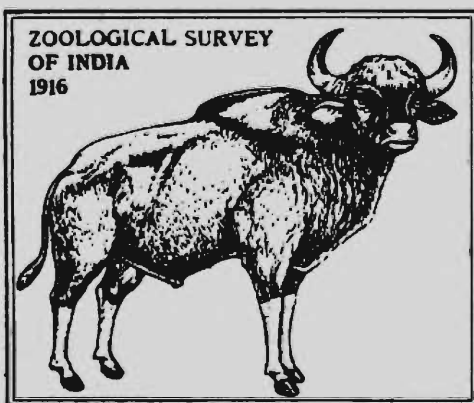


TECHNICAL MONOGRAPH No. 5

**Coccidia and Coccidiosis
of Poultry and Farm
Animals of India**

by

A. K. MANDAL



**ZOOLOGICAL SURVEY
OF INDIA**

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FARM ANIMALS OF INDIA

BY

A. K. MANDAL

Zoological Survey of India, Calcutta



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1980

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INTRODUCTION

The Coccidian parasites have long drawn the attention of a very large number of Protozoologists, Veterinarians and Medical men as the causative agents of dreadful disease, coccidiosis, particularly in domestic animals. Investigations on these parasites have been started in this subcontinent since early twentieth century. Bhatia's monumental work on the fauna of British India, Sporozoa, was published in 1938. In between Pellerdy's two classical editions (1965 and 1974) on Coccidia and Coccidiosis, the MS of the present author's Coccidia of Indian Vertebrates was prepared but published in 1976. All these publications had some inadequacies so far as the Coccidia of poultry and farm animals of India are concerned. Therefore, the necessity to have a comprehensive biological monograph on Coccidian parasites of poultry and farm animals of Indian subregion is a long felt need.

The coccidian parasites exclusively belonging to the family Eimeriidae have been incorporated in the present volume. The organisms like the *Toxoplasma* though come under Coccidia have not been taken into account for the sake of convenience. Therefore the organisms dealt herewith can be defined as the individuals where the male and the female gametes are dissimilar and their development takes place independently and the male gametocytes produce many microgametes.

While reviewing each species the morphology of the oocyst has been given at the beginning followed by the type host along with the developmental stages wherever available. Generally the original morphological and biological descriptions of each species have been retained as such with a slight modification in the terminology for the sake of uniformity. All the synonymies have been given under each species along with all the recorded references. Species described from Zoological Gardens have been kept as such.

The keys to the identification of species have not been given as it is not possible to determine the species without consulting the detailed description of the parasite given in the text. Most of the workers are having almost similar opinion regarding the key to the identification of species in this group (Pellerdy, 1974).

Though the parasites dealt with in this book were mainly of domestic animals the author would deem his endeavour a success if it is useful to workers in various fields.

MATERIAL AND METHODS

While studying coccidia, the collection and preservation of oocysts, intestinal smears and histological sections of the intestine and other organs of the host are generally taken into consideration. The different methods those are adopted in studying this particular group have been vividly discussed by Davis (1973). In India, Patnaik (1966a) developed some techniques for developing pure strain in chicken coccidia. However, some important procedures followed for the collection and preservation of materials in studying this group are dealt hereunder.

The oocysts are generally obtained after direct examination of faecal samples from the droppings. However, a mechanical extractor is also used for collecting rectal samples particularly from farm animals. It consists of a hollow plastic cylinder of diameter 2 cm and about 20 cm long designed at an angle of 45° at the tip with smooth edge (Swan, 1970). The plastic cylinder is placed inside the anus and the extractor is removed with a slight downward pressure which allows the air to enter inside the rectum. This process ultimately leads to stimulate defecation. Sometimes the finger is pushed inside the rectum by putting the hand-gloves in hands. The slight movement of the finger inside stimulates defecation in animals,

In order to bring the faecal samples to the laboratory, a separate vial for each sample is used, half-filled with 2.5% potassium dichromate ($K_2Cr_2O_7$) keeping a little air-space above. Each consignment is properly labelled — citing the name of the host, locality etc. For sporulation, the sample is placed in petri dish containing 2–4% (best is 2.5%) potassium dichromate or any other flat container to a depth of few millimetres so that there should be a ready supply of O_2 inside the container to the oocyst, without which the sporulation is not possible. Sometimes the tap water is also used for the sporulation of oocysts.

In order to remove excess debris, the process for repeated washing and sedimentation was followed and screened through a fine-meshed wire gauze. The floatation method is also applied for obtaining the maximum number of oocysts on the surface by using a saturated solution of sodium chloride of 1.2 specific gravity or 33.1% aqueous solution of zinc sulphate. Most satisfactorily the Sheather's sugar solution, can be prepared by dissolving 500 gm of sucrose in 320 ml of distilled water. Melted phenol, 6.5 gm is added to the mixture, subsequently after stirring the sample with water and centrifugation at 15,000 r.p.m. for about 5 minutes, the supernatant fluid is removed. The Sheather's solution was added and kept for half an hour or so after placing a cover slip on the surface level of the fluid inside the centrifuge tube. The oocysts will adhere to the cover slip and can be examined under microscope (Kenneth *et al.*, 1977). It is generally adopted when the number of oocyst are scanty in the sample.

For examination of oocysts under microscope a small quantity of the surface materials (generally after floatation method) from the fluid was transferred to a slide with the flattened end of a glass rod and then a cover glass is placed over it. If the sample is to be examined directly from dichromate solution, a little amount of material from the petri dish or vial can be placed on the slide and examined under low power microscope. The debris as far as practicable can be removed from the drop with the help of a needle and then a cover slip is placed over it for detailed examination.

Due to the impervious outer wall of the oocysts, it is generally not possible to stain them and as such very difficult to examine the internal structures. However, authors like Monne and Honig (1954) have used hypochlorite for removing outer wall of the oocysts. Davis and Smith (1960) have used antiformin for the same purpose and fluorescence stain like acridine orange etc. has been used which gave satisfactory result for observing the details inside the oocysts. Some intra vitam stains (Mandal, 1976) can also be used to observe the oocysts under microscope which give better performance for the internal structures. However, for counting the number of sporocysts and sporozoites it is better to crush the oocyst with the help of slight pressure on the cover glass simply by turning the fine adjustment while using oil immersion lens. In order to obtain the endogenous stages the scrapings from the intestinal mucosa and the parts of the intestine or other tissues are to be fixed in 10% formalin or Bouin's Duboscq-Brassil's fluid. A serial paraffin section of 5–8 μ in thickness was cut for tissue preparations after following the usual histological techniques. It is stained with Heidenhain's iron-haematoxylin and differentiated in 1% iron alum solution followed by the process of counter staining with the eosin. At the time of postmortem examination of the diseased animals particularly in the abomasum and intestine, gross lesions like white pin-heads, nodular structures are generally found. On teasing the white pin-point lesions, the merozoites are found fully packed up inside. After usual histological preparations of these organs a large number of immature and mature giant schizonts (globidia) can also be traced in the section along with the merozoites,

A brief of the general organisation and structure of the organisms belonging to Coccidia have been given below. This will give a general idea of the group and explain the technical terms used while describing them.

Diagram illustrating the structure of a sporozoite within an oocyst wall, showing various labeled components:

- MICROPYLE CAP
- MICROPYLE
- POLAR GRANULE
- STIEDA BODY
- SMALL REFRACTILE GLOBULE IN SPOROZOITE
- LARGE REFRACTILE GLOBULE IN SPOROZOITE
- SPOROCYST
- OOCYST RESIDUUM
- SPOROCYST RESIDUUM
- SPOROZOITE NUCLEUS
- SPOROZOITE
- INNER LAYER OF OOCYST WALL
- OUTER LAYER OF OOCYST WALL

another is effected by means of oocyst (Fig. 1) which may have an independent existence and can be defined as resistant seed-like bodies, containing one or more sporocysts or sporozoites protected by a firm envelope. The oocyst can be regarded as a contrivance to enable the parasite to withstand the difficulties of the outside world until they pass again into the body of a suitable host. Once the oocyst gets its entrance inside the body of the new host, the sporozoites liberate and the development begins which is contaminative i.e. the oocysts are injected with the food in which the sporozoites have already been passed.

(b) *Form, structure and reproduction.*—In the life history (Fig. 2) of this group of parasite the starting point may be considered as sporozoite which it possesses a sickle-shaped or fusiform body. The sporozoite after being set free in the body of the new host nourishes itself and grows at the expense of the host. This is the trophic phase and the organism during this phase is described as the trophozoite. The trophozoite is known as schizont when it is about to enter an asexual reproduction, the divisionary process is termed as schizogony and the products of division are called merozoites. Some of the merozoites become gametocytes, differentiate into macro and microgametocytes which ultimately give rise to macro and microgametes respectively, and this process is called gametogony. The fusion of the two gametes results in the formation of zygote, secretes a distinct membrane around, become passive spherical body known as oocyst which is the resistant stage and can survive for a long period outside the host and is regarded as transmissive phase.

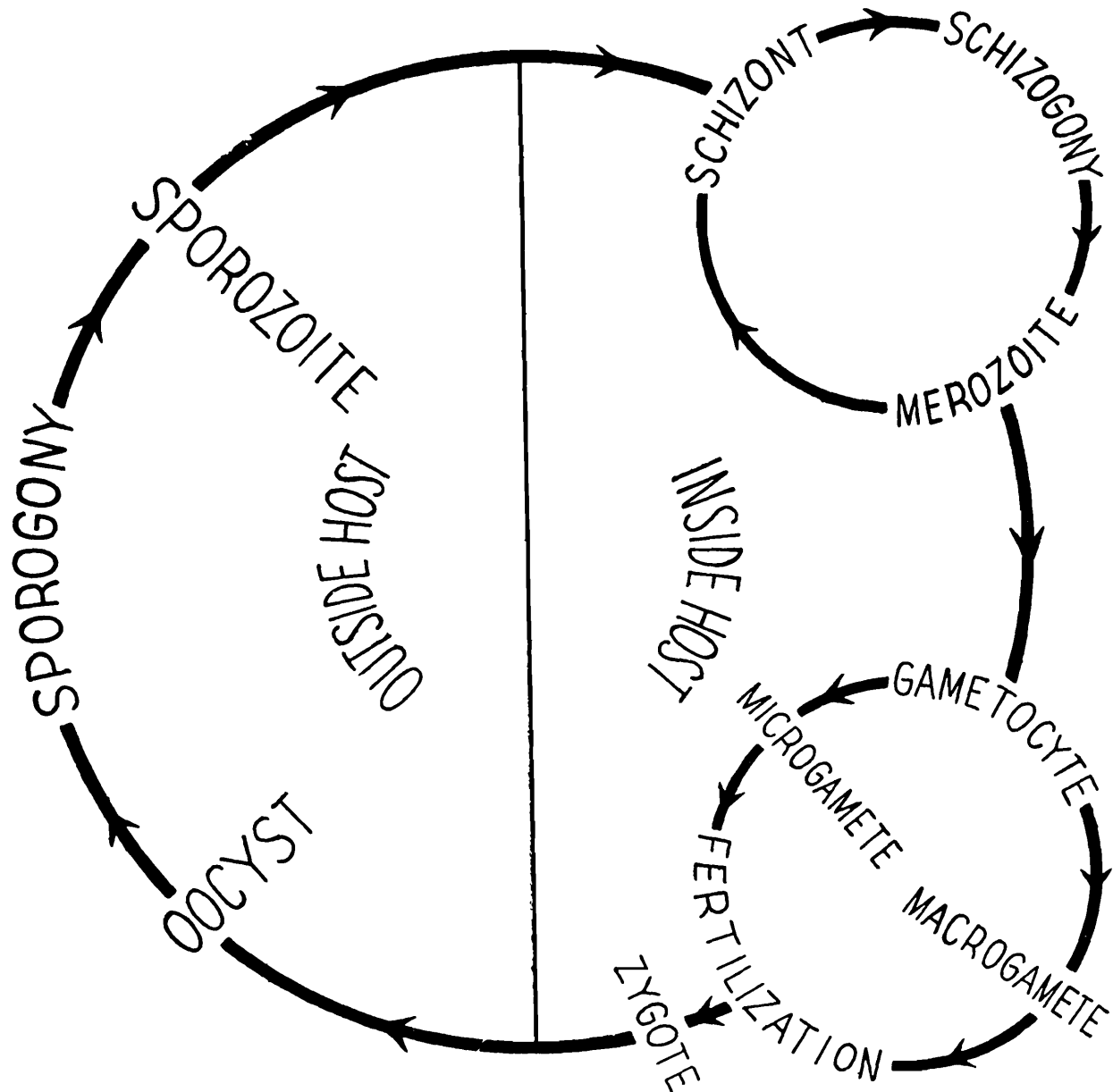


Fig. 2. Diagrammatic representation of life-cycle of a Coccidian Species.

Cellular division of the protoplasm within the oocyst gives rise to the formation of the number of sporoblasts, ultimately forms the sporocysts. The sporocyst inside develops a small or large number of germs or sporozoites. The sporozoites are treated as infective bodies and start the cycle again. During excystation the steida body of the sporocyst disappears in some cases or sometimes a portion of it remains. The sporozoite becomes active and leaves the cyst after the removal of the sub-steidal body.

ULTRASTRUCTURE OF DIFFERENT FORMS

(a) *Sporozoites*.—Sporozoites (Fig. 3) are fusiform in shape and situated within a parasitophorous vacuole which is formed after their entry into host cells. Ultrastructural study reveals that they are surrounded by a pellicular complex consisting of an outer membrane or plasmalemma, inner membrane complex and a row of sub-pellicular microtubules. Outer membrane is about $90\text{\AA}$ thickness while inner membrane complex measures $150\text{\AA}$ thick. In many parasites this complex appears as two membranes in close apposition. There are varying number of microtubules radiating from the most distal polar ring and extending posteriorly as far the nucleus

Usually near the anterior end of the nucleus there is a cytostome which may be functional as in *Eimeria ninakohlyakimovae*. The anterior end of sporozoites is nipple like and demarcated by electron dense two polar rings. There is hollow, truncated cone-shaped structure within the anterior end of the sporozoite. This is termed as conoid, the wall of which consists of spirally arranged fibrillar structure. In addition to these, rhoptries are present in the anterior region and micronemes are found in the anterior and middle portions of the sporozoites. Rhoptries are generally two in number within the species of *Eimeria* while the micronemes are numerous.

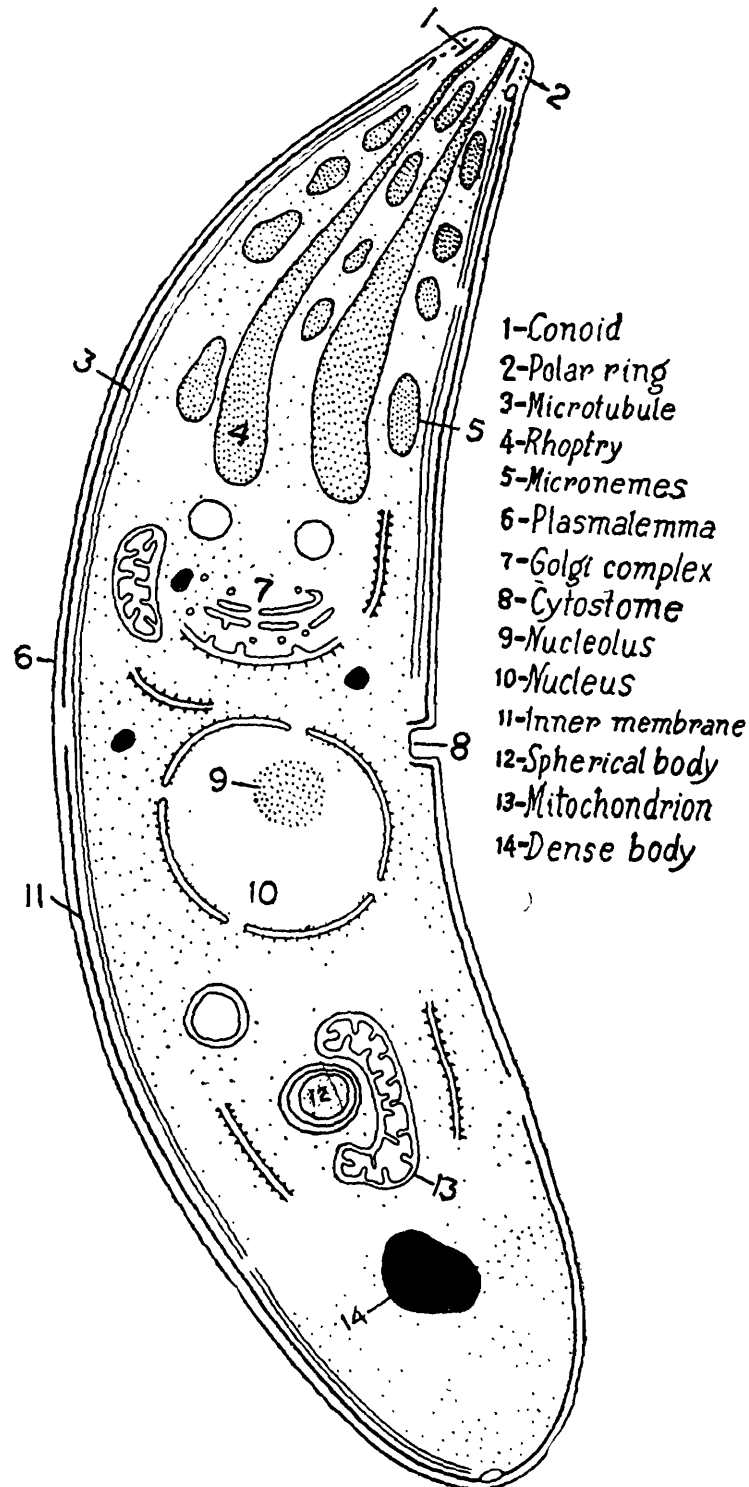


Fig. 3. Schematic drawing of sporozoite/merozoite of a Coccidian parasite as observed under EM.

(b) *Merozoites*.—Merozoites (Fig. 3) are having the same shape and location as those of sporozoites. They are generally smaller in size. But in ultrastructure merozoites closely resemble sporozoites excepting some minor points. For example (i) in merozoites some of the microtubules reach up to the posterior end of the parasites and (ii) merozoites of some *Eimeriina* (viz., *E. dinophili*, *E. bovis* and *E. stiedae*) possess only one polar ring.

(c) *Gametocytes*.—The gametocytes are also found within a parasitophorous vacuole. But they are surrounded by a membrane originating from the host cells. The pellicle of the gametocyte of *Eimeria* usually consists of two membranes excepting in few species where a single membrane is found. The outer membrane is termed as plasmalemma. The inner membrane appears to be composed of two closely apposed unit membranes excepting in some species in which it appears to be interrupted.

(i) *Macrogametocytes*.—In the macrogametocytes of some *Eimeria* species there are some intravacuolar tubules extending from their pellicle to the membrane of the parasitophorous vacuole. Some workers have the opinion that these vacuoles help in transportation of material between the parasite and the host-cell. Few cytostomes are also present along with the pellicles of the gametocytes.

In macrogametocytes there are plenty of wall-forming bodies which help in the formation of oocyst-wall. These bodies are of two types—one is homogenously osmiophilic and located beneath the pellicle while the other is sponge like and usually located more centrally associated with endoplasmic reticulum or Golgi-complex. The nucleus is single and relatively large usually with a compact nucleolus.

(ii) *Microgametocytes*.—The mature microgametocyte possesses many peripherally located nuclei which contain no nucleolus. Of course, nucleolus is visible within the nucleus of immature microgametocyte. During gametogenesis the axonemes of the microgamete are formed apparently from the centrioles which lie near the nucleus. With the outward growth of the axoneme the plasmalemma of the microgametocyte starts invaginating around the anterior portion. By that time a condensed portion of the nucleus and an elongated mitochondrion move into the developing microgamete. The basal bodies of the axoneme lie near the anterior end of the microgamete whereas the mitochondrion and the nucleus lie posterior to the basal bodies. The microgamete when completely formed may be having two or three axonemes, depending on the species of *Eimeria*.

