli* infection, season and geographical locality. As a general rule, the mean number of oocysts per gram, number of *Eimeria* species present and the frequency of *E. intestinalis* were higher in litter system than in case of cage system of rearing. Further poor hygienic conditions were found associated with higher mean oocyst counts, higher number of species involved in mixed infection and greater frequency of very pathogenic *E. intestinalis*. 