COCCIDIA OF DOMESTIC FOWL

Eimeria acervulina Tyzzer

(Fig. 4A)

1929. *Eimeria acervulina* Tyzzer, *Am. J. Hyg.*, **10**: 269; Ray, 1946, Presidential Address *Indian Sci. Congr.* p. 136; Gill, 1954, *Indian J. vet. Sci. and Anim. Husb.* **24**: 245; *Indian vet. J.*, **31**: 95. Gill and Lall 1961, *Indian J. vet. Sci. and Anim. Husb.* **31**: 315; Patnaik, 1963, *Orissa vet. J.* **1**: 25; Kudo, 1966, *Protozoology*, p. 693; Bhatia and Pande, 1968c, *Indian J. Microbiol.*, **8**: 75; Rahman and Anantaraman, 1970, *Mysore J. agric. Sci.*, **4**: 57; Chandra and Chhabra, 1972, *Orissa vet. J.*, **7**: 6; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 220.

Description.—The Oocysts are egg-shaped or oval, smooth walled and yellowish in colour with uniformly thick wall except at the anterior end where it was slightly

thin. It measures 17.7μ – 20.2μ by 13.7μ – 16.3μ with a mean 19.5μ by 14.3μ . Shape index is 1.1–1.4 with a mean 1.25. The micropyle is found at the narrower end. The wall is double-contoured and has a smooth surface. No oocystic residual body is formed, but a polar granule is visible in most sporulated, and even in some unsporulated oocyst. There is no inner residual bodies.

Sporulation time.—24 hours.

Dimension of the oocysts reported by other authors are as follows:

12–23 by 9–17 μ with a mean 16 by 13 μ (Levine, 1961); 17–19 by 14 μ (Soltys, 1966); 13–22 by 10–16 μ with a mean 18 by 13.5 μ (Tacla, 1967); 18–20 by 14–16 μ with a mean 19.5 by 14.3 μ (Pellerdy, 1974).

Type host.—Domestic fowl, *Gallus domesticus* (= *Gallus* sp.).

Other hosts.—Bob white, *Colinus v. virginianus*; Californian Valley Quail, *Lophortyx californicus*; Plumed Quail, *Oreortyx picta plumifera* are also harbouring oocyst morphologically similar to the present species (Pellerdy, 1974).

Distribution.—U.P. and Orissa.

Endogenous stages.—This species is found in the epithelial cells of the anterior portion of the small intestine mainly at the duodenal loop and hind gut. Sometimes it invades the caeca or the rectum. Authors like Doran and Farr (1961, 1965), Doran, Jha and Rinaldi (1962), Doran (1966) adopted different methods in elucidating the life history of *E. acervulina* and found only one schizogonic generation and stated that the sporozoites penetrate the tip of the villi and then proceeded to the lamina propria. But Vetterling and Doran (1966) observed four schizogonic generations. The first generation schizont got maturation by the 36th–48th hour after inoculation and measured 9.1–11.3 μ in diameter producing 16 merozoites each measuring 4–4.5 μ long. The small second generation schizont matured by the 45th–56th hour. They measured 5–5.5 μ in diameter also producing 16 merozoites of 3.9–4.5 μ in length without forming a residuum. The third generation matured by the 56th–72nd hour and measured 3.9 by 5.5 μ in size. Each schizont produced eight merozoites each measuring 5.2–5.8 μ long, arranged around a residuum. The fourth generation schizont measured 9.4 by 6.7 μ matured by the 80th–96th hour. Each schizont produced 32 long merozoites, each of 9.1–10.3 μ in size with a large residuum. In all cases the schizonts were found to locate supranuclearly inside the host cell. The microgametocyte measured 6.7–7.8 μ in diameter each produced 2.2–3.3 μ long microgamete. The macrogametocyte measured 14.5–19 μ in diameter.

Long (1967a) reported that the first generation schizont matured by the 36th hour and measured 5–8 μ in diameter, producing 8–16 merozoites. The smaller bodies which probably be represented a second schizogony appeared in 48th hour. Third schizont appeared in the 72nd–81st hour measured 6–11 μ in diameter having 16–32 merozoites. The fourth schizont measured 5 μ in diameter containing 8–16 merozoites each of 5–6 μ long. Gametogony occurred in the anterior part of the small intestine on the 4th day. The microgametocyte measured 11 by 9 μ .

Tyzzer, the describer of this species regarded it as non-pathogenic. Mortality occurred in case of severe infection. But afterwards this species is considered as a pathogenic one. Sometimes whitish lesions are found both at the serosal and mucosal surfaces. In heavy infection colonies are seen at the posterior part of the intestine.

***Eimeria brunetti* Levine**

(Fig. 4B)

1942. *Eimeria brunetti* Levine, *Cornell. Vet.*, **32**: 430; Boles and Becker, 1954, *Iowa Stat. Coll. J. Sci.*, **29**: Gill, 1958, *Poultry Coccidiosis Scheme Ann. Rep. Indian Council agric. Res.* (1957-58) 14; Davies, 1963, *Vet. Rec.*, **75**: 1; Dubey and Srivastava, 1968; *Indian J. Microbiol.*, **8**: 257; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 224.

Description.—The Oocyst measures 20.7 μ –30.3 μ in length and 18.1 μ –24.2 μ in width, with an average 26.8 μ by 21.7 μ ; the shape is described as oval, resembling *E. maxima* oocyst, from which it differs by being smaller and having a thinner wall. In the sporulated oocyst, polar granules are present, but no residual body is found. The oocysts obtained from this country measure 24 μ –30 μ by 20 μ –23 μ with sporocysts 11 μ –16 μ by 5 μ –10 μ in size and are structurally similar to *E. brunetti*.

Sporulation time.—24–48 hours.

Dimension of the oocysts reported by other authors are as follows:

14–34 by 12–26 μ with the average 23 by 20 μ (Becker, Zimmermann and Pattillo 1955), 15–30 by 12–25 μ with an average 22.2 by 18 μ (Tacla, 1967), 23–29 by 11–24 μ with an average 25.7 by 18 μ (Pohl, 1964), 23–16 μ (Roepke and Lonsing, 1968) 22–25 by 18–22 μ (Pellerdy, 1974).

Type host.—Domestic fowl, *Gallus* sp.

Other hosts.—From the type host.

Distribution.—Jabalpur, M.P.

Endogenous stages.—Located mainly at the lower portion of the small and the large intestine. Sometimes it may be found in the anterior half of the small intestine or at the neck of the caeca. Boles and Backer (1954) encountered endogenous cycle at the ileum, rectum and cloaca. The first generation schizont measured 30 by 20 μ producing about 200 merozoites. The second generation schizont was having 50–60 merozoites being smaller in size than the first generation schizont. The macrogamete measured 25 by 27 μ enclosing a plastic granule. The microgametocyte appeared to some extent in large size. However, the authors might have dealt with a mixed infection.

Pellerdy (1960) could not come to conclusion about the size of the second generation schizont which was smaller than the previous or the first generation schizont. Davies (1963) followed the similar opinion as stated by Boles and Becker (1954).

Phol (1964) found the oval schizont sub-epithelially measured 5–10 by 6–7.5 μ in size at the third day after inoculation. The mature spindle-shaped merozoites were found each measuring 5–8 μ long. A few macrogametocytes were also found on the fourth day. The prepatent period is about 5 days.

Since the presentation of pure *E. brunetti* strains is difficult in all cases, it awaits further investigation.

This species is pathogenic and caused heavy mortality. The complete blockage of the large intestine with exudate inside the small intestine are frequently encountered with the infection of this parasite.

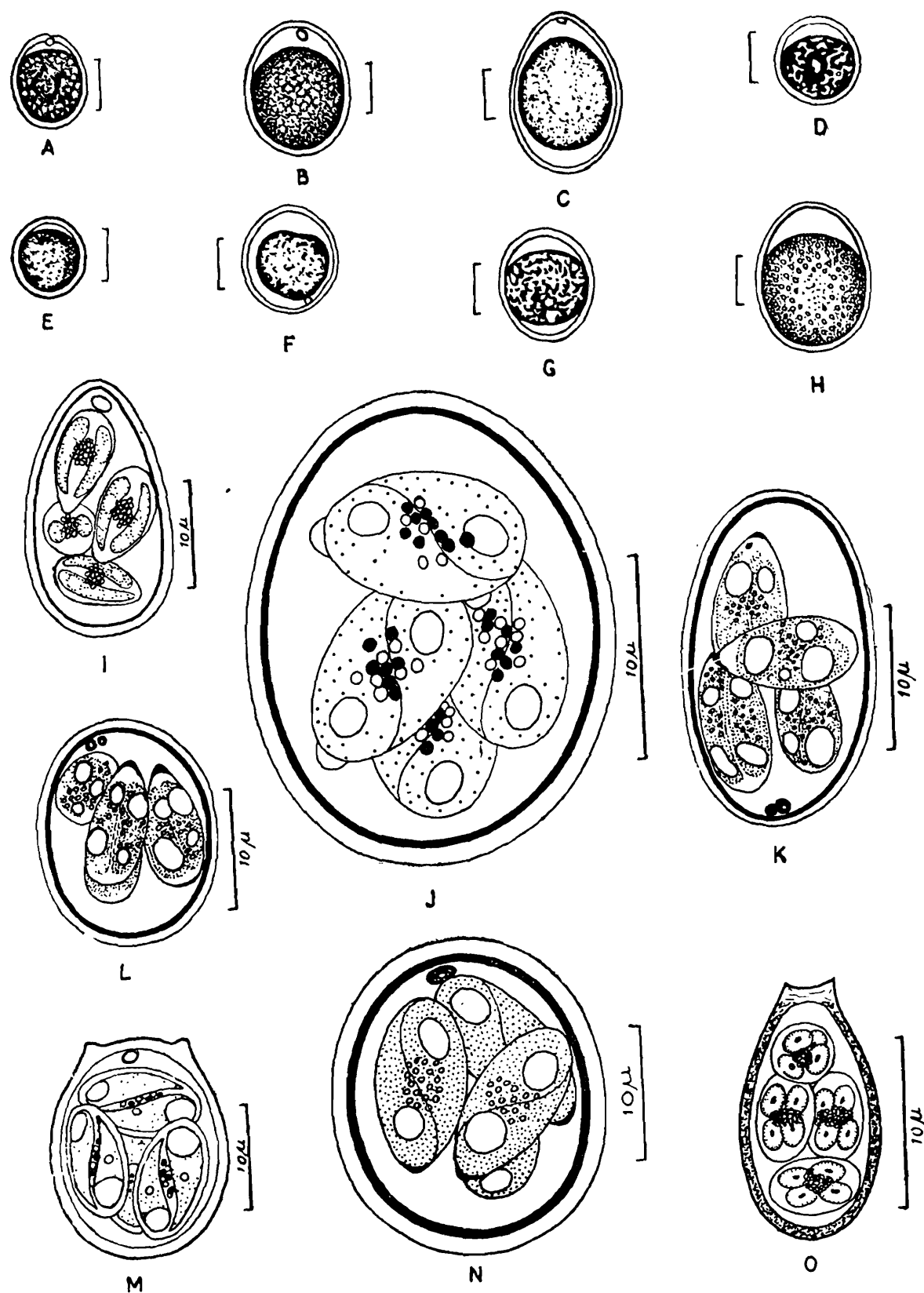


Fig. 4. (A-H). Diagrams of unsporulated oocysts of:
 A) *E. acervulina*; B) *E. brunetti*; C) *E. maxima*; D) *E. mitis*; E) *E. mivati*;
 F) *E. necatrix*; G) *E. praecox*; H) *E. tenella*.
 (I-O). Diagrams of sporulated oocysts of :
 I) *E. adenoeides*; J) *E. dispersa*; K) *E. meleagridis* L) *E. meleagrimitis*;
 M) *E. anatis* N) *E. battakhi*; O) *Wenyonella anatis*.

Eimeria hagani Levine

1938. *Eimeria hagani* Levine, *Cornell. Vet.*, **28**: 263; Gill, 1954a, *Indian J. vet. Sci.*, **24**: 245; Patnaik, 1963, *Orissa vet. J.*, **1**: 25; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 230.

Description.—The oocyst dimensions are 15.8 μ –20.9 μ in length and 14.3 μ –19.5 μ in width averaging 19.1 μ by 17.6 μ . The shape is broadly ovoid, the wall double contoured, with a smooth surface. A micropyle is absent. Polar granule remains in the mature oocyst after sporulation.

Sporulation time.—24–48 hours.

Type host.—Domestic fowl, *Gallus domesticus* (= *Gallus* sp.).

Other hosts.—From the type host.

Distribution.—Mukteshwar, U.P.; Orissa.

Endogenous stage.—Little is known about the endogenous stages of this parasite. They are generally localised at the anterior part of the small intestine.

Remarks.—Pellerdy (1974) stated that the morphological description of the species is inadequate. It could only be differentiated with certainty by applying cross-immunity tests and a complete description of the endogenous stages. However, this species is antigenically unique [Edgar 1977, cited by Ruff, and Reid (1977) in the chapter on avian coccidia in the *Parasitic Protozoa* edited by Kreier, J. P. 1977].

Regarding pathogenicity some pin point haemorrhages were noted at the mucosa in cases of experimental infection.

Eimeria maxima Tyzzer

(Fig. 4C)

1929. *Eimeria maxima* Tyzzer, *Am. J. Hyg.*, **10**: 269; Ray, 1945, Presidential Address *Indian, Sci. Congr.*, p. 136; Gill, 1954, *Indian J. vet. Sci. and Anim. Husb.*, **24**: 245; Patnaik, 1963, *Orissa vet. J.*, **1**, 25; Kudo, 1966, *Protozoology*, p. 693; Bhatia and Pande, 1968b, *Indian J. Anim. Hlth.*, Rahman and Anantaraman, 1970, *Mysore J. agric. Sci.*, **4**: 157; Chandra and Chhabra, 1972, *Orissa vet. J.*, **7**: 6; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 231.

Description.—The sporulated oocysts are ovoid, egg-shaped or ellipsoidal, 27 μ –34 μ by 16 μ –28 μ (mean 31 μ by 23 μ) in size; with the light yellowish-brown and occasionally rough oocystic wall of 1.3 μ in thickness. A polar granule present but oocystic residuum absent. The ovoid sporocyst, with slightly narrower extremities measuring 15 μ –20 μ by 8 μ –9 μ (mean 17 μ by 9 μ) in size. A prominent 'Stieda' body present. The elongated sporozoites, each of 15 μ by 4 μ in size has a large refractile globule on the broader end and a smaller globule towards the narrower end.

Sporulation time.—48 hours.

Dimension of the oocysts reported by other authors are as follows:

26–49 by 22–31 μ (Kotlan, 1961); on average 31 by 23 μ (Long, 1959); 25–42 by 21–27 μ with a mean 33.7 by 24 μ (Tacla, 1967); 30–33 by 22–26 μ (Soltys, 1966); 21–42 by 16–30 μ with a mean 29.3 by 22.6 μ (Pellerdy, 1974).

Type host.—Domestic fowl, *Gallus* sp.

Other hosts.—Unknown.

Distribution.—Orissa; Mathura, U.P.

Endogenous stages.—These are found at the middle of the intestine sometimes at the duodenum and ileum. Tyzzer (1929) studied the life cycle of *Eimeria maxima* in detail. He found schizonts at the tips of the villi, measured 10 by 8 μ producing 8–16 merozoites. Each of the microgametocyte was found with granular cytoplasm and measured 34 by 22 μ , produced 500–600 peripherally arranged microgametes. Challey and Johnson (1968) noted the sporozoites penetrating the epithelial cells of the villi prior to lamina propria, sometimes engulfed by macrophages of two types. They reported that the first generation schizont appeared at the 48th hour containing 25–50 merozoites in the crypts. The second generation schizont produced 8–12 merozoites and matured by 72nd hour.

This species may cause severe pathological changes with haemorrhagic enteritis associated with a thickening of the intestinal wall.

***Eimeria mitis* Tyzzer**

(Fig. 4D)

1929. *Eimeria mitis* Tyzzer, *Am. J. Hyg.*, **10**: 269; Ray, 1945b, Presidential Address. *Indian Sci. Congr.*, p. 136; Gill, 1954, *Indian J. vet. Sci. and Anim. Husb.*, **24**: 245; Patnaik, 1963, *Orissa vet. J.*, **1**: 25; Kudo, 1966, *Protozoology*, p. 693; Rahman and Anantaraman, 1970, *Mysore J. agric. Sci.*, **4**: 157; Chandra and Chhabra, 1972, *Orissa vet. J.*, **7**: 6; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 234.

Description.—The Oocysts are yellowish tinged, smooth-walled. The size range varies from 12.3 μ –20.7 μ in length and 10.7 μ –19.2 μ in width with an average of 17.0 μ by 15 μ . The shape index ranges from 1.0–1.3, with the average of 1.1. Polar granule present in the sporulated oocyst but without any oocystic residuum. Sporocysts 4 in number, ovoid in shape, measuring 9 μ by 6.5 μ (average) in size with prominent stieda body.

Sporulation time.—48 hours.

Dimensions of the oocysts reported by other authors are as follows:

11–21 by 10–18 μ with a mean 15.6 by 13.8 μ (Joyner, 1958); 10–21 by 9–18 μ with a mean 16 by 13 μ (Levine, 1961); 11–19 by 10–17 μ (Pellerdy, 1974).

Type host.—Domestic fowl, *Gallus domesticus* (= *Gallus* sp.).

Other hosts.—From the type host.

Distribution.—Mukteswar, U.P. and Orissa.

Endogenous stages.—Found mainly at the anterior half of the small intestine within the epithelial cells. Colonies are uniformly distributed and the schizonts are found at the anterior portion of the small intestine. They produce 6–24 or more bent merozoites, each measures 5 μ in length. The gametocytes develop more posteriorly. The microgametocytes are subspherical, measuring 9–14 μ in diameter. A residuum is left after the production of many microgametes. The microgametes are large and provided with plastic granules. Tyzzer (1929) and Joyner (1958) studied the life cycle of *Eimeria mitis* and found that the first schizont generally appeared inside the epithelial cells of the villi. The schizogonic processes occurred at the anterior portion of the small intestine. Each schizont produces 6 to 24 or more bent merozoites, measuring 6 μ in length. The gametocytes develop in the posterior portion of the small intestine. The microgametocytes measured 9–14 μ in diameter with a residuum inside and produced many microgametocytes. The large macrogametocytes were provided with plastic granules. Joyner (1958) noted the prepatent period as 4–5 days. It is treated as nonpathogenic but recent studies

explored the fact that the severe mortality might occur in young chicks due to this parasite.

***Eimeria mivati* Edgar and Seibold**

(Fig. 4E)

1964. *Eimeria mivati* Edgar and Seibold, *J. Parasit.*, **50**: 193; Pellerdy, 1974, *Coccidia and Coccidiosis* p. 235; Gill and Grewal, 1974, *Poultry guide*, **6**: 14.

Description.—Oocysts are ellipsoidal to ovoid in shape measuring $10.7\ \mu$ – $20.0\ \mu$ in length and $10.1\ \mu$ – $15.3\ \mu$ in width with a mean $15.6\ \mu$ by $13.4\ \mu$. The shape index ranges from 1.0 to 1.3. The oocyst wall consists of three layers (viz. – exo, middle and endo membranes). Micropyle is always present. Each sporulated oocyst possesses 4 sporocysts and a refractile polar granule approximately $1\ \mu$ in diameter. A residual mass is also present inside the sporocyst approximately 2 – $3\ \mu$ in diameter. Stieda body remains at the end of the thin walled sporocyst. The sporocyst measured $7.3\ \mu$ – $12.1\ \mu$ in length and $5.0\ \mu$ – $6.1\ \mu$ in width with an average $10.5\ \mu$ by $5.6\ \mu$. Each sporulated oocyst is provided with two sporozoites in each of the 4 sporocysts. The sporozoites are crescent or banana-shaped with pointed anterior and blunt posterior ends, measuring $11.1\ \mu$ – $13.0\ \mu$ in length and 1 – $9\ \mu$ $2.5\ \mu$ in width averaging $11.7\ \mu$ by $2.1\ \mu$. Each possesses a large eosinophilic globule located posteriorly and an almost spherical nucleus slightly anterior to the centre.

Sporulation times: 12 hours or more.

Type host.—Domestic fowl, *Gallus domesticus* (= *Gallus* sp.).

Other hosts.—From the type host.

Distribution.—Izatnagar, U.P

Endogenous stages.—Mainly occur at the duodenal loop towards the ileum, rectum and caeca. Long (1967a) encountered the endogenous cycle of *E. mivati* at the anterior portion of the small intestine. He noted the first generation schizont, measuring 9 – $11.7\ \mu$ by 9 – $11.1\ \mu$, which produced 10 – 30 merozoites of 9.6 – 10.6 by 2.1 – $3.00\ \mu$ in size, without affecting the host cell nucleus. These schizonts appeared in the 36th hour. The second generation schizonts matured by the 55th–65th hour and measured 4.8 – 10.9 by 3.9 – $7.5\ \mu$ with the mean 9.2 by $7.2\ \mu$. Each schizont produced 16 – 20 merozoites, each of 5.6 – $8.8\ \mu$ long surrounding a residuum of 7 – $8\ \mu$ in diameter. The merozoites invade the jejunum and ileum, sometimes to the caeca and rectum. The third generation schizont measured 5.8 – $7.7\ \mu$ by 4.5 – $6.7\ \mu$, giving rise to 14 merozoites of 5.6 – $6.7\ \mu$ by 1 – $1.3\ \mu$ in size with a residuum of 5 – $6\ \mu$ in diameter. It is also treated as a pathogenic species.

***Eimeria necatrix* Johnson**

(Fig. 4F)

1930. *Eimeria necatrix* Johnson, *Oregon Agric. Expt. Sta.*, p. 119; Ray, 1945b, Presidential Address. *Indian Sci. Congr.*, p. 136; Gill, 1961, *Indian J. vet. Sci., and Anim. Husb.*, **31**: 304; Patnaik, 1963, *Orissa vet. J.*, **1**: 25; Kudo, (1964) *Protozoology*, p. 693; Bhatia and Pande, 1968a, *Indian J. Microbiol.*, **8**: 129; Rahman and Anantaraman, 1970, *Mysore J. Anim. Sci.*, **4**: 157; Chandra and Chhabra, 1972, *Orissa vet. J.*, **7**: 6; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 237.

Description.—The oocysts are broad-ovoid in shape but more stocky, and have one end less pointed, measuring $15.5\ \mu$ – $23.3\ \mu$ by $13.6\ \mu$ – $20\ \mu$ with a mean $20.5\ \mu$ by $16.8\ \mu$. The shape index is 1.0 – 1.6 with a mean 1.26 . The oocyst wall is smooth and double contoured. There is no micropyle. No oocystic residual body is

found. The sporocysts are elongated measuring 10 μ in length and 6 μ in width which completely filled the space present inside the oocysts. A polar body is frequently present.

Sporulation time.—48 hours.

Dimension of the oocysts reported by other authors are as follows:

15–25 by 14–20 μ with a mean 20.5 by 17 μ (Becker *et al.*, 1956) 20 by 17 μ (Soltys, 1966); 15–25 by 12–22 μ with a mean 21 by 19 μ (Tacla, 1967); 18–21 by 13–15 μ with a mean 17.7 by 15.5 μ (Mohamed, 1969); 13–23 by 4–18 μ with a mean 16.7 by 14.2 μ (Pellerdy, 1974).

Type host.—Domestic fowl, *Gallus domesticus* (= *Gallus* sp.).

Other host.—From the same host.

Distribution.—Mukteswar, Mathura, U.P.; Orissa.

Endogenous stages.—The parasite invades mainly the jejunum or mid gut, sometimes the infection is found at the anterior and the lower portion of the small intestine. The first generation schizont measures 17.1 by 12.9 μ and produces 48 merozoites. The merozoites are banana-shaped and each of them has a nucleus close to the pointed end. The second generation schizont is large measuring 63 by 49 μ , and produces 32–132 merozoites of 10.5 by 3.5 μ in size with a granular cytoplasm and a nucleus close to the anterior end. The third generation schizont produces 4–8 small merozoites. The sexual stages are found at the caeca or at the large intestine. The macrogametocyte measures 13.1 by 12.6 μ with a large nucleus surrounded by a halo and the microgametocyte measures 12.5 by 14.3 μ .

Tyzzer, Theiler and Jones (1932); Davis (1956) and Mohamed (1969) were the pioneers in elucidating the life cycle of *Eimeria necatrix*. Free sporozoites were noted inside the intestinal lumen 6 hours after inoculation. Eventually, the sporozoites are found to enter the lamina propria become round, along with loss of glycogen but without affecting the hyaline globule.

First generation schizont measured 17.1 by 12.9 μ and was recorded after 36th hour from the date of inoculation. The schizont was found to contain 48 merozoites.

The second generation or the large schizont measured 63 by 49 μ in size appeared by the 78th hour after inoculation. In the histological sections, the schizont measured 43.8–51.7 by 23.1–28.2 μ with a mean 44.5 by 27.8 μ . Each schizont matured within 109th hour and produced 32–132 merozoites, measuring 10.5 by 3.5 μ with a granular cytoplasm and a nucleus lying at the anterior end. The merozoites were found to invade the caeca and rectum after liberation and ultimately leading either to gametocytes or to third generation schizonts.

Mohamed (1969) found the third generation schizonts in the caecal mucosa at the 132nd hour. The schizonts produced 16 smaller merozoites. The gametocytes occurred in the caeca. The macrogametocyte measured 13.1 by 12.6 μ while the microgametocyte measured 12.5 by 14.3 μ .

Van Doornick and Becker (1957) stated that the sporozoites invade the lamina propria earlier than the crypt of Leiberkuehn. Sometime they are being engulfed by macrophages.

Tyzzer (1932) recorded the prepatent period as 7 days; 6 days as stated by Davis (1956), and Mohamed (1969) reported the same as 150 hours. So far the pathogenicity is concerned, this species occupied a position next to *E. tenella*. Massive dilation at the middle intestine along with white and dark spot were visible at the serosal surface. Clotted blood along with mucus debris was found at the mucosal surface of the intestine due to sloughing of epithelial tissues.

Eimeria praecox Johnson

(Fig. 4G)

1930. *Eimeria praecox* Johnson, *Oregon. Agric. Expt. Sta.*, p. 119; Ray, 1945b, Presidential Address. *Indian Sci. Congr.*, p. 136; Gill, 1954a, *Indian J. vet. Sci., and Anim. Husb.*, **24**: 245; Patnaik, 1963, *Orissa vet. J.*, **1**: 25; Kudo, 1966, *Protozoology*, p. 693; Chandra and Chhabra, 1972, *Orissa vet. J.*, **7**: 6; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 244.

Description.—The oocysts spherical to elliptical in shape measuring 17.7 μ –24.4 μ in length and 13.0 μ –19.2 μ in width with an average 21.2 μ by 15.64 μ . The colour of the oocyst is yellowish and the wall is smooth with an average 0.72 μ in thickness. The shape index is 1.1–1.6 with an average 1.3. Micropyle in distinct, polar granule present in sporulated oocyst but without any oocystic residuum. Sporocysts are elongated to ovoid in shape.

Sporulation time.—48 hours at room temperature.

Dimensions of the oocysts reported by other authors are as follows:

20–25 by 16–20 μ with a mean 21.3 by 17.1 μ (Tyzzer *et al.*, 1932); 16–25 by 15–20 μ with a mean 20.4 by 17.5 μ (Long, 1967b); 23.8 by 20.6 μ (Pellerdy, 1974).

Type host.—Domestic fowl, *Gallus domesticus* (= *Gallus* sp.).

Other hosts.—From the type host.

Distribution.—Tarai belt, U.P.

Endogenous stages.—Mainly found at the upper portion of the intestine. Tyzzer, Theiler and Jones (1932) encountered two schizogonic processes while studying the endogenous cycles of *E. praecox*. The schizont appeared in the lamina propria of the anterior portion of the small intestine at the 40th hour after infection. It measured 9–10 μ in diameter and produced 16 merozoites.

Long (1967b) found the larger schizonts in the epithelial cells of the villi, measured 20 μ in diameter. The smaller one measuring 14 μ in diameter gives rise to 16–20 merozoites was found in the deeper part of the villi. The first schizont appeared in the 83rd hour and the smaller one in 65th hour.

Lee and Millard (1971) studied the fine structure of *Eimeria praecox*. They encountered three schizogonic generations. The first schizont appeared in epithelial cells of the duodenum, within the parasitophorous vacuole having elongated merozoites. The first and second generation schizonts produced 16 and 16–32 merozoites respectively. In the third generation schizont asynchronous merozoite formation was noticed. Gametocytes occurred in the 83rd hours. Mature macrogametes and microgametocytes were noticed at 91st hour. The microgametocyte measured 10–14 μ having a large residuum.

The prepatent period was 88 hours according to Johnson (1930); Edgar and Seibold (1964) stated the same for 84 hours and Long (1967b) reported it for 105 hours after infection.

Eimeria tenella (Railliet and Lucet) Fantham

(Fig. 4H)

1891. *Eimeria avium*, *Coccidium tenellum* Railliet and Lucet, *Bull. Soc. Zool.*, France, **16**: 246.
 1891. *Coccidium tenellum* Railliet and Lucet, *Bull. Soc. Zool.*, France, **16**: 216.
 1893. *Coccidium globusum* Labbe, *C. R. Acad. Sci.*, Paris, **116**: 1300, *Ibid.*, **117**: 407.

1909. *Eimeria tenella* Fantham, *Proc. zool. Soc. London*, **14**: 43; Ray, 1945b, Presidential Address. *Indian Sci. Congr.*, p. 136; Gill, 1954a, *Indian J. vet. Sci. and Anim. Husb.*, **24**: 245; Gill and Ray, 1957, *Proc. zool. Soc. Calcutta, Mukherjee Memor.*, p. 357; Nath, Dutta and Sagar, 1960, *Res. Bull. (NS) Panjab Univ.*, **11**: 227; 1962, *Res. Bull. (N.S.) Panjab Univ.*, **12**, 215; 1965, *Res. Bull. (N.S.) Panjab Univ.*, **16**: 151; Patnaik 1963, *Orissa vet. J.*, **1**: 25; 1966b, *Indian vet. J.*, **43**: 414, 868; Kudo, 1966, *Protozoology*, p. 690; Chandra and Chhabra, 1972, *Orissa vet. J.*, **7**: 6; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 246.
1913. *Eimeria bracheti* Gerard, *Arch. Protistenk.*, **29**: 193.
1933. *Eimeria globosa* Levine and Becker, *Iowa Sta. Coll. J. Sci.*, **8**: 83.

Description.—The oocysts are broad-ovoid in shape, one end being slightly narrower than the other. The wall is double contoured, 1 μ –1.5 μ in thickness and shows a moderate sized micropyle. The oocyst measures 19.2 μ –26 μ in length and 16 μ –22 μ in width (mean 22.6 μ in length, 26 μ in width) at room temperature (60°–80°F), required for completion of the sporulation. Most sporulated oocysts develop sporocysts and a refractile granule, mostly polar in position with an outer residual body. The sporocyst measures 11 μ in length and 7 μ in width with an opening at the pointed end sealed by a slightly protruding stieda body. The sporozoites are elongated banana-shaped, measuring 6 μ –8 μ in length, with some spherical hyaline material in the granular cytoplasm near the blunt end, and along the outline of the nucleus. A granular sporocystic residuum is present.

Dimension of the oocysts reported by other authors are as follows:

24.5 by 18.2 μ (Scholtyseck, 1953); 14–31 by 9–25 μ with a mean 22.9 by 19.1 μ (Levine, 1961) 21–23 by 17–19 μ (Soltys, 1966); 16–27 by 15–24 μ with a mean 21 by 16.6 μ (Pellerdy, 1974).

Type host.—Domestic fowl, *Gallus domesticus* (= *Gallus* sp.).

Other host.—Pellerdy (1965) listed few with great doubts.

Distribution.—Mukteswar, U.P.; Calcutta, West Bengal; Orissa.

Endogenous stages.—Rose (1967) reported that the young birds generally get more infection than the older ones. It is generally found at the epithelium and later towards the submucosa of the caecal pouches.

Lotz and Leek (1963) found that the sporulated oocysts excyst in one or two hours after ingestion. The sporozoites 12.8 μ long are released in the intestine through the oocystic micropyle. They are slightly bent, sickle-shaped bodies, pointed at one end, blunt at the other.

Tyzzer (1929) found the invading sporozoites lying in the caecal glands encircled by a parasitophorous vacuole. He also reported that the schizonts were frequently present in the macrophages. Pattillo (1959); Challey and Burns (1959) found the sporozoites also in the macrophages. Scholtyseck (1953); Scholtyseck, Strout and Haberkorn (1969) observed sporozoites in connective tissues. They also found half-phagocytized parasites in the macrophages. Investigations by Leathem (1969) revealed that many sporozoites preferred to migrate between the cells prior to penetration and moved to the deeper part of the lamina propria. He did experiment on caecaectomized chickens with pure strains and found both the schizogonic and gametogonic stages developed close to caecal orifice.

Pellerdy (1974) found almost similar results as obtained by Leathem (1969). He also carried out an experiment on caeca ectomized chicken and noticed that the sporozoites and the merozoites occurred in the mucosa of the caecal stump, although they even invaded the rectal mucosa in considerable numbers. The mucous membrane showed inflammatory changes and petechial haemorrhages, depending on the severity of infection. Pellerdy concluded that caecaectomized chickens were never fatally affected by *E. tenella*.

Generally the first generation schizonts occurred in the epithelial cells of the caecal mucosa. Merozoites spindle-shaped appeared in a mass inside the layer of the lumen at the 60th–72nd hour from the date of inoculation, each measuring 2–4 μ by 1.5 μ in size.

The second generation merozoites possessed an eccentric nucleus close to the pointed end. They are found in fair numbers in the caecal contents, produced gametocytes. The microgametocytes were large and multinucleated and the microgametes are produced from those nuclei.

This species is highly pathogenic. Characteristic bleeding and thickening of the caecal walls are usually found in such infection.

Wenyonella gallinae Ray

1945a. *Wenyonella gallinae* Ray, *Curr. Sci.*, **14**: 275; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 261; Mandal, 1976, *Rec. zool. Surv. India*, **70**: 39.

Description.—Oocysts oval or egg-shaped with double envelope, the outer being thick than the inner one. Oocyst measures 28.5 μ –34.5 μ in length with a mean 31.5 μ and 19.5 μ –21.5 μ in width with a mean 20.5 μ . The shape index is 1.5. Micropyle present. Oocystic residuum absent. Cytoplasm granular and fills up the oocyst. Sporocysts pyriform in shape, measuring 17.5 μ –19.5 μ in length with a mean 18.5 μ and 7.5 μ –9.2 μ in width with a mean 8.3 μ . The shape index is 2.2. Sporocystic residuum present as granular mass. Sporozoites are club-shaped.

Sporulation time.—4–5 days.

Type host.—Domestic fowl, *Gallus gallus domesticus* (= *Gallus* sp.).

Other hosts.—Unknown.

Distribution.—Mukteswar, U.P.

Endogenous stages.—Unknown.

Remarks.—Ray (1945a) infected three young chickens with sporulated oocyst of the species dealt with which revealed the prepatent period as 7 days in one bird and 8 days in the rest two. Oocyst were discharged for three days. From the slight pestiness and discolouration of the droppings, the author inferred a certain degree of pathogenicity.

Isospora sp.

1965. *Isospora* sp. Shah and Joshi, *Indian J. Microbiol.* **5**: 27; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 260.

Description.—The oocysts are subspherical or sometimes spherical and measuring 16 μ –33 μ by 15 μ –31 μ (mean 23 μ by 20.4 μ). The wall consists of two layers; the external one is smooth 1 μ thick and light yellow, the internal one is 0.5 μ thick and brownish yellow. There is no micropyle. No oocystic residuum is formed during sporulation but there are often one or two polar bodies. The thick walled sporocysts hold a stieda body and the sporocystic residuum. The sporozoites are narrow at one end and bear yellowish globule on the other broad end.

Host.—Domestic fowl, *Gallus domesticus*, (= *Gallus* sp.).

Other hosts.—Unknown.

Distribution.—Madhya Pradesh.

Endogenous stages.—Unknown.

Remarks.—From domestic fowl so far 2 species of *Isospora* viz. *I. gallinae* Schltyo-seck, 1954 and *I. gallinarum* Kornieko and Glebezdin, 1963 have been reported. Pellerdy (1974) expressed a doubt about the validity of both the species. He presumed that both of them are *I. lacazei* Labbe, 1893 of sparrow and have erroneously been described, pointing the continuous contact of the hens with other birds like sparrow. On the report of the occurrence of *Isospora* sp. in domestic fowl from India he had the similar opinion as stated above.

The wide host range [vide Mandal, 1976] of *Isospora lacazei* along with the chance of contamination in addition to the variation in size of the oocysts and sporocysts, it is sometimes difficult to identify an Isosporan species. It is quite possible that the present species is nothing but *Isospora lacazei* found due to contamination.

COCCIDIA OF DOMESTIC TURKEY

***Eimeria adenoeides* Moore and Prawn**

(Fig. 4, I)

1951. *Eimeria adenoeides* Moore and Brown, *Cornell. Vet.*, **41**: 124, Clarkson, 1956, *Nature*, **178**: 196; 1958, *Parasitol.*, **48**: 70; Patnaik, 1963, *Orissa vet. J.*, **1**: 25; Kudo, 1966, *Protozoology*, p. 694; Bhatia, 1968b, *Indian J. Microbiol.*, **8**: 239; Chauhan, Bhatia, Arora, Agrawal and Ahluwalia, 1973, *Indian J. Anim. Sci.*, **43**: 163; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 206.

Description.—Oocysts double contoured with smooth surface, usually elliptical in shape measuring $19\ \mu$ – $31\ \mu$ in length with a mean $26\ \mu$ and $12.6\ \mu$ – $21.0\ \mu$ in width with a mean $16\ \mu$. Oocystic residuum absent but with 1 to 3 polar granules. Sporocysts elongate-ovoid apparently with a stieda body.

Sporulation time.—24 hours.

Dimension of the oocysts reported by other authors are as follows:

19–13 by 13–21 μ with the mean 26 by 16 μ (Moore and Brown, 1951); 18–21 by 14–17 μ (Svanbaev, 1957a); 21–30 by 13–20 with the mean 25.6 by 16.2 μ (Clarkson, 1958); 19–32 by 14–18 μ with the mean 27.2 by 16.6 μ (Golemansky, 1962).

Type host.—Domestic Turkey, *Meleagris g. gallopavo* L.

Other hosts.—From the type host.

Distribution.—Lucknow, U.P., Orissa.

Endogenous stages.—Mainly found at the caeca but extended to the lower portion of the small intestine and even up to the large intestine. Sometimes it is restricted to caeca only.

Moore and Brown (1951); and Clarkson (1956, 1958) encountered the parasites in the caecum and ileum. The sporozoites were noticed to invade the tip and sides of the villi, in epithelial cells and in the glandular epithelium. The first generation schizont measured 30 by 18 μ producing numerous merozoites each measuring 4.5–7 μ by 1.5 μ . The second generation schizont appeared after 96–108th hour from the date of inoculation. It was 10 μ in diameter and produced 10–24 merozoites of 10 μ by 3 μ . The first generation schizonts preferred to lie below or next to the nucleus while the second generation schizonts preferred to establish themselves subnuclearly.

The gametogonic stages appeared in the glandular epithelium after the 114th hour from the date of inoculation. The mature macrogametes measured 20 by 18 μ

having large cytoplasmic granules. The nucleus of the macrogametocytes encircles a central karyosome surrounded by a pale halo. The microgametes are found along with the irregular shaped residuum inside the microgametocytes.

While studying the schyzogony in bovine cell cultures Doran (1970) observed that the sporozoites preferred to penetrate the cells 5 hours after infection and many schizonts developed by the 48th hours. This species is pathogenic in Turkey.

Remarks.—While dealing with coccidia of Turkey at Lucknow, U.P., Bhatia (1968b) came across a species and described, as “Ellipsoidal oocysts, with smooth double-contoured wall, measured 20–28 μ by 14.6–17.3 μ (mean 25.6 μ by 16.4 μ , from 50 oocysts) with a length — width ratio of 1.36–1.81 (mean 1.56). The 1.2 μ thick oocystic wall had the outer layer yellowish or light green and the inner with a violate or bluish hue. Oocystic residuum was absent. One or two polar granules were present. Micropyle was perceptible occasionally as a light area. Sporocysts, 10.6–14.6 μ by 6.6 μ (mean 12.6 μ by 6.6 μ) in size, were elongate-ovoid and with a narrower end. Stieda body present. Sporocystic residuum present as scattered granules. Sporozoite measuring 9.3 μ by 2.0 μ , with one end broadly rounded and the other narrower, and two refractile globules the larger lying at the broader end and the smaller towards the narrower extremity and with a small but distinct nucleus situated between the two. Scrapings from regions of the hind gut yielded oocysts inside the caecal epithelial cells.”

The author expressed a doubt in differentiating *E. adenoides* with *E. meleagridis*. However, it appears that the author was dealing with *E. adenoides*.

***Eimeria dispersa* Tyzzer**

(Fig. 4J)

1929. *Eimeria dispersa* Tyzzer, *Am. J. Hyg.*, **10**: 269; Patnaik, 1963, *Orissa vet. J.*, **1**: 25; Kudo, 1966, *Protozoology*, p. 694; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 207.

Description.—The oocysts are broadly oval in shape. In many cases it shows a double-contoured and in some there is only one dark wall. It measures 17.6 μ –26.4 μ in length and 15.4 μ –22.4 μ in width with a mean 22.7 μ by 18.8 μ . The sporont fills the greater part of the oocyst. Stieda body present. There is no evidence of an outer residual body within the oocyst. Sporocystic residual bodies represented by some coarse granules.

Dimension of the oocysts reported by other authors are as follows:

23 by 19 μ (from Quail) and 18–26 by 15–22 μ (from Pheasant), (Tyzzer, 1929); 22–231 by 18–24 μ with the mean 26 by 21 μ (Hawkins, 1952).

Sporulation time.—45 hours.

Type host.—Bob white, *Colinus virginianus*.

Other hosts.—(i) Common Quail, *Coturnix coturnix coturnix*. (ii) Domestic fowl, *Gallus* sp. (iii) Mexican Turkey, *Meliagris mexicana* (iv) English Pheasant, *Phasianus colchicus torquatus* (v) Common ring-necked pheasant *Phasianus colchicus*. (vi) Hazel hen, *Tetrastes bonasia* (vii) Domestic Turkey, *Meleagris gallopavo gallopavo*.

Distribution.—Orissa.

Endogenous stages.—Scizonts are localized in the epithelial cells of the small intestine and are of two types. The smaller one is provided with 15 merozoites each measuring 4–6 μ by 1 μ and the larger one possesses 50 merozoites. The gametocytes are found in the duodenum. Macrogametocyte is 7–8 μ in diameter with a

large karyosome lies inside a parasitophorous vacuole. The macrogamete is 18–20 μ in diameter with cytoplasmic granules at the periphery. The microgametocyte is 20 μ in diameter. Each microgamete is provided with a pair of flagella. This species is slightly pathogenic, the colour of the duodenum changes to cream, followed by the dilation of the entire intestine.

***Eimeria innocua* Moore and Brown**

1952. *Eimeria innocua* Moore and Brown, *Cornell Vet.*, **42**: 395; Patnaik, 1963, *Orissa vet. J.*, **1**: 25; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 210.

Description.—The oocysts are more or less round in shape. The double contoured oocystic wall have a smooth surface. The oocyst measured 18.6 μ –25.9 μ in length and 17.3 μ –24.5 μ in width with a mean 22.4 μ by 20.9 μ . There is no evidence of polar body in the sporulated oocyst. Sporulation occurs within 24–48 hours.

Dimension of the oocysts reported by other authors are as follows:

19–28 by 17–24 μ with a mean 23.9 by 20.9 μ (Golemansky, 1964); 19–26 by 17–24 with a mean 22.4 by 20.9 μ (Pellerdy, 1974).

Type host.—Domestic turkey, *Meleagris gallopavo gallopavo*.

Other hosts.—From the type host.

Distribution.—Orissa.

Endogenous stages.—Found at the caecal pouch. Moore and Brown (1952) found that this coccidium invades the small intestinal epithelium particularly at the tip of the villi except at the crypts.

Prepatent period was noted as 5 days (Moore and Brown, 1952). Non-pathogenic.

***Eimeria gallopavonis* Hawkins**

1952. *Eimeria gallopavonis* Hawkins, *Mich. Sta. Coll. Tech. Bull.*, **226**: i; Gill, 1954b, *Indian vet. J.*, **31**: 92; Bhatia, 1968b, *Indian J. Microbiol.*, **8**: 239; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 209.

Description.—Oocyst elliptical measured 22.2 μ –327 μ in length with a mean 27.1 μ and 15.2 μ –19.4 μ in width with a mean 17.2 μ . The oocystic wall double contoured with a smooth surface and no evidence of any micropyle. No oocystic residual body is formed but with a distinct polar granule. The sporocysts are elongate ovoid with one end pointed. The inner residual body represented by scattered granules.

Sporulation time.—24 hours.

Dimension of the oocysts reported by other authors are as follows:

24–35 by 17–23 μ with a mean 29.5 by 19.3 μ (Golemansky, 1964). 22–23 by 15–19 μ with a mean 27.1 by 17.2 μ (Pellerdy, 1974).

Type host.—Domestic Turkey, *Meleagris gallopavo gallopavo*.

Other hosts.—(i) Indian turkey, *Meleagris* sp. (ii) Domestic Turkey, *Meleagris* sp.

Distribution.—Lucknow, Izatnagar, U.P.

Endogenous stages.—Found mainly at the large intestine sometimes at the caeca. Hawkins (1952) reported two schizogonic processes. The first schizont appeared

at the third day after inoculation in the epithelial cells of the ileal and rectal mucosa. Each of them was provided with 10–12 relatively large merozoites. The second generation schizont larger in size measuring about 20 μ in diameter occurred supranuclearly in the ileal, caecal and rectal epithelial cells on the 4th day. They produced many small merozoites.

Farr (1964) reported three schizogonic processes. He observed that the first generation schizont measured 25–40 by 28–30 μ appeared in the crypts of Lieberkuehn each giving rise to 40 merozoites of 8–10 by 1.6 μ in size. The second generation schizonts were smaller measuring 9 μ in diameter appeared at the 96th hour and each schizont produced 8–12 merozoites. The third schizogonic generation appeared at the 144th hour. The schizonts were localized subnuclearly inside the hypertrophied host cells. Gametocytes were seen first on the 4th day after infection. The macrogametes appeared; having a granular cytoplasm and a nucleus surrounded by a pale halo. The microgametocytes occurred subnuclearly. This species is highly pathogenic. The infected area are filled with white exudate mainly of oocyst.

Gill (1954b) experimentally transferred the oocyst of *E. gallopavonis* to *Gallus domesticus* and traced the infection.

***Eimeria meleagridis* Tyzzer**

(Fig. 4K)

1927. *Eimeria meleagridis* Tyzzer, *J. Parasit.*, **13**: 215; Gill, 1954b, *Indian vet. J.*, **31**: 92; Kudo, 1966, *Protozoology*, p. 693; Bhatia, 1968b, *Indian J. Microbiol.*, **8**: 293; Pande, Bhatia, Chauhan and Garg, 1970, *Indian J. Anim. Sci.*, **40**: 154; Chauhan, Bhatia, Arora, Agrawal and Ahluwalia, 1973, *Indian J. Anim. Sci.*, **43**: 163; Pellerdy 1974, *Coccidia and Coccidiosis*, p. 211.

Description.—Oocyst ellipsoidal measuring 19 μ –29.7 μ in length with a mean 23.8 μ and 14.5 μ –23.0 μ in width with a mean 17.3 μ . It is provided with a smooth wall with one or more polar granules and without any oocystic residuum. Each sporocyst reveals a steida body at the tapering end with granular residual mass.

Dimension of the oocysts reported by other authors are as follows:

20–31 by 15–21 μ with a mean 24.4 by 18.1 μ (Hawkins, 1952), 22 by 16 μ (Clarkson, 1959). 18–31 by 12–19 μ with a mean 23.7 by 16.8 μ (Golemansky, 1962), 19–30 by 14–23 μ with a mean 23.8 by 17.3 μ (Pellerdy, 1974).

Type host.—Domestic Turkey, *Meleagris gallopavo*.

Other host.—Mexican Turkey, *Meleagris meleagris*.

Distribution.—U.P.

Endogenous stages.—Mainly found at the caeca, sometimes into the large and lower portion of small intestine. Tyzzer (1927) in an experiment with a turkey of 8–10 weeks old, found the parasite inside the caeca. Many stages were also occurred in the epithelium of the colon and the posterior part of the small intestine.

Morehouse (1949) encountered the endogenous stages in the terminal part of the small intestine. Hawkins (1952) found the endogenous cycles in the caecal epithelial cells at 9th hour from the date of inoculation. The first generation schizonts measured 20 by 15 μ , each producing 50–100 merozoites of 7 μ by 1.5 μ in size. The second generation schizonts appeared in the 60th–72nd hour produced, 10–14 merozoites of 10 by 2 μ in size. Some of the second generation schizonts took part in the development of gametocytes on the 4th day after infection and the rest proceeded to continue the third schizogonic process.

The macrogametocyte measured 8–10 μ in diameter and reached up to 20 μ at the mature stage with a large nucleus and granular cytoplasm. The microgametocyte measured two or three times larger than the cell nucleus. Both the gametocytes occurred in the subnuclear position.

Clarkson (1959) reported the first generation schizonts in the jejunum at the 54th hour from the date of infection. He recognised some early released sporozoites in the intestine, 2 hours after infection with characteristic movements. Non-pathogenic.

Remarks.—Pande *et al.* (1970) came across the oocysts from Amherst Pheasant at Lucknow Zoological garden, U.P. and described as “Oocysts ovoidal (50 measured), 22–27 μ by 17–20 μ in size (mean 23.6 μ by 18.0 μ), with a length-width ratio of 1.2–1.4 (mean 1.26). Oocystic wall 1.5 μ thick, smooth, double-contoured, the outer layer being yellowish green and the inner dark brown in colour. A micropyle and polar cap absent. One or 2 polar granules present. Oocystic residuum absent. Sporocysts elongate-ellipsoidal, of 12–14 μ by 5.5–7 μ in size (mean 13.0 μ by 6.5 μ). Stieda body present as a small dark knob. Sporocystic residuum present as scattered granules. Sporozoite elongated, with one end broadly rounded and the other somewhat narrower, a large globule lying towards the broader end and a small near the pointed end, with centrally placed nucleus.”

***Eimeria meleagrimitis* Tyzzer**

(Fig. 4L)

1929. *Eimeria meleagrimitis* Tyzzer, *Am. J. Hyg.*, **10**: 269; Gill, 1954b, *Indian vet. J.*, **31**: 92; Patnaik, 1963, *Orissa vet. J.*, **1**: 25; Kudo, 1966, *Protozoology*, p. 694; Bhatia, 1968b, *Indian J. Microbiol.*, **8**: 239, Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 212.

Description.—The oocyst measuring 15 μ –21 μ by 12 μ –17 μ (mean 18.5 μ by 15.6 μ from 30 oocysts), with length-width ratio of 1.08–1.38 (mean 1.19). It was having somewhat sub-spherical or broadly oval shape with a smooth double-contoured wall. The 1 μ thick oocystic wall had the outer layer of yellowish-green and the inner with a dark blue colour. Micropyle and oocystic residuum absent. One or two polar granules were present. The ovoid sporocyst measured 8 μ –12 μ by 5.3 μ –6.0 μ (mean 9.6 μ by 5.4 μ) in size. Stieda body present; sporocystic residuum also present as scattered granules tending to clump towards the middle. Sporozoite banana-shaped, with narrower but rounded extremities having two refractile globules, the larger at the broader and the smaller towards the tapering extremity and a small nucleus lying between the two, towards the middle.

Sporulation time.—48 hours.

Dimension of the oocysts reported by other authors are as follows:

16–20 by 13–17 μ with a mean 18.1 by 15.3 μ (Tyzzer, 1929); 16–27 by 13–22 μ with a mean 19.2 by 10.3 μ (Hawkins, 1952); 16–25 by 13–19 μ with a mean 20.1 by 17.3 μ (Clarkson, 1959); 15–20 by 13–19 μ with a mean 17.8 by 16.4 μ (Golemansky, 1962).

Type host.—Domestic Turkey, *Meleagris gallopavo*.

Other hosts.—From the type host.

Distribution.—Lucknow, Izatnagar, U.P.; Orissa.

Endogenous stages.—Found at the duodenum and upper jejunum. Hawkins (1952) and Clarkson (1959) were the pioneer workers in studying the endogenous

stages of *E. meleagridis*. Both of them observed the sporozoites invading the small intestine in the epithelial cells of the villi. The sporozoites were slender with one end round and the other end pointed. The nucleus is placed centrally.

Hawkins (1952) encountered the second generation schizonts on the 4th day from the date of inoculation and each producing 10–12 merozoites of 5–6 μ by 1.2 μ in size.

Clarkson (1959) noted the first generation schizonts below the brush border of the epithelial cells, some are located subnuclearly in the 60th hour from the date of inoculation. The second generation schizonts matured by the 3rd day, producing merozoites of 7 by 1.5 μ in size. The third generation schizont also produced the similar merozoites as the second generation but differs in having a residuum and in its subnuclear position. Horton-Smith and Long (1961) also noted the 3rd generation schizonts.

Fayer (1969) observed that some posterior eosinophilic granules and smaller anterior granules appeared at the 12th hour from the date of inoculation each measuring 2–3 μ in diameter. These granules were aggregated in the gland, developed into the first generation schizont and measured 8 by 7 μ producing 9–10 merozoites of 4–6 μ by 1.5 μ in size.

Doran and Vetterling (1968) studied the schizogony in the turkey intestinal cell and bovine kidney cell cultures. The early stages appeared 5 hours and 48 hours from the date of inoculation in the bovine and turkey cell cultures respectively. The schizonts appeared 48–154 hours and produced 12–28 merozoites. The large schizonts measured 50–115 μ by 20–70 μ occurred only in the bovine cell culture. Each schizont produced more merozoites than those occurred in natural infection. The gametocytes measured 15 μ by 11 μ and occurred mostly at the tips of the villi in the jejunum. In case of massive infection the entire small intestine was found to be infected. The microgametocyte possessed many nuclei and arranged peripherally. Each produced slender microgametes with a centrally placed large residuum.

Mostly pathogenic. Duodenum enlarges along with the haemorrhage at the other region of the intestine.

Clarkson (1959) noted the prepatent period as 114–118 hours.

Remarks.—Bhatia (1968b) obtained a species and stated that in size range and the sporulation time the oocysts come close to the description of *E. meleagridis* Tyzzer. The sizes approximate those of Tyzzer (16.2–20.5 μ by 13.2–17.2 μ , average 18.1 μ by 15.3 μ). The sporozoite, however, revealed in addition to a colourless globule at the larger end, another smaller globule towards the tapering end. In spite of this minor variation, the species is identified as *E. meleagridis*.

COCCIDIA OF DOMESTIC DUCK

Eimeria anatis Scholtyseck

(Fig. 4M)

1955. *Eimeria anatis* Scholtyseck, *Arch. Protistenk.*, **100**: 431, Bhatia, 1968b, *Indian J. Microbiol.*, **8**: 245; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 159.

Description.—Oocyst nearly spherical or ovoid with a truncated end and a smooth double contoured wall of 1 μ thick. It measures 15 μ –19 μ in length with a mean 16.9 μ and 11 μ –15 μ in width with a mean 14.3 μ . The outer layer is colourless but the thick inner layer is straw coloured. Micropyle prominent, measuring 4 μ

wide and thickening at the ends. Oocystic residuum absent but provided with one or two polar granules. Sporocyst ovoid with one pointed end measuring $8\text{ }\mu$ – $10\text{ }\mu$ in length with a mean $9.3\text{ }\mu$ and $5\text{ }\mu$ – $8\text{ }\mu$ in width a mean $6.1\text{ }\mu$. Steida body absent, sporocystic residuum present as loose mass at the centre. Sporozoite elongated pyriform measuring $6\text{ }\mu$ – $7\text{ }\mu$ in length and $2.7\text{ }\mu$ in width with one narrower end and the other end broadly rounded. Two refractile globules lying in different position on the sporozoite.

Sporulation time.—3 days.

Dimension of the oocysts reported by other authors are as follows:

14–19 by 11–16 μ with a mean 16.8 by 14.1 μ (Kenneth *et al.* 1971 and Pellerdy, 1974).

Type host.—Mallard, *Anas p. platyrhyncha* (= *Anas* sp.).

Other host.—From the same host.

Distribution.—Lucknow, U.P.

Endogenous stages.—Examination of duodenum and some parts of the ileum revealed isolated oocysts of similar nature attached to villar epithelial cells.

Other stages unknown.

***Eimeria battakhi* Dubey and Pande**

(Fig. 4N)

1963. *Eimeria battakhi* Dube and Pande, *Curr. Sci.*, **32**: 329; Pellerdy, 1974, *Coccidia and Coccidiosis* p. 159; Mandal, 1976, *Rec. zool. Surv. India*, **70**: 39.

Description.—Oocysts subspherical to ovoid, double walled the outer being thinner than the inner one. It measures $19\text{ }\mu$ – $24\text{ }\mu$ in length with a mean $21\text{ }\mu$ and $16\text{ }\mu$ – $21\text{ }\mu$ in width with a mean $18\text{ }\mu$. The shape index is 1.16. Cytoplasm centrally placed, coarsely granular with small refractile globules. Micropyle and oocystic residuum absent. The sporocysts are elongately ovoid, measuring $11\text{ }\mu$ – $13\text{ }\mu$ in length with a mean $12\text{ }\mu$ and $6\text{ }\mu$ – $8\text{ }\mu$ in width a mean $7\text{ }\mu$. The shape index is 1.7. The narrower end is provided with a small knob (steida body). Sporocystic residuum present as a compact mass. The sporozoites are elongated each with one broader and other narrower ends. It measures $9\text{ }\mu$ – $11\text{ }\mu$ in length with a mean $10\text{ }\mu$ and $2\text{ }\mu$ in width. A clear vacuolated area is seen on the posterior rounded end in addition to the centrally placed nucleus.

Sporulation time.—24–32 hours.

Type host.—Domestic duck, *Anas platyrhyncha domestica* (= *Anas* sp.).

Other host.—Unknown.

Distribution.—Mathura, U.P.

Endogenous.—Unknown.

***Wenyonella anatis* Pande, Bhatia and Srivastava**

(Fig. 4, O)

1965. *Wenyonella anatis* Pande, Bhatia and Srivastava, *Sci. & Cult.*, Calcutta, **31**: 393; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 164, Mandal, 1976, *Rec. zool. Surv. India*, **70**: 39.

Description.—Oocysts oval with double wall of equal thickness, each oocyst measures $11.5\text{ }\mu$ – $17.5\text{ }\mu$ in length with a mean $14.5\text{ }\mu$ and $7.5\text{ }\mu$ – $10.5\text{ }\mu$ in width with

a mean 8.8 μ . The shape index is 1.6. Cytoplasm coarsely granular and occupies the whole surface of the oocyst. Micropyle and oocystic residuum present. Sporocyst ovoid in shape, measures 5.7 μ –7.2 μ in length with a mean 6.4 μ and 4.3 μ –5.3 μ in width with a mean 4.8 μ . The shape index is 1.3. Sporocystic residuum present as coarsely granular mass of dark appearance. Sporozoites are ovoid with a nucleus at the middle, having narrow anterior and broad posterior ends. Sporozoite measures 2.8 μ by 2 μ . The shape index is 1.4.

Sporulation time.—48–62 hours.

Dimensions of the oocysts reported by other authors are as follows:

11–17 by 7–10 μ (Pellerdy, 1974).

Type host.—Domestic duck, *Anas platyrhynchos domestica* (= *Anas* sp.).

Other hosts.—Unknown.

Distribution.—Mathura, U.P.

Endogenous stages.—Unknown.

Wenyonella gagari Sarkar and Ray

1968. *Wenyonella gagari* Sarkar and Ray, *Proc. Indian Sci. Congr.*, p. 499; Sarkar, 1968, *Studies on some sporozoa in birds*. D. Phill, Thesis, Calcutta University; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 164; Mandal, 1976, *Rec. zool. Surv. India*, **70**: 39.

Description.—Oocysts pitcher-shaped having three layers of 1.8 μ in thickness. The outer being yellow, middle greenish and the inner yellowish pink. At the narrow pole there is a prominent micropyle of 4.8 μ in diameter with fluted 4.6 ridges at its outer broader. Oocyst measures 22.8 μ –264 μ in length and 16.8 μ –19.2 μ in width with a mean 24.0 μ in length and 18.5 μ in width. Oocystic residuum absent. Four sporocysts are vial shaped each measuring 13.2 μ –15.6 μ in length with a mean 13.8 μ and 7.2 μ –9.6 μ in width with a mean 8.4 μ . Sporocystic residuum present as a small cluster of minute refractile granules. 'Steida' body present. Sporozoites bulb-shaped measuring 9.6 μ in length and 3.6 μ in width at broader end. It possesses a large vacuole at the broader pole.

Sporulation time.—24 to 48 hours.

Dimension of the oocysts reported by other authors are as follows:

23–26 by 17–19 μ with a mean 24 by 18.5 μ (Pellerdy, 1974) as described by the authors.

Type host.—Domestic duck, *Anas boschas* Linnaeus (= *Anas p. platyrhynchos* Linnaeus) (= *Anas* sp.).

Other hosts.—Unknown.

Distribution.—Basirhat, West Bengal.

Endogenous stage.—Unknown.

COCCIDIA OF CATTLE

Eimeria alabamensis Christensen

(Fig. 5A)

1941. *Eimeria alabamensis* Christensen, *J. Parasit.*, **27**: 203; Gill, 1960b, *Proc. Indian Sci. Congr.*, p. 430; Patnaik, 1963, *Orissa vet. J.*, **1**: 25; 1965, *Agra Univ. J. Res. (Sci.)*, **13**: 239; Kudo, 1966, *Protozoology*, p. 687; Gill, 1968, *Proc. zool. Soc. Calcutta*, **21**: 101; Bhatia, Pande Chauhan and Arora, 1968, *Acta. vet. Acad. Sci. Hung.*, **18**: 115; Levine and Ivens, 1970, *Ill. Biol. Monogr.* **44**: 68; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 724.

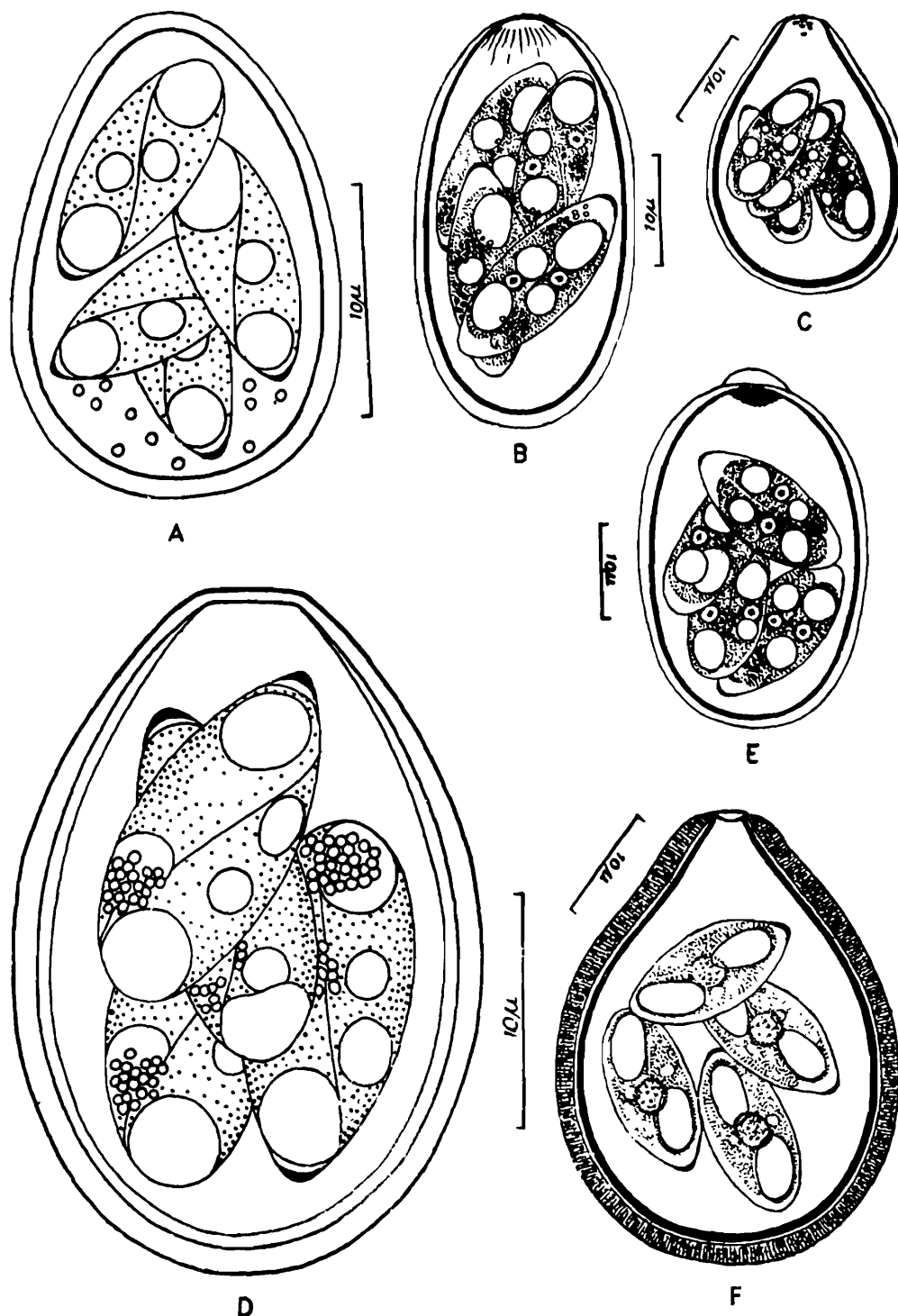


Fig. 5. (A-F). Diagrams of sporulated oocysts of :
 A) *E. alabamensis*; B) *E. auburnensis*; C) *E. bareillyi*; D) *E. bovis*;
 E) *E. brasiliensis*, F) *E. bukidonensis*.

Description.—Oocysts are pyriform to subellipsoidal, measuring $17\ \mu$ – $24\ \mu$ by $12\ \mu$ – $16\ \mu$ (mean $21\ \mu$ by $14\ \mu$) in size (length/width ratio 1.3–1.6, mean 1.5). The oocystic wall double layered, almost colourless or light yellowish, $1.3\ \mu$ thick. Micropyle and micropylar cap absent. Oocystic residuum and polar granule absent. Parachute-shaped cap at each rounded end of developing sporocysts were initially found but disappearing with the development of sporozoites. Sporocysts are elongat-ovoid, with slightly narrow ends measuring $11\ \mu$ – $16\ \mu$ by $5\ \mu$ – $6\ \mu$ (mean $11.9\ \mu$ by $5.2\ \mu$) in size. Steida body absent. Sporocystic residuum absent. Sporozoites are elongated, banana-shaped, $9\ \mu$ by $2.6\ \mu$ in size, with one end broader and other tapering, having coarsely granular cytoplasm with three or more refractile

globules, the larger at the wider end and the smaller towards the narrower tip. Sporulation completed in 8–10 days.

Dimension of oocyst reported by other authors are as follows:

13–16 by 11–13 μ with a mean 15.2 by 12.8 μ , (Patnaik, 1965); 14–24 by 12–16 μ (Rakovec and Brglez, 1966); 17–24 by 12–16 μ with a mean 21 by 14 μ (Bhatia *et al.*, 1968); 13–25 by 11–17 μ (Levine and Ivens, 1970) 13–24 by 11–16 with a mean 18.9 by 13.4 μ (Pellerdy, 1974).

Type host.—Ox, *Bos taurus*.

Other host.—(i) Buffalo, *Bubalus bubalis*, (ii) Indian cattle, *Bos indicus* (= *Bos* sp.).

Distribution.—Izatnagar, Agra, Mathura, U.P.; Karnal, Haryana.

Prevalence.—Davis, Boughton and Bowman (1955) found 93% infection in dairy calves from United States; Hasche and Todd (1959a) got 42% infection in cattle from Wisconsin; Ruiz and Oritz (1961) obtained 20% infection in calves from Costa Rica; Balconi (1963) received 43% infection in cattle from Guatemala; Szanto, Mohan and Levine (1964) obtained 17% infection in cattle from Illinois, Missouri, Texas and Wyoming; Patyk (1965) received 9% infection in calves from Poland; Patnaik (1965) got 1% infection in buffaloes from Agra, India; Joyner *et al.* (1966) observed 14% infection in cattle from England; Nyberg, Helfer and Knapp (1967) got 1% infection in cattle from Oregon; Svanbaev (1967a) received 8% infection in calves from Kazakhstan; Bhatia *et al.* (1968) reported 3% infection in buffaloes from Mathura, U.P.; Vassiliades (1969) reported 2% infection in cattle from Senegal; Sayin (1969) got 10% infection in buffaloes from Turkey; Jacobson and Worley (1969) observed 0.4% in calves from Montana.

Endogenous stages.—Generally found in the small intestine, sometimes in the caecum and upper colon. Davis, Bowman and Boughton (1957) encountered the parasite in the nuclei of the epithelial cells of the small intestine. Sporozoites were almost spindle-shaped, measuring 3–7 μ by 1.5–3 μ . Each sporozoite eventually rounded up and transformed into a schizont of 3–3.5 μ in diameter. The mature schizont measures 8–18 μ in diameter, with 16–32 sickle-shaped merozoites of 7–9 μ by 1.4–2.1 μ in size. These Schizont are generally encountered in the terminal segments of the small intestine. Both the gametocytes (macro and micro) are located intranuclearly in the epithelial cells of the villi of small intestine. The microgametocyte measures 8.4–25.2 μ by 7–21 μ with the mean 15.6 μ by 11.5 μ , while the macrogametocyte measures 7–19.6 μ by 7–11.9 μ with the mean 12 μ by 9.1 μ . Sampson, Hammond and Ernst (1971) encountered two schizogonic processes. The large schizont measures 11–18.5 μ by 8.5–11 μ with 6–14 short merozoites. The smaller one measures 5.5–13 μ by 5–8.5 μ having 6–10 long-slender merozoites. Generally it is non-pathogenic, but sometimes it may exhibit some pathological symptoms in the laboratory. Davis, Bowman and Boughton (1967) observed that the infection of this parasite causes serosal enteritis in the lower half of the small intestine along with the massive destruction of the epithelial cells, with leucocytic infiltration and villar edems. It destroyed the cell along with the nucleus. Double and multiple infections were found in a single cell. The schizonts as well as gametocytes might occur simultaneously in one and the same nucleus.

Prepatent period is 6–11 days as noted by Davis, Boughton and Bowman (1955); 7–9 days according to Smith and Davis (1965); 7–8 days according to Svanbaev (1967a).

***Eimeria auburnensis* Christensen and Porter**

(Fig. 5B)

1939. *Eimeria auburnensis* Christensen and Porter, *Proc. Helminth. Soc. Wash.*, **6**: 45; Gill, 1960, *Proc. Indian Sci. Congr.*, p. 430; Patnaik, 1963, *Orissa vet. J.*, **1**: 25, 1965, *Agra Univ. J. Res. (Sci.)*, **13**: 239; Patnaik and Pande, 1965, *Indian J. vet. Sci.*, **35**: 33; Bhatia and Pande, 1967, *Acta. Vet. Acad. Sci. Hung.*, **17**: 351; Bhatia, Pande, Chauhan and Arora, 1968, *Acta. vet. Acta. Sci. Hung.*, **18**: 115; Levine and Ivens, 1970, *Ill. Biol. Monogr.*, **44**: 61; Bhatia Pande, Chauhan and Garg, 1971, *Indian J. Anim. Sci.*, **41**: 549; Pande, Bhatia, Chauhan and Garg, 1971, *Indian J. Anim. Sci.*, **41**: 345; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 725.
1939. *Eimeria ildefonsoi* Torres and Ramos, *Argu. Inst. Pesquisas Agronom*, **2**: 79.
1954. *Eimeria bombayensis* Rao and Hiregaudar, *Bombay vet. Coll. Mag.*, **4**: 24; Gill, 1973, *J. Res.*, **10**: 442.
1959. *Eimeria* sp. Pop-Cenith and Brodjochki, *Acta vet. Beograd*, **9**: 65.

Description.—Oocysts are ovoid or ellipsoidal, each with a narrow micropylar end, of 31 μ –44 μ by 20 μ –27 μ (mean 38 μ by 24 μ) in size, (length width ratio is 1.36–1.74 mean 1.58). Oocystic wall smooth but occasionally coarsely granular, yellowish brown, 1.5 μ –2.00 μ thick. Micropyle 3 μ –3 μ wide. Micropylar cap absent. Oocystic residuum absent. Two or three polar granules present in some oocysts. Sporocysts elongate-ovoid or elongate-ellipsoidal, 17 μ –21 μ by 8 μ –9 μ (mean 19 μ by 8 μ) in size. Steida body present as a dark knob over the narrower end. Sporocystic residuum present as a centrally situated mass of granules or in scattered groups or arranged as a streak along the sporozoites. Sporozoites elongate, with one end broader and the other narrower, 15 μ –18 μ by 4 μ in size with two refractile globules; the larger towards the wider end and the smaller towards the narrower end with a nucleus surrounded by fine granules lying between the two globules.

Sporulation completed in 3–4 days.

Dimension of the oocyst reported by others are as follows:

31–44 μ by 20–27 μ with a mean of 38 μ by 24 μ (Bhatia *et al.*, 1968); 35–44 μ by 19–26 μ with a mean 37 μ by 22 μ (Nyberg and Hammond, 1965); 32–46 μ by 20–25 μ with a mean 38.4 μ by 23.1 μ , (Pellerdy, 1974).

Type host.—Ox, *Bos taurus*.

Other hosts.—(i) Indian cattle, *Bos indicus* (= *Bos* sp.) (ii) Zebu, *Bos indicus* (iii) Buffalo, *Bubalus bubalis*.

Distribution.—Izatnagar, Agra, Mathura, U.P.; Karnal, Haryana.

Prevalence.—Davis and Bowman (1952) found cent per cent infection in calves from Alabama; Hasche and Todd (1959a) obtained 45% infection in cattle from Wisconsin; Szanto, Mohan and Levine (1964) reported 46% infection in beef calves from Illinois Nyberg, Helfer and Knapp (1967) observed 14% infection in cattle from Oregon; Jacobson and Worley (1969) got infection in 32% calves and 12% cattle from Montana; Torres and Ramos (1939) reported 32% infection in cattle from Brazil; Supperer (1952) found 3% infection in cattle from Australia; Watking (according to Lapage) observed 91% infection in calves from Devonshire, England; Joyner *et al.* (1966) got infection in 34% cattle of England; Marinkelle (1964) reported 32% infection in calves from Columbia; Ruiz and Oritz (1961) observed 1% infection in calves from Costa Rica; Balconi (1963) reported 43% infection in cattle from Guatemala; Watanebe and Iwata (1956) reported 2% infection in cattle from Japan; Chroust (1964) observed 18% infection in calves from Czechoslovakia; Patyk (1965) noted 15% infection in calves from Poland; Vassiliades (1969) reported 12% infection in cattle from Senegal; Svanbaev (1967) observed 5% infection in cattle Kazakhstan. According to Lee and Armour (1959) this species

was very common at Vom Nigeria; Sayin (1969) reported 44% infection in buffaloes from Turkey; Patnaik (1965) found 19% infection in buffaloes from Agra, India; Bhatia *et al.* (1968) got 32% infection in buffaloes from Mathura, U.P., India.

Endogenous stages.—Several authors have worked on the endogenous cycles of *E. auburnensis*. Hammond, Clark and Miner (1961) were the first who attempted to trace the life cycle of this parasite. They reported the sexual stages in the ileal villi and in the mesodermal cells of the lamina propria. The microgametocytes were measured 67–103 μ by 48–83 μ with the mean 85 μ by 65 μ containing thousands of microgametes. Each microgamete measured 4–8 μ by 0.5–0.75 μ with two flagella about 10–12 μ long.

Davis and Bowman (1962) encountered the giant schizont measuring 78–250 μ by 48–150 μ with the mean 140 μ by 92 μ in the lamina propria of the small intestine. Each microgametocyte measured 36–288 μ by 27–150 μ with the mean 125.5 μ by 79.5 μ .

Chobotar and Hammond (1967) described the globidial schizont measuring 78–250 μ by 48–150 μ with the mean 140–92 μ located in the epithelial cells lining the crypt of Lieberkuehn.

Scholtyssek, Hammond and Earnst (1966) studied the ultrastructural structures and noted the glycogen granules of 0.3–1.0 μ in diameter at the margin of the macrogametes associated with one or more adjacent granules. The dark bodies were large measuring 1.5 μ in diameter. The wall forming bodies measuring 1.7 μ in diameter differentiated from the dark bodies by their slightly larger size. The parasitophorous vacuole relatively large containing amorphous electron-dense material appeared around the macrogametes. The process of pinocytosis was encountered in the macrogametes, (Scholtyssek, Hammond and Chobotar, 1967).

Hammond, Scholtyssek and Miner (1967) reported thousands of irregularly arranged nuclei inside the microgametocytes, except at the surface while studying the ultrastructure. The glycogen granules were not seen but large and small thick walled vacuoles, either empty or containing electron-dense material were encountered. The parasitophorous vacuoles were present at early development of microgametes but usually not found around the mature ones.

Hammond, Scholtyssek and Chobotar (1969) studied the ultrastructures of the microgametocytes. They noticed a compact nucleolus and relatively few electron-dense masses in the nucleus of developing microgametocytes. The basal body of the flagellum appeared at the anterior end of the mature microgamete with a large mitochondrion.

Hammond, Ernst and Chobotar (1967) and Hammond, Chobotar and Ernst (1968) encountered broadly lanceolate sporozoites measuring 16–21 μ by 3.5–9 μ with the mean 18.7 μ by 5.6 μ . Each sporozoite is vesicular having a large refractile body at the posterior end with one or more smaller bodies anterior to the nucleus. There is a nipple like projection at the anterior end, occasionally with median rod like bodies.

Chobotar (1968) reported mature smaller schizonts measuring 6–12 μ by 5–9 μ with the mean 8.5 μ by 6 μ in the lamina propria of small intestine, 12–14 days after inoculation. Each schizont is provided with 4–11 spindle-shaped merozoites measuring 7–9 μ by 1–2 μ with the mean 8 μ by 1.5 μ . The microgametocyte measured 61–151 μ by 42–109 μ with the mean 103 μ by 70 μ .

In India, Patnaik and Pande (1965) and Bhatia and Pande (1967) described the endogenous stages. However, they were dealing with a mixed infection.

Prepatent period.—According Christensen and Porter (1939) it is 24 days; Hammond, Clark and Miner (1961) reported as 18–20 days; Svanbaev (1967) encountered the same as 18–19 days; Chobotar (1968) noted it as 16–17 days.

***Eimeria bareillyi* Gill, Chhabra and Lall**

(Fig. 5C)

1963. *Eimeria bareillyi* Gill, Chhabra and Lall, *Arch. Protistenk.*, **106**: 571; Bhatia, Pande, Chauhan and Arora, 1968, *Acta vet. Acad. Sci. Hung.*, **18**: 115; Chhabra, 1968, *Indian vet. J.*, **45**: 31; Levine and Ivens, 1970, *Ill. Biol. Monogr.*, **44**: 43; Pande, Bhatia and Chauhan, 1971, *Indian J. Anim. Sci.*, **41**: 151; Bhatia, Pande, Chauhan and Garg, 1971, *Indian J. Anim. Sci.*, **41**: 549; Shahstri, Krishnamurthy and Ghaffor, 1973. *Indian J. Anim. Res.*, **7**: 23; 1974, *Indian J. vet. Sci.*, **51**: 301; Pellerdy, 1974. *Coccidia and coccidiosis*, p. 721; Shastri and Krishnamurthy, 1975, *Indian J. Anim. Sci.*, **45**: 46; Krishnamurthy and Shastry, 1976, *Riv. Parasit.*, **37**: 71.

Description.—Oocysts are pyriform, with the narrower anterior end truncated and slightly flattened, measuring 24–31 μ in length and 15 μ –21 μ in width with a mean 28 μ by 19 μ . The length-width ratio is 1.3–1.8 with the mean 1.4. A few granular mass is seen small body lying below the micropyle both is unsporulated and sporulated oocysts. Oocystic wall double-layered, yellowishbrown, 1.3 μ thick. Micropyle 3.5 μ –6.0 μ (mean 4.8 μ) wide. Micropylar cap absent. Oocystic residuum and polar granule absent. Sporocysts elongate-ovoid, with one end broader and the other pointed, measuring 15 μ –18 μ by 7 μ –8.5 μ (mean 17 μ by 7.3 μ) in size. Stieda body present as small protuberance, sporocystic residuum either centrally placed or scattered at the middle. Sporozoites elongate, somewhat banana-shaped, 12 μ by 4 μ in size, with one end broader and the other pointed. It is provided with two refractile globules, the larger is at the broader end and smaller one lying between the centrally placed nucleus and the pointed anterior end.

Sporulation time.—3–4 days.

Dimension of the oocysts reported by other authors are as follows:

24–31 by 15–21 μ , mean 28.0 by 19.0 μ (Bhatia *et al.*, 1968); 28.6–135.0 by 20.0 25.7 μ , mean 31.6 by 22.6 μ (Krishnamurthy and Shastry, 1976).

Type host.—Buffalo, *Bubalus bubalis*.

Other hosts.—Indian cattle, *Bos indicus* (= *Bos* sp.).

Distribution.—Bareilly, Izatnagar, Mathura, U.P.; Marathwada, Maharashtra.

Prevalence.—Bhatia *et al.* (1968) found 5% infection of buffaloes from Mathura, U.P.; Shastri *et al.*, (1974) reported some infection also from Maharashtra.

Endogenous stages.—While studying the endogenous cycle of *E. bareillyi*, Pande, Bhatia and Chauhan (1971) found prominent, whitish, opalescent areas of 3–6 mm in diameter at the anterior portion of the jejunum. Typically pyriform oocysts were also obtained, measuring 23–27 by 13–17 μ with the mean of 24.6 by 15 μ , Oocystia Wall is of 1.3 μ thick carrying a prominent and almost flat micropyle, 4–5 μ wide from mucosal scrapings. The microgametocyte measuring 20–37 μ . by 18–25 μ and possesses 2.63 μ long microgamete. The macrogametocyte measured 23–25 by 14–17 μ enclosing a large nucleus and plastic granules. The parasites are located supranuclearly in the epithelial cells of the villi and subnuclearly in the epithelial cells of the crypts. The schizogonic stages have not yet been observed. Shastry and Krishnamurthy (1975) found this species abundantly in the middle third of jejunum throughout the length of the villi.

Prepatent period 12–13 days (Shastry and Krishnamurthy, 1975).

Eimeria bovis (Zublin) Fiebger

(Fig. 5D)

1908. *Coccidium bovis* Zublin (in partim) Schweiz. Arch. Thkde., **50**: 123.
1912. *Eimeria bovis* Fiebger, *Die tierischen Parasiten der Hausund Nutztiere. Ein Lehr — und Handbuch mit Bestimmungstabellen fur Tiesarzte und Studierende.* Wein and Leipzig. xvi+424 pp; Ware, 1936, *Rep. of Indian vet. Res. Inst. For 1935-36*; Gill, 1960, *Proc. Indian Sci. Congr.*, Bombay, p. 430; 1968, *Proc. zool. Soc., Calcutta*, **21**: 101; Patnaik, 1963, *Orissa vet. J.*, **1**: 25; 1965, *Agr. Univ. J. Res. (Sci.)*, **13**: 239; Patnaik and Pande, 1965, *Indian J. vet. Sci.*, **35**: 33; Kudo, 1966, *Protozoology*, p. 686; Bhatia, Pande, Chauhan and Arora, 1968, *Acta. vet. Acad. Sci. Hung.*, **18**: 115; Levine and Ivens, 1970, *Ill. Biol. Monogr.*, **44**: 48; Bhatia, Pande, Chauhan and Garg, 1971, *Indian J. Anim. Sci.*, **41**: 345; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 731.
1921. *Eimeria canadensis* Bruce (in partim), *J. Amer. vet. Med. Assoc.*, **58**: 638.
1927. *Eimeria smithi* Yakimoff and Galouzo, *Arch. Protistenk.*, **58**: 185.
1935. ?*Globidium fusiformis* Hassan, *Indian J. vet. Sci. and Anim. Husb.*, **5**: 777.
1935. *Eimeria* (*Globidium*) *bovis* Reichnow, *Lehrbuch der Protozoenkunde*, Jena, p. ?
1959. *Eimeria aarevi* Rao and Bhatwadeker, *Bombay vet. Coll. Mag.*, **8**: 23; Patnaik, 1965, *Agra Univ. J. Res. (Sci.)*, **13**: 239; Gill, 1973, *J. Res.*, **10**: 442.

Description.—Oocysts broadly ovoid, with a narrower micropylar end, 23 μ –43 μ by 15 μ –26 μ (mean 28 μ by 21 μ) in size (length-width ratio 1.2–1.5, mean 1.36). Oocystic wall smooth, double layered, light yellowish brown in colour, 1.5 μ thick. Micropyle present as a light area at narrower end. Micropylar cap absent. Oocystic residuum and polar granule absent. Sporocyst elongate-ovoid, 15 μ –17 μ by 6 μ –7 μ (mean 16 μ by 6.6 μ) in size. Steida-body present at the narrower end as dark knob. Sporocystic residuum granular arranged along the longitudinal axis of the sporozoite. Sporozoite is elongated, somewhat banana-shaped, 13 μ by 3 μ in size with finely granular cytoplasm, having two refractile globules—the larger is at its wider end and the other towards the tapering extremity, with centrally placed nucleus surrounded by small granules.

Sporulation time.—3–4 days.

Dimension of the oocysts reported by other authors are as follows:

30–35 by 20 μ (Zublin, 1908); 23–34 by 17–23 μ with a mean 27.7 by 20.3 μ (Christensen, 1941); 25–33 by 14–23 μ with a mean 28 by 20 μ (Nyberg and Hammond, 1965).

Type host.—Ox, *Bos taurus*.

Other host.—(i) Zebu, *Bos indicus*, (ii) Buffalo, *Babalus bubalis*, (iii) Indian cattle (Domestic), *Bos indicus* (= *Bos* sp.).

Distribution.—Agra, Mathura, Izatnagar. U.P.; Aurey Milk Colony, Bombay.

Prevalence.—Boughton (1945) found 41% infection in bovine from U.S.; Hasche and Todd (1959a) observed 41% in cattle from Wisconsin; Szanto, Mohan and Levine (1964) got 52% infection in beef calves from Illinois; Nyberg, Helfer and Knapp (1967) reported 62% in cattle from Oregon; Jacobson and Worley (1969) received 61% infection in calves and 30% in cattle from Montana; Fitzgerald (1962) reported as a predominant species in the cattle of Utah; Supperer (1952) observed 66% infection in cattle in from Austria; Joyner *et al.* (1966) reported 75% infection in Bovis from England; Chroust (1964) received 69% infection in calves from Czechoslovakia; Patyk (1965) got 23% infection in calves from Poland; Torres and Ramos (1939) found 49% infection in cattle from Brazil; Balconi (1963) reported 41% infection in cattle from Gautemala; Ruiz (1959) got 7% infection in cattle from San Jose, Costa Rica abattoir; Vassiliades (1969) got 21% in cattle from Senegal; Yakimoff, Gousseff and Rastegaieff (1932) reported 40% infection in the cattle of Uzbekistan; Yakimoff (1933) received 47% infection in Zebu, 30% in cattle

and 23% in buffalo from Azerbaidzhan; Marchenko (1937) reported 54% infection in cattle from North Caucasus; Patnaik (1965) reported 52% infection in buffalo from Agra, U.P.; Rao and Hiregaudar (1954) found some infection in buffalo from Bombay, India; Svanbaev (1967) got 26% in cattle from Kazakhstan; Bhatia *et al.* (1968) reported 31% in buffalo from Mathura, U.P.; Sayin (1969) got 34% infection in buffalo from Turkey.

Endogenous stages.—Hammond *et al.* (1946) observed the sporozoites in the small intestine invading the endothelial cells of the lacteals in the villi. The schizonts appeared after 5 days and formed the giant schizonts after 14–18 days from the date of inoculation. Each schizont measured 207–435 μ by 134–267 μ with the mean 281 μ by 203 μ containing numerous merozoites. The schizonts appeared as white balls were visible in naked eyes. The sexual stages in the epithelial cells of intestinal glands, caecum and colon had also been observed by the same authors. The macrogamete was provided with plastic granules inside the cytoplasm.

Hammond, Anderson and Miner (1963), first pointed out the second schyzogonic generation. The mature schizonts were encountered in the epithelial cells of the caecum and colon, each measuring 9 by 10 μ in diameter, containing 30–36 merozoites of 3.5 μ by 1.1 μ in size. Finally, the merozoite attained the size of 6–7 μ in length.

Hammond, Ernst and Goldman (1965) studied the first generation merozoites in details, each merozoite measured 11–16 μ by 1–2 μ with the mean 13.5 μ by 1.4 μ in size. The merozoites showed flexing and gliding movements *in vitro* and revealed a dark cap-like covering with a terminal pore anteriorly. Some prominent granules in the posterior 2/3, and a rod-like structure extending along the middle of the merozoites were found. The nucleus was localized at the posterior third of the body and the chromatin was arranged around the periphery of the nucleus.

Sheffield and Hammond (1966) studied the ultrastructure of first generation merozoites. They detected spindle-shaped merozoite with 22 subpellicular fibrils from a polar ring, formed at the anterior part of the merozoites. The conoid consists of one or more fibrils, wound in a tight helix and two rhoptries passed through the conoid. Numerous glycogen granules, ribosomes and one or two mitochondria were encountered in the cytoplasm. The golgi apparatus located at the flattened anterior end of the nucleus. The endoplasmic reticulum consists of numerous cisternae present both posterior and anterior to the nucleus.

Hammond, Ernst and Miner (1966) allowed the sporozoites to invade up to 8 days and found the daughter nuclei along the periphery of the schizonts with the pellicular invagination. Round or elliptical blastopores measuring 5–20 μ in diameter were recorded on the 12th day. A single row of the blastopores was also detected at the periphery formed by the nuclei which ultimately extended as radial outgrowths leaving a short survival residual bodies of various sizes.

Scholtyssek, Hammond and Ernst (1966) studied the ultrastructure of the macrogametes. Glycogen inclusions measuring 0.3–1.3 μ in diameter, lipoid bodies and wall forming bodies about 1.8 μ long were observed in the macrogametes. Microtubules measuring about 500 Å in diameter and 1000 Å deep appeared as blind pouches on the surface of the macrogamete. The nucleus provided with relatively large nucleolus having prominent granules in the karyosome and some pores on the nuclear membrane.

Sheffield and Hammond (1967) noted the ultrastructural structure of the first schizont. They noticed that the cytoplasm was divided into many blastopores. Many nuclei were formed resulting from the repeated divisions and arranged at the periphery of each blastopore. They formed a complex structure in the cytoplasm of each merozoite at the anterior end. A thickened layer under the cyto-

plasmic membrane appeared in the inner membrane of the merozoite. A central opening located to the membrane corresponding the conoid was also noticed with the subpellicular fibrils. The merozoites developed through the blastopores to a cone-shaped projection along with finger like bud, containing the rhoptries of a nucleus. Golgi apparatus and other cytoplasmic structures appeared from the blastopores. The blastopores hold the attachment of the merozoite which remained as such until the attachment was dislocated.

Hammond, Scholtyseck and Miner (1967) studied the fine structures of the macrogametocytes. Endoplasmic reticulum with canals containing electron-dense material, many thick-walled vesicles, glycogen granules and mitochondria were noticed in the macrogametocytes. The microgametocyte measured 12–18 μ in diameter containing many microvilli along the free surface and provided with a narrow parasitophorous vacuole. Occasionally the microgametocyte was provided with micropore about 1100 Å wide and 1100 Å deep on the surface.

In India very little work on the endogenous stages has been done. Patnaik and Pande (1965), and Bhatia and Pande (1967) attempted to describe the schizogonic processes in the small intestine of buffalo but the species were tentatively identified. However, they were dealing with mixed infection. Pande *et al.* (1968) described several stages from the same host but did not assign them as *E. bovis*.

Prepatent periods.—16–21 days according to Hammond, Davis and Bowman, 1944, 18–20 days as noted by Hammond *et al.* (1946); 7–16 days have found by Senger *et al.* (1959) and 17–18 days by Svanbaev (1967a).

***Eimeria brasiliensis* Torres and Ramos**

(Fig. 5E)

1939. *Eimeria brasiliensis* Torres and Ramos, *Argu. Inst. Pesquisas, Agronon.*, **2**: 79; Gill, 1960, *Proc. Indian Sci. Congr.*, p. 430; 1968, *Proc. zool. Soc. Calcutta*, **21**: 101; 1973, *J. Res.*, **10**: 442; Patnaik, 1963, *Orissa vet. J.*, **1**: 25; 1965, *Agra. Univ. J. Res. (Sci.)*, **13**: 239; Kudo 1966, *Protozoology*, p. 687; Levine and Ivens, 1970, *Ill. Biol. Monogr.*, **44**: 66; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 738.
1952. *Eimeria boehmi* Supperer, *Osterreich zool. Ztschr.*, **3**: 591.
1952. *Eimeria orlovi* Basanov, (*vide* Pellerdy, 1974).
1959. *Eimeria gokaki* Rao and Bhatwadekar, *Bombay vet. Coll. Mag.*, **8**: 23; Gill, 1973, *J. Res.*, **10**: 442.
1961. *Eimeria helenae* Donciu, *Cercetari asupra coccidiilor la ammalele domestice in R.P.R. Bucurestie. Ed. Acad. Rep. Pop. Rom., Bucarest.*, 89 pp.

Description.—Oocysts ellipsoidal or ovoidal, 31 μ –44 μ by 20 μ –29 μ (mean 39 μ by 27 μ) in size length-width ratio 1.35–1.56, (mean 1.44). Oocystic wall double layered, colourless to slightly yellowish-brown, 1.3 μ thick. Micropyle 6 μ –7 μ wide. Micropylar cap present measuring 8 μ –10 μ by 0.8 μ –3.0 μ (mean 9.0 μ by 2.3 μ) in size. Oocystic residuum and polar granule absent. A light small homogenous protoplasmic granular mass, as a small body present below the micropyle in most of the oocysts either unsporulated or sporulated. Sporocysts elongate-ovoid, 17 μ –21 μ by 8 μ –9 μ (mean 20 μ by 8.4 μ) in size. Steida-body present as a fine cap at the narrow pole. Sporocystic residuum present as small granular mass at different positions near the centre, to one side or towards the poles. Sporozoites elongate banana-shaped, of 16 μ by 14.7 μ in size, with one end broader and the other tapering bluntly with a large refractile globule at the wider end and a smaller at the narrower tip located between the nucleus surrounded by fine granules.

Sporulation time.—5–6 days.

Dimension of the oocyst reported by others are as follows;

34–43 by 24–30 μ with the mean 37 by 27 μ (Torres and Ramos, 1939); 34–49 by 21–33 μ (Supperer, 1952); 37 by 26 μ (Bazanov, 1952, cited by Orlov, 1956); 38 by 26 μ (Donciu, 1961); 31–34 by 20–29 μ with the mean 39 by 27 μ (Bhatia, Pande *et al.*, 1968); 37–38 by 21–28 μ (Rakovecz and Brglez, 1966); 33–42 by 23–30 μ with the mean 38.5 by 26 μ (Ernst, Stevens and Cooper, 1971).

Type host.—Ox, *Bos taurus*.

Other hosts: (i) Buffalo, *Bubalus bubalis*. (ii) Indian cattle, *Bos indicus* (*Bos* sp.).

Distribution.—Mathura, Izatnagar, U.P; Bombay; Karnal, Haryana.

Prevalence.—Hasche and Todd (1959a, b) found 3% infection in cattle from Wisconsin. Bhatia *et al.* (1968) got 2% infection in water buffalo in India. The percentage of infection varies from 1.6% to 7% as reported by different authors (Levine and Ivens, 1970) from Brazil, England, Austria, Rumania, Kazakhstan and Turkey.

Endogenous stages.—Unknown.

***Eimeria bukidnonensis* Tubangui**

(Fig. 5F)

1931: *Eimeria bukidnonensis* Tubangui, *Philipp. J. Sci.*, **44**: 253; Gill, 1960, *Proc. Indian Sci. Congr.* p. 430; 1968, *Proc. zool. Soc. Calcutta*, **21**: 101; 1973, *J. Res.*, **10**: 442; Patnaik, 1963, *Orissa Vet. J.*, **1**: 25; 1965, *Agra Univ. J. Res. (Sci.)*, **13**: 239; Hiregaudar and Rao, 1966, *Indian vet. J.*, **43**: 782; Bhatia, Pande, Chauhan and Arora, 1968, *Acta vet. Acad. Sci. Hung.*, **18**: 115; Levine and Ivens, 1970, *Ill. Biol. Monogr.*, **44**: 74; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 739.

1935. *Eimeria thianethi* Gwelessiany, *Ann. de Paras.*, **13**: 115.

Description.—Oocysts pyriform, measuring 38 μ –46 μ in length with a mean 42 μ and 25 μ –35 μ in width with a mean 31 μ . The length/width ratio is 1.2–1.5. Oocystic wall dark, yellowish to brown, two-layered, the thicker outer wall is of 2.9 μ with interrupted radial striations/streaks and spotted or speckled with irregular refractile dark protuberances and the inner wall of 1.0 μ thickness. On rupture of the outer oocystic coat, minute granules liberated on the inner coat. Micropyle is situated at the narrow end, 3.8 μ –4.7 μ (mean 4.0 μ) wide. Micropylar cap absent. Sporocysts ovoid, measuring 15 μ –19 μ in length with a mean 17 μ and 8 μ –11 μ in width with a mean 9 μ . Stieda body present as a dark cap over the narrower end. Sporocystic residuum formed a rounded mass of having fine granules and mostly situated at the centre. Sporozoites elongated with one end much broader and the other bluntly pointed measuring 13.3 μ in length and 5.3 μ in width having a large globule at the broader end and a nearly central nucleus.

Sporulation time.—5–7 days.

Dimension of the oocysts reported by other authors are as follows:

47–50 by 33–38 μ with a mean 48.6 by 35.6 μ (Tubangui, 1931); 33–41 by 24–28 μ with a mean 36.6 by 26.7 μ (Christensen, 1941); 34–50 by 26–34 μ with a mean 39 by 30 μ (Svanbaev, 1967); 43–54 by 29–39 μ (Levine and Ivens, 1970).

Type host.—Domestic cow, *Bos indicus* (= *Bos* sp.).

Other host.—From the type host and Buffalo, *Bubalus bubalis*.

Distribution.—Mathura, Izatnagar, U.P. Karnal, Haryana.

Prevalence: Szanto, Mohamad and Levine (1964) found 1% infection in beef calves from Illinois; Jacobson and Worley (1969) got 9% in calves and 4% in

cattle from Monatana; Joyner *et al.* (1966) observed 2% in cattle from England; Patyk (1965) received 3% in Calves from Poland; Patnaik (1965) obtained 3% in buffaloes from Agra, India; Bhatia *et al.* (1968) noted 5% infection in buffaloes from Mathura, India; Svanbaev (1967) recorded 9% in cattle from Kazakhstan.

Endogenous stages.—Very little is known about the endogenous cycle of *E. bukidnonensis*. Davis and Bowman (1964) found binucleated schizont measuring 5.5 μ in diameter after 11 days from the date of infection inside the parasitophorous vacuole of 11 μ wide and about 12 feet back from the caecum. Also they reported numerous merozoites, each measuring 9–13 μ long, throughout the small intestine after 13 days from the date of infection. Large number of oocysts were observed beneath the epithelium about half way down to the muscularis mucosa after 25 days.

Prepatent period.—10 days according to Baker (1939), 15–17 days as noted by Davis and Bowman (1964) and according to Svanbaev (1967) it is 24–25 days.

***Eimeria canadensis* Bruce**

(Fig. 6A)

1921. *Eimeria canadensis* Bruce, *J. Amer. Vet. Med. Assoc.*, **58**: 638; Gill 1960, *Proc. Indian Sci. Congr.*, p. 430; 1968, *Proc. zool. Soc. Calcutta*, **21**: 101; 1973, *J. Res.* **10**: 442; Patnaik, 1963, *Orissa Vet. J.*, **1**: 25; 1965, *Agra Univ. J. Res. (Sci.)*, **13**: 239; Patnaik and Pande, 1965, *Indian J. vet. Sci.*, **35**: 33; Bhatia, Pande, Chauhan and Arora, 1968, *Acta vet. Acad. Sci. Hung.*, **18**: 115; Levine and Ivens, 1970, *Ill. Biol. Monogr.*, **44**: 55; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 741.
- 1931a. *Eimeria zurnabadensis* Yakimoff, *Arch. Protistenk.*, **75**: 157.
1954. *Eimeria bombayensis* Rao and Hiregaudar, *Bombay Vet. Coll. Mag.*, **4**: 24; Gill, 1973, *J. Res.*, **10**: 442.

Description.—Oocysts ellipsoidal, 25 μ –37 μ by 18 μ –28 μ (mean 31 μ by 22 μ) in size length-width ratio 1.3–1.7 (mean 1.4). Oocystic wall double-layered, light yellowish, 1.2 μ thick. Micropyle is visible as a flattening of the pole and without any micropylar cap. Oocystic residuum and polar granule absent. Sporocyst elongate-ovoid measuring 13 μ –17 μ by 6.6 μ –8.9 μ (mean 16 μ by 7.5 μ) in size. Steida-body present as a dark cap over the narrow end. Sporocystic residuum present as loose granules in linear masses or distributed along the sides. Sporozoites elongated, banana-shaped, 14 μ by 3 μ with one end wider and the other tapering, having a centrally situated nucleus, with a large refractile globule situated at the wider end and two smaller ones lying between the nucleus and the narrow tip, the one towards the latter being the smallest.

Sporulation time.—3–4 days.

Dimension of the oocysts reported by other authors are as follows:

28–38 by 20–29 μ with a mean 33 by 24 μ (Levine and Ivens, 1970); 28–37 by 20–27 μ with a mean 32.5 by 23.4 μ (Pellerdy, 1974).

Type host.—Ox, *Bos taurus*.

Other host.—(i) Buffalo, *Bubalus bubalis*. (ii) Indian Cattle, *Bos indicus* (= *Bos* sp.).

Distribution.—Mathura, Agra, Izatnagar, U.P.; Karnal, Haryana.

Prevalence.—Hasche and Todd (1959a) found 35% infection in cattle from Wisconsin; Balconi (1963) found 39% infection in the cattle of Guatemala; Szanto Mohan and Levine (1964) got 35% infection in cow calves from Illinois; Joyner *et al.* (1966) obtained 13% in cattle from England; Bhatia *et al.* (1968) reported 9% infection in buffaloes from Mathura U.P.; Sayin (1969) got 20% infection in buffaloes of Turkey; Jackson and Worley (1969) obtained 5% infection in calves and 3% in cattle from Montana.

Endogenous stages.—Unknown. Patnaik and Pande (1965) attempted to study the endogenous cycle. However, probably they were dealing with infection. Prepatent period is not known.

***Eimeria cylindrica* Wilson**

(Fig. 6B)

1931. *Eimeria cylindrica* Wilson, *Va. Agric. Exp. Sta. Tech. Bull.*, **42**: 1; Ray and Das Gupta, 1936, *Proc. Indian Sci. Congr.*, p. 345; Bhatia, 1938, *The Fauna of Br. India including Ceylon and Burma*, Protozoa. Sporozoa, London, p. 179; Ray, 1941, *Rep. Syst. Protozoologist Imp. Vet. Ins.* Mukteswar for years ending 17th August, 1941; Gill, 1960, *Proc. Indian Sci. Congr.*, Bombay, p. 430; 1968, *Proc. zool. Soc. Calcutta*, **21**: 101; Patnaik, 1963, *Orissa Vet. J.*, **1**: 25; 1965, *Agra Univ. J. Res. (Sci.)*, **13**: 239; Patnaik and Pande, 1965, *Indian J. vet. Sci.*, **35**: 33; Kudo, 1966, *Protozoology*, p. 687; Bhatia, Pande, Chauhan and Arora, 1968, *Acta vet. Acad. Sci. Hung.*, **18**: 115; Levine and Ivens, 1970, *Ill. Biol. Monogr.*, **44**: 60; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 742.

Description.—Oocysts are cylindrical or somewhat sub-cylindrical, measuring 20 μ –34 μ by 12 μ –17 μ (mean 26 μ by 14 μ) in size; length-width ratio 1.8–2.3 (mean 1.83). Oocystic wall two layered, colourless or somewhat straw coloured, 1.3 μ thick. Micropyle and micropylar cap absent. Oocystic residuum and polar granule absent. Sporocysts elongate-ovoid, 9 μ –19 μ by 4 μ –6 μ (mean 10.4 μ by 5.2 μ) in size. Steida-body present at the narrow end. Sporocystic residuum present as a few scattered granules in different position. Sporozoites elongated, banana-shaped 7 μ –9 μ by 2.0 μ –2.6 μ (mean 7.6 μ by 2.1 μ) in size with the large refractile globule at the wider end and the smaller globule located anterior to the centrally situated nucleus but towards the narrower and tapering end.

Sporulation time.—2–3 days.

Dimension of the oocysts reported by other authors are as follows:

16–27 by 12–15 μ with a mean 23.3 by 12.3 μ (Pellerdy, 1973); 16–30 by 12–17 μ with a mean 21–25 by 13–15 μ (Levine and Ivens, 1970).

Type host.—Ox, *Bos taurus*.

Other host.—(i) Buffalo, *Bubalus bubalis*. (ii) Indian Cattle, *Bos indicus* (= *Bos* sp.).

Distribution.—Agra, Mathura, Izatnagar, U.P. and Orissa; Karnal, Haryana

Prevalence.—Hasche and Todd (1959a) found 20% infection in cattle from Wisconsin; Supperer (1952) got 4% in cattle from Austria; Chroust (1964) reported 8% in calves from Czechoslovakia; Szanto, Mohan and Levine (1964) observed 12% in beef calves from Illinois; Patyk (1965) noted infection in calves from Poland Patnaik (1965) observed 7% in buffaloes from Agra, India; Joyner *et al.* (1966) reported 13% in cattle from England; Nyberg, Helfer and Knapp (1967) got 10% in cattle from Oregon; Jacobson and Worley (1969) reported 2% infection in calves from Montana; Vassiliades (1969) received 6% infection in cattle from Senegal; Sayin (1969) reported 5% infection in buffaloes from Turkey.

Endogenous stages.—Unknown. Patnaik and Pande (1965) studied the endogenous stages in buffaloes, but the species was not considered as *E. cylindrica* because the authors were dealing with the mixed infection.

***Eimeria ellipsoidalis* Becker and Frye**

(Fig. 6C)

1929. *Eimeria ellipsoidalis* Becker and Frye, *J. Parasit.*, **15**: 175; Gill, 1960, *Proc. Indian Sci. Congr. Bombay*, p. 430; 1968, *Proc. zool. Soc. Calcutta*, **21**: 101; 1973, *J. Res.*, **10**: 442; Patnaik, 1963, *Orissa Vet. J.*, **1**: 25; 1965, *Agra Univ. J. Res. (Sci.)*, **13**: 239; Patnaik and Pande, 1965; *Indian J. vet. Sci.*, **35**: 33; Kudo, 1966, *Protozoology*, p. 687; Bhatia, Pande, Chauhan and Arora, 1968, *Acta vet. Acad. Sci. Hung.*, **18**: 115; Levine and Ivens, 1970, *Ill. Biol. Monogr.*, **44**: 57; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 743.

Description.—Oocysts ellipsoidal to slightly ovoid, 15 μ –26 μ by 12 μ –16 μ (mean 20 μ by 14 μ) in size, length-width ratio 1.2–1.6 (mean 1.44). Oocystic wall double layered, light yellowish green, 1.3 μ thick. Micropyle present as a small light area at one pole with a slight thinness of its wall. Micropylar cap absent. Oocystic residuum and polar granule absent. Sporocyst elongate-ovoid 10 μ –13 μ by 5 μ –6 μ (mean 12.2 μ by 5.4 μ) in size. Steida body present as a somewhat flattened dark knob. Sporocystic residuum present as a mass of loose granules either centrally situated or towards the poles. Sporozoites elongate, banana-shaped, with one end broad and the other blunt, 11 μ by 2.6 μ in size, with a prominent refractile globule behind the wider end and the centrally placed nucleus surrounded by small granules.

Sporulation time: 3–4 days.

Dimension of the oocysts reported by other authors are as follows:

12–27 by 10–18 μ average 17 by 13 μ (Christensen, 1941); 21 by 15 μ (Cordero del Campillo, 1960); 18–26 by 13–18 μ , average 23 by 16 μ (Levine and Ivens 1967); 15–25 by 12–16 μ , average 20 by 12 μ (Bhatia *et al.*, 1968); 18–28 μ by 16–18 μ , average 21.6 by 15.3 μ (Patnaik, 1965).

Type host.—Ox, *Bos taurus*.

Other host.—(i) *Buffalo*, *Bubalus bubalis*. (ii) Indian cattle, *Bos indicus* (= *Bos* sp.).

Distribution.—Agra, Mathura, Izatnagar, U.P.; Karnal, Haryana.

Prevalence.—From South Eastern United States, Boughton* (1945) reported 45% cases of bovine coccidiosis. Hasche and Todd (1959) got infection in 43% cattle at Wisconsin; Szanto, Mohan and Levine (1964) came across 40% infection in cow calves of Illinois. Nyberg, Helfer and Knapp (1967) reported 33% case from the cattle of Oregon. From Montana, Jacobson and Worley (1969) got 14% infection in cow calves and 3% in adult. Ruiz (1959) reported 3% and Ruiz and Ortiz (1961) got 4% cases at Costa Rica. From Guatemala, Balconi (1963) recorded 47% infection; Supperer (1952) came forward with 15% infection from Austria so also Chroust (1964) from Czechoslovakia who received 34% infection, Patyk (1965) got 13% infection from Poland; Joyner *et al.* (1966) reported 26% infection from cattle of England. Vassiliades (1969) got 12% infection in Senegal. Yakimoff, Gousseff and Rastegaieff (1932) reported 23% cases of Oxen coccidia form Uzbekistan. Yakimoff (1933) got 27% infection in Oxen, 6% in zebu and 52% of water buffaloes in Azerbaidzhan. From Japan, Iwata (1956) (Cited by Levine & Ivens, 1970) got 4% infection in cattle. Patnaik (1965) found 21% infection in buffaloes from Agra and Bhatia *et al.* (1968) received 20% infection at Mathura from buffalo.

Endogenous stages.—Boughton (1945) reported the endogenous stages in the epithelial walls of the mucosa of the small intestine. Merozoites were detected in the scrapings of small intestinal mucosa 11 days after inoculation (Hammond, Sayin and Miner, 1963). The fully developed schizonts measured 9–15 by 7.5–15 μ with a mean of 11 by 9 μ and each of them gave rise to 24–36 merozoites. The merozoite measured 8–11 μ by 1–2 μ . The gametocytes were found at the terminal

segment of the small intestine, mainly at the ileum. The immature gametocytes were detected by them 8 days after inoculation and the mature one was detected after 11 days at the bottom of the crypts in the epithelial cells. After 14 days the fully developed micro and macrogametes were also detected by the same authors. The former measured 12–16.5 μ by 11–16.5 μ (average 15 μ by 13 μ) and produced 2–3 μ long microgametes. Patnaik and Pande (1965) detected endogenous stages in the intestine of domestic buffalo but they were dealing with mixed infections. The schizogony of this species was studied by Speer and Hammond (1971) in Madin Darby bovine Kidney, embryonic bovine Trachea, synovial or spleen cell cultures. Sporozoites measured 5–6 by 2.4 μ after one day, having three refractile globules measuring 1.5 μ in diameter with an-eccentric nucleus. After sometime, the sporozoites rounded off and formed the schizonts measuring 5.9 by 5.4 μ . The authors could trace 4–42 nuclei inside the schizont on the 4th day. With a little difference they got almost similar results in all types of *in vitro* cell cultures.

***Eimeria ovoidalis* Ray and Mandal**

(Fig. 6D)

1961. *Eimeria ovoidalis* Ray and Mandal, *Proc. Indian Sci. Congr.*, p. 411; 1962, *Anim. Helth.*, **3**: 27–32; Levine and Ivens, 1970, *Ill. Biol. Monogr.*, **44**: 43; Patnaik 1965, *Agra Univ. J. Res. (Sci.)*, **13**: 239; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 772; Mandal, 1976, *Rec. zool. Surv. India*, **70**: 39.

Description.—Oocyst ovoidal, measuring 32.00 μ –40.00 μ in length with a mean 35.5 μ and 20 μ –28 μ in width with a mean 23.8 μ . Micropyle present. Oocystic residuum absent. Sporocysts oval, measuring 14–16 μ in length and 8 μ –9 μ in width. Sporocystic residual mass coarsely granular. Steida body present at the narrow end. Sporozoites ovoidal measuring 8–9 μ in length and 4–6 μ in width.

Sporulation time.—90–120 hours.

Type host.—Buffalo calf, *Bubalus bubalis*.

Other hosts.—Unknown.

Distribution.—Diary farm at Calcutta, West Bengal.

Prevalence.—After obtaining a single infection of this species from a buffalo-calf the authors described the present species from West Bengal. Patnaik (1965) got 7% infection in the buffaloes at Agra U.P.

Endogenous stage.—Unknown.

Remarks.—The validity of this species remains doubtful as stated by Levine and Ivens (1970). This species has got some resemblance with *E. canadensis* but the authors failed to compare it while describing the species as new. However, Patnaik (1965) considered this species as synonym of *E. wyomingensis*.

***Eimeria pellita* Supperer**

(Fig. 6E)

1952. *Eimeria pellita* Supperer, *Osterreich Zool. Ztschr.*, **3**: 591; Bhatia, Pande, Chauhan and Arora, 1968, *Acta vet. Acad. Sci. Hung.*, **18**: 115; Levine and Ivens, 1970, *Ill. Biol. Monogr.*, **44**: 73; Gill, 1973, *J. Res.*, **10**: 442; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 746.
1954. *Eimeria khurodensis* Rao and Hiregaudar, *Bombay vet. Coll. Mag.*, **4**: 24; Hiregaudar and Rao 1966, *Indian vet. J.* **43**: 782; Gill, 1973, *J. Res.*, **10**: 442.

Description.—The oocysts are ovoid in shape, measuring 36.2 μ –40.9 μ in length and 26.5 μ –30.2 μ in width with a micropyle on the flattened narrower end. The

wall is of uniform thickness, dark brown in colour, with densely placed numerous protuberances which give it a velvety appearance. Oocystic polar granule and residuum absent. The sporocystic residual body is sharply delineated and measured $7\ \mu$ by $5\ \mu$. Stieda body absent, sporocystic residuum present, usually compact. Sporozoites with 2 refractile globules are noticed.

Sporulation time.—10–12 days.

Type host.—Ox, *Bos taurus*.

Other host.—(i) Indian cattle, *Bos indicus* (= *Bos* sp.).

Distribution.—Mathura, U.P.

Prevalence.—From Austria, Supperer (1952) recorded this species in 5% cattle. Joyner *et al.* (1966) got 4.5% infection in England.

Endogenous stages.—Unknown.

Remarks.—Bhatia *et al.* (1968) considered this species as a synonym of *E. bukidnonensis*. But the structure of the oocystic wall and shape of the oocyst are different and due to which Levine and Ivens (1970) denied the synonym.

***Eimeria subspherica* Christensen**

(Fig. 6F)

1941. *Eimeria subspherica* Christensen, *J. Parasit.*, **27**: 203; Gill, 1960, *Proc. Indian Sci. Congr.*, p. 430; 1968, *Proc. zool. Soc. Calcutta*, **21**: 101; Patnaik, 1963, *Orissa vet. J.*, **1**: 25; 1965, *Agra Univ. J. Res. (Sci)*, **13**: 239; Patnaik and Pande, 1965, *Indian J. vet. Sci.*, **35**: 33; Bhatia, Pande, Chauhan and Arora, 1968, *Acta vet. Acad. Sci. Hung.*, **18**: 115; Bhatia, Pande, Chauhan and Garg, 1971, *Indian J. Anim. Sci.*, **41**: 549; Levine and Ivens, 1970, *Ill. Biol. Monogr.*, **44**: 71; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 747.

Description.—The oocysts are colourless subspherical (rarely spherical) in shape. The oocystic wall is smooth, sometimes pale yellowish in colour, double layered, $0.7\ \mu$ – $1.0\ \mu$ thick. The oocysts measure $9\ \mu$ – $14\ \mu$ in length and $8\ \mu$ – $12\ \mu$ in width with a mean $11\ \mu$ by $10.4\ \mu$. Micropyle, oocystic residuum, polar granules absent. The sporocysts are elongate-ovoid with small stieda body measuring $7\ \mu$ – $10\ \mu$ in length and $4\ \mu$ – $5\ \mu$ in width, with a mean $8\ \mu$ by $3.5\ \mu$, containing no sporocystic residuum. Sporozoites wider at one end than the other, lying length-wise head to tail within the sporocyst. Sporozoite is provided with a clear globule at the broader end.

Sporulation time.—4–5 days.

Type host.—Ox, *Bos taurus*.

Other hosts.—(i) Buffalo, *Bubalus bubalis*. (ii) Indian Cattle, *Bos indicus* (= *Bos* sp.).

Distribution.—Agra, Mathura, Izatnagar, U.P., Karnal, Haryana.

Prevalence. From Wisconsin, Hasche and Todd (1959a) detected 11% infection in cattle. Szanto, Mohan and Levine (1964) observed this species in 8% calves in Illinois. From Oregon 8% cattle was found to be infected with this species as detected by Nyberg, Helfer and Kneapp (1967). From Costa Rica, Ruiz and Ortiz (1961) obtained 3% infection. Balconi (1963) reported 12% infection in cattle from Guatemala. Joyner *et al.* (1966) reported 28% infection in cattle from England and Vassiliades (1969) got 6% infection in cattle from Senegal. Patnaik (1965) got 21% infection from buffalo at Agra, U.P., Bhatia *et al.* (1968) also reported 16% infection from the buffalo, at Mathura, U.P. From Turkey, Sayin (1969) reported 15% infection in buffalo.

Endogenous stages.—Unknown.

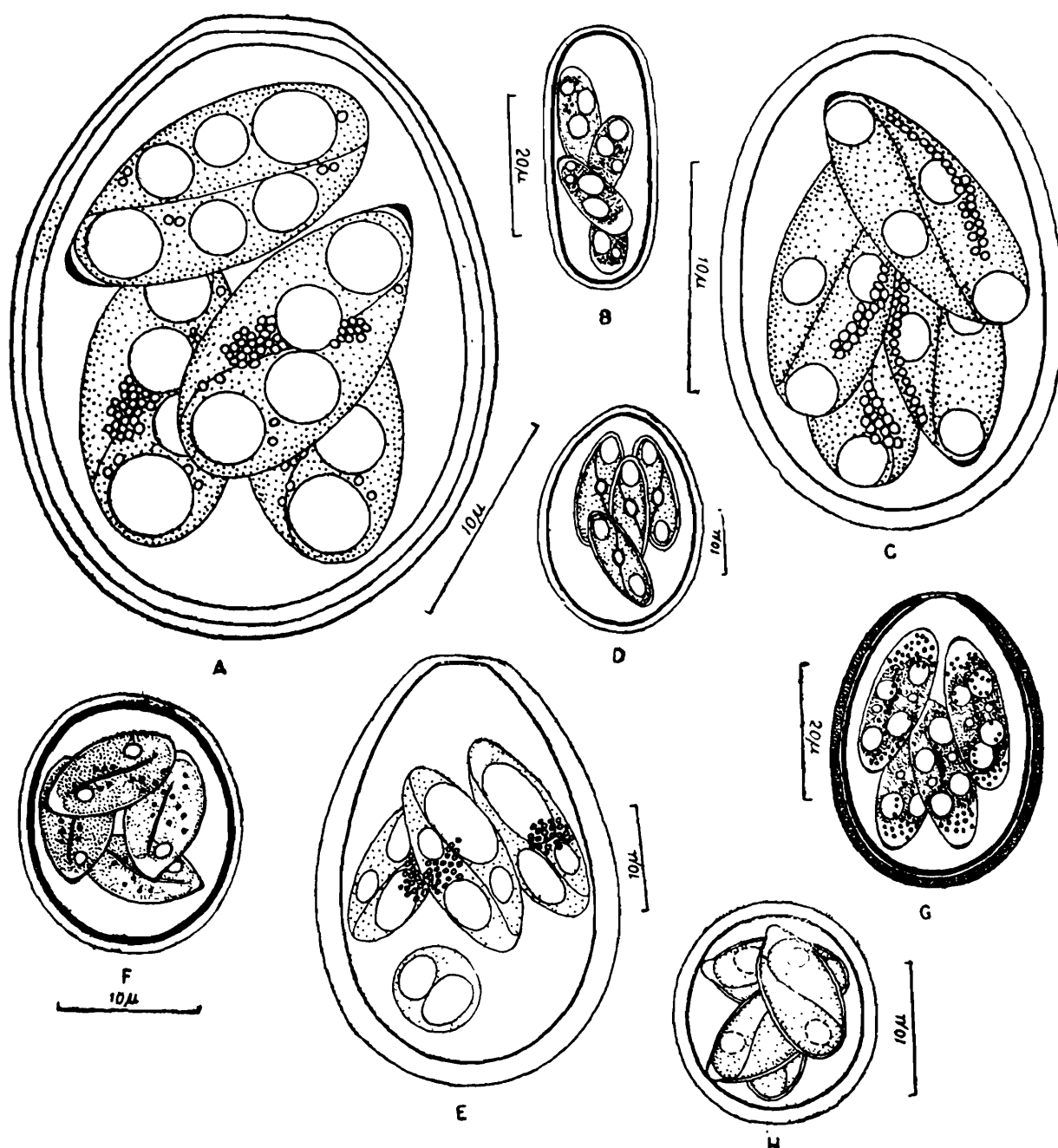


Fig. 6. (A-H). Diagrams of sporulated oocysts of:

- A) *E. canadensis*; B) *E. cylindrica*; C) *E. ellipsoidalis*; D) *E. ovoidalis*;
E) *E. pellita*; F) *E. subspherica*; G) *E. wyomingensis*, H) *E. zurnii*.

***Eimeria wyomingensis* Huizinga and Winger**

(Fig. 6G)

1942. *Eimeria wyomingensis* Huizinga and Winger, *Trans. Am. microsc. Soc.*, **61**: 131; Gill, 1960, *Proc. Indian Sci. Congr.*, p. 430; 1968, *Proc. zool. Soc. Calcutta*, **21**: 101; 1973, *J. Res.*, **10**: 442; Patnaik, 1963, *Orissa Vet. J.*, **1**: 25; 1965, *Agra Univ. J. Res. (Sci.)*, **13**: 239; Kudo, 1966, *Protozoology*, p. 687; Bhatia, Pande, Chauhan and Arora, 1968, *Acta vet. Acad. Sci. Hung.*, **18**: 115; Levine and Ivens, 1970, *Ill. Biol. Monogr.*, **44**: 72; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 748.
1956. *Eimeria mundaragi* Hiregaudar, *Curr. Sci.*, **25**: 197; Gill, *J. Res.*, **10**: 442.

Description.—Oocysts egg-shaped, measuring 37 μ –44 μ in length and 26 μ –31 μ in width with a mean 11 μ by 28 μ , length-width ratio 1.4–1.65 (mean 1.48). Oocystic wall thick, yellowish brown, double layered the outer coat rough of 1.99 μ

thickness, heavily and uniformly punctate and the inner of $0.66\ \mu$ thickness. Micropyle present, $4.0\ \mu$ – $6.6\ \mu$ wide (mean $5.0\ \mu$). Oocystic residuum and polar granule absent. Sporocysts elongate-ovoid, with one end narrower, $21\ \mu$ – $24\ \mu$ by $8\ \mu$ – $9\ \mu$ (mean $22.0\ \mu$ by $8.6\ \mu$) in size. Sporocystic residuum granular, and granules lying along the sporozoites or concentrated towards the poles. Sporozoites elongated measuring $7\ \mu$ – $8\ \mu$ in length and $5\ \mu$ at the broadest diameter, with two large refractile globules—one at the wider end and the other towards the narrower end with the nucleus between them.

Sporulation time.—6–7 days.

Dimension of the oocysts as reported by other authors are as follows:

36–46 by 26–32 μ with the mean 40 by 28 μ (Huizinga and Winger, 1942); 37–41 by 22–26 μ with the mean 38.3 by 24.8 μ (Patnaik, 1965); 37–45 by 26–31 μ with the mean 40.3 by 28.1 μ (Pellerdy, 1974).

Type host.—Ox, *Bos taurus*.

Other hosts.—(i) Domestic buffalo, *Bubalus bubalis*. (ii) Indian cattle, *Bos indicus* (= *Bos sp.*).

Distribution.—Agra, Mathura, Izatnagar, U.P., Karnal, Haryana.

Prevalence.—Szanto, Mohan and Levine (1964) found 6% infection in cow calves from Illinois, Patyk (1965) found 1% infection in calves from Poland; Joyner *et al.* (1966) found the same in 14% of cattle from England; Bhatia *et al.* (1968) obtained 5% infection in buffaloes from Mathura Uttar Pradesh, and Sayin (1969) got 0.7% infection in buffaloes from Turkey.

Endogenous stages.—Unknown.

***Eimeria zuernii* (Rivolta) Martin**

(Fig. 6H)

- 1878. *Cryptospermium zurnii* Rivolta, *Gior. Anat. Fisiol. e. Pat. Anim. Pissa.*, **4**: 220.
- 1891. *Coccidium zurnii* Railliet and Lucet, *Bull. Soc. Zool. France*, **16**: 246.
- 1908. *Coccidium bovis* Zublin (in partim), *Schweiz Arch. Thkde.*, **50**: 123.
- 1909. *Eimeria zuernii* Martin, *Rev. Vet. Toulouse.*, **34**: 201; Cooper, 1926, *Proc. Indian Sci. Congr.*, p. 291; Wenyon, 1926, *Protozoology*, 2 Vols., p. 842; Bhatia, 1938, *The Fauna of British India, including Ceylon and Burma*, Protozoa: Sporozoa, p. 194; Gill, 1960, *Proc. Indian Sci. Congr.*, p. 430; Patnaik, 1965, *Agra Univ. J. Res. (Sci.)*, **13**: 239; Kudo, 1966, *Protozoology*, Charles C Thomas, U.S.A., p. 686; Gill, 1968, *Proc. zool. Soc. Calcutta*, **21**: 101; Bhatia, Pande, Chauhan and Arora, 1968, *Acta vet. Acad. Sci. Hung.*, **18**: 115; Levine and Ivens, 1970, *Ill. Biol. Monogr.*, **44**: 46; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 749.
- 1912. *Eimeria bovis* Fiebiger (in partim) *Die tierischen Parasiten der Haus-und Nutztiers. Ein. Lehr-und Handbuch mit Bestimmungstabellen fur Tierarzte und Studierende.* Wein and Leipzig. XVI + p. 424.
- 1921. *Eimeria canadensis* Bruce, *J. Amer. vet. Med. Assoc.*, **58**: 638.

Description.—Oocysts are spherical, subspherical or bluntly ellipsoidal-ovoidal in shape, measuring $14\ \mu$ – $22\ \mu$ in length and $13\ \mu$ – $19\ \mu$ in width with a mean $17\ \mu$ by $16\ \mu$. The length-width ratio is 1.0–1.2 with a mean 1.12. Oocystic wall is smooth, double-layered, light yellowish-green in colour measuring $1.5\ \mu$ thick. Micropyle and micropylar cap absent. Oocystic residuum and polar granule also absent. Sporocyst elongate-ovoid measuring $8.0\ \mu$ – $10.5\ \mu$ in length and $5.0\ \mu$ – $7.0\ \mu$ in width with a mean $9.9\ \mu$ by $6.0\ \mu$ with rounded ends. Stieda body present as a faintly dark cap over the narrower anterior end. Sporocystic residuum present as loosely scattered granules. Sporozoites stumpy, $9\ \mu$ by $3\ \mu$ in size, with a

refractile globule lying behind the wider rounded end-the other end being abruptly pointed having the nucleus at its middle.

Sporulation time.—3–4 days.

Dimension of the oocyst reported by other authors are as follows:

15–22 by 13–18 μ with the mean 17.8 by 15.6 μ (Martin, 1909); 13–29 by 12–20 μ with the mean 20.9 by 16.4 μ (Wenyon, 1926); 17.6 by 15.5 μ , (Richardson and Kendall, 1957); 12–26 by 12–16 μ with the mean 17.6 by 14.6 μ , (Davis and Bowman, 1957); 14–21 by 10–17 μ with the mean 17.1 by 14.6 μ , (Cordero del Campillo, 1960); 16–20 by 15–18 μ with the mean 18 by 17 μ (Nyberg and Hammond, 1965); 12–29 by 10–21 μ with the mean 17–20 by 14–17 μ (Levine and Ivans, 1970).

Type host.—Ox, *Bos taurus*.

Other host.—(i) Domestic buffalo, *Bubalus bubalis*, (ii) Indian cattle, *Bos indicus* (= *Bos* sp.).

Distribution.—Izatnagar, Agra, Mathura, U.P., Orissa and Karnal Haryana.

Prevalence.—Tubangui (1931) found 11% infection in zebues and 9% in carabaos from Philippines; Yakimoff, Gouseff and Rastegaieff (1932) found 13% from oxen in Uzbekistan; Yakimoff (1933) found 18% in Oxrn, 6% in zebues and 37% in buffaloes from Azerbaidzhan; Marchenko (1937) found infection 20% from Cattle in North Caucasus; Torres and Ramos (1939) got 38% in cattle from Brazil; Boughton (1945) obtained 42% in bovine from United States; Supperer (1952) observed 11% in cattle from Austria; Watanabe and Iwata (1956) got 3% infection in cattle from Japan; Hasche and Todd (1959a) received 26% infection in cattle from Wisconsin; Riuz (1959) obtained 1% infection in cattle and Riuz and Ortiz (1961) observed 2% in calves from Costa Rica; Balconi (1963) reported 25% in cattle from Guatemala; Szanto, Mohan and Levine (1964) observed 37% infection in cow calves from Illinois; Chroust (1964) got 83% infection in cattle from Czechoslovakia; Patnaik (1965) reported 36% infection in buffalo from Agra, U.P.; Patyk (1965) reported 16% infection in calves from Poland; Joyner *et al.* (1966) observed 64% in cattle from England; Nyberg, Helfer and Knapp (1967) reported 23% infection in cattle from Oregon; Svanbaev (1967) received 30% infection in cattle from Kazakhstan; Bhatia *et al.* (1968) got 16% infection in buffaloes from Mathura, U.P.; Jacobson and Worley (1969) observed 6% infection in calves and 5% in cattle from Montana; Sayin (1969) observed 49% in buffaloes from Turkey; Vassiliades (1969) got 38% infection in cattle from Senegal.

Endogenous stages.—Davis and Bowman (1957) obtained mature schizont measuring 10 μ by 13 μ with 24–26 merozoites arranged encircling the central residuum of 2.1 μ in diameter. Each merozoite measured 12.2 μ by 5.4 μ with a nucleus near the tapering end and two refractile globules. The macrogametes appeared 12 days after the inoculation and measured 13.5 by 10.6 μ with a centrally placed nucleus having irregular karyosome and cytoplasmic granules. The microgametocytes measured 13.8 by 9.7 μ with comma-shaped microgametes arranged in rows along the periphery. Both the macrogametocyte and microgametocytes established in the terminal segment of the small intestine, caecum, colon and rectum.

Prepatent period was estimated about 18 days and 15 days by Pellerdy (1965) and Svanbaev (1967a) respectively.

Remarks.—The controversy about the spelling of the specific name “*zuernii*” is vividly discussed by Levine and Ivans (1967) and Pellerdy (1974). Therefore, instead of “*zurnii*” it should be spelt as “*zyernii*” and followed as such.

Isospora sp.

1926. *Isospora* sp. Cooper and Gulati, *Mem. Dept. Agr. India Vet. Ser.*, **3**: 191; Bhatia, 1938, *The fauna of Br. India, including Ceylon and Burma*, Protozoa: Sporozoa, London, p. 173.

Description.—Oocysts usually subspherical, occasional spherical measuring 21 μ –33 μ in length and 20 μ –32 μ in width with a mean 27 μ by 25 μ . Oocyst wall smooth, colourless, pale-lavender or pale-yellowish, composed of a single layer about 1 μ thick, sometimes apparently lined by a thin membrane. Micropyle and oocystic residuum absent. Several irregular refractile polar granules present. Sporocysts lemon-shaped, quite thick-walled measuring 14 μ –20 μ by 10 μ –12 μ with a mean 17 μ by 11 μ . Sporocystic stieda body is a button shaped cap, with a dependent globular, hyaline mass (substile body) protruding into the interior of the sporocyst. Sporocystic residuum finely granular. Sporozoites appear sausage-shaped, not arranged in any particular order within the sporocyst. Sporocystic residuum and sporozoites enclosed in a membrane, forming more or less a ball within sporocyst.

Sporulation time.—24 hours.

Host.—Domestic cattle, *Bos indicus* (= *Bos* sp.).

Distribution.—Dhupatul, Kochlai, Assam, Shillong, Meghalaya; Sundarban, West Bengal.

Endogenous stages.—Unknown.

Remarks.—The report of an *Isospora* sp. from domestic cattle is vividly explained by Levine and Mohan (1960) and Mandal (1965). *Isospora* sp. of Cooper and Gulati is also indistinguishable from that of *Isospora lacazei* found in sparrow. But the description of *Isospora* sp. by Cooper and Gulati is too meager. It follows "Oocysts were quite round and within twenty-four hours two fully formed sporoblasts were seen in all cases" The detail description of the oocyst of *Isospora* sp. is mainly based on Levine and Mohan (1960) and Mandal (1965).

COCCIDIA OF SHEEP AND GOATS

Eimeria arloingi (Marotel)

(Fig. 7A)

- 1905b. *Coccidium arlongi* Marotel, *Rec. Med. Vet.*, **33**: 243; 1905a, *Bull. Soc. Vet. Lyon*, Feb. **5**: 52.
1909. *Eimeria arolongi* Martin, *Rev. Vet. Toulouse*, **34**: 201; Wenyon, 1926, *Protozoology*, 2 Vols., London, p. 844; Ray, 1949, *Ind. Fam.*, **10**: 487; Rao and Hiregaudar, 1954, *Bombay Vet. Coll. Mag.*, **4**: 29; Gill and Katiyar, 1961, *Indian J. Vet. Sci. and Anim. Husb.*, **31**: 212; Ray, 1961, *Anim. Helth.*, **2**: 1; Singh, 1963, *Punjab Vet.*, **3**: 1; Shah and Joshi, 1963, *J. Vet. An Husb. Res.*, **7**: 9; Pande, Bhatia, Dubey and Srivastava, 1964, *Indian J. Microbiol.*, **4**: 67; Singh, 1963, *Punjab Vet.*, **3**: 1; 1964, *Agra Univ. J. Red. (Sci.)*, **13**: 233; Sivdas, Rajan and Nair, 1965, *Indian Vet. J.*, **42**: 474; Sharma, Deorani, 1966, *Indian Vet. J.*, **43**: 122; Jha, 1966, *Indian J. Anim. Helth.*, **5**: 33; Jha and Subramanian 1965, *Indian J. Anim. Helth.*, **4**: 1; 1966, *Indian Vet. J.*, **43**: 588; Bhatia and Pande, 1966, *Sci. and Cult.*, **32**: 378; Kudo, 1966, *Protozoology*, p. 687; Singh and Pande, 1967b, *Ann. Paras., Hum. Comp.*, **42**: 141; Pande, Bhatia, Chauhan and Kala, 1967, *Indian J. Vet. Sci.*, **37**: 58; Bhatia and Pande, 1969, *Indian Vet. J.*, **46**: 399; 1970, *Orissa Vet. J.*, **5**: 128; Levine and Ivens, 1970; *Ill. Biol. Monogr.*, **44**: 95; Bali, 1972, *J. Res. Panjab Agric. Univ.*, **9**: 226; Misra and Mohapatra, 1972, *Orissa Vet. J.*, **7**: 9; Chauhan, Bhatia, Arora, Agrawal and Ahluwalia, 1973, *Indian J. Anim. Sci.*, **43**: 163; Bhatia, Chauhan, Arora and Agrawal, 1973, *Indian J. Anim. Sci.*, **43**: 944; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 774; Krishnamurthy and Kshirsagar, 1976, *Nat. Sci. J. Marathwada Univ.*, **15** (Sec. 8): 153.
- 1931b. *Eimeria aemula* Yakimoff, *Bull. Soc. Path. Exot.*, **24**: 644.
1952. *Eimeria hawkinsi* Ray, *Proc. 29th Indian Sci. Congr.*, p. 314, 1961, *Anim. Hlth.*, **2**: 1; Jha and Subramanian, 1965, *Indian J. Anim. Hlth.*, **4**: 1.

Description.—The capped and typically ellipsoidal oocysts of pale brownish yellow to orange in colour, exhibited a great variation in size, measuring $24.65\ \mu$ – $37.4\ \mu$ in length with a mean $20.3\ \mu$. The prominent crescent-shaped polar cap, lying above the micropyle, measured $3.4\ \mu$ – $7.6\ \mu$ by $1.7\ \mu$ – $3.4\ \mu$ in size. The shape index of the oocysts ranged from $0.61\ \mu$ – 0.82 . The oocystic residuum absent. Sporocyst elongate-ovoid with a rather truncated small end. Stieda body absent or vestigial. Sporocyst measures $11\ \mu$ – $17\ \mu$ in length and $6\ \mu$ – $10\ \mu$ in width with a mean $13\ \mu$ – $15\ \mu$ by $7\ \mu$ – $8\ \mu$. Sporocystic residuum present. Sporozoite elongated lying lengthwise, head to tail with in the sporocyst. Sporozoite is usually provided with a large, clear globule at the broader end and a small one at the smaller end.

Sporulation time.—1 or 2 days.

Dimension of oocysts reported by other authors are as follows:

17–42 by 13–27 μ (Christensen, 1938a); 24–38 by 18–20 (Hones, 1942); 25–38 by 17–25 μ (Balozet, 1932); 40–45 by 25–30 μ (Prasad, 1960); 29–41 by 20–28 μ , average 2376 by 2414 μ , (Restani, 1966); 22–36 by 16–26 μ average 28 by 19–21 μ , (Levine and Ivens, 1971).

Type host.—Domestic goat, *Capra hircus* (= *Capra* sp.).

Other hosts.—(i) From the type host (ii) Domestic sheep, *Ovis* sp (iii) Ladak goat, *Capra ibex* (iv) Rocky mountain bighorn sheep, *Ovis canadensis*, (v) Moufflon, *Ovis musimon*, (vi) Argali, *Ovis amon*.

Distribution.—Hyderabad, Andhra Pradesh; Orissa, West Bengal, Uttar Pradesh, Madhya Pradesh, Bombay, Bihar, Punjab and also in the Zoological garden, Lucknow.

Prevalence.—Most common in sheep. Christensen (1938a) found in 90% of sheep from Idaho, Maryland, New York and Wyoming. From Tunisia, Balozet (1932) obtained it in 52% of sheep and 56% of goat. Jacob (1943) reported it in 58% of sheep and 11% in goats from Germany. From Kazakhstan, Svanbaev (1957b) reported this species in 52% sheep and goats while examining 302 sheep and 78 goats. In India, this species is predominant in goats; rather than in sheep.

Location.—Small intestine.

Endogenous stages.—Endogenous development is still uncertain. However, Lotze (1953) was the first who could trace giant schizont measuring 146 by 122 μ in lambs with a number of merozoites each measuring 9 by 2 μ after inoculating single oocyst. Levine, Ivens and Fritz (1962) studied two types of schizont in kid. The giant schizont measured 280 by 150 μ in size and supposed to be of *E. arloingi*. The giant schizont is provided with profuse number of merozoites, each measuring 10–12 μ by 0.8–1.2 μ . The small schizont measured 10–14 by 9–10 μ with a mean 12 μ by 9 μ having 12–16 merozoites, measuring 9 μ by 0.8 μ . But they thought that the small schizont might be either *E. arloingi*, *E. crandallis*, *E. christenseni* or might be a fourth species which had not yet began to produce oocyst in the faeces. However, Sayin (1965) saw only one type of immature giant schizont measuring 140 by 100 μ in the ileum of a goat. Levine, Ivens and Fritz (1962) observed the microgametes. The microgametes 3.5 by 0.4 μ in size were slender, crescent or comma-shaped, arranged at the periphery around a central residuum within the mature microgametocytes of 11–26 by 8–16 μ in size. The microgametocyte measuring 12–24 by 8–15 μ in size, was granular and have large nucleus with delineated karyosome. But Sayin (1965) detected microgametocytes measuring 15–23 by 10–14 μ and the macrogametocytes of 18–29 by 22.2–24.8 μ in size. Sometimes the gametocytes aggregate to form white plaques 5 mm in diameter on the mucus membrane of the small intestine.

Lotze *et al.* (1964) detected the giant schizonts in the mesenteric lymph nodes of sheep and goats, each measuring 32–110 μ in diameter in goat and 30–36 μ in sheep.

From India, Singh and Pande (1967b) and Pande *et al.* (1967) studied the endogenous stages in the large intestine of a goat and found both the micro and macrogametocytes measuring 23.8–30.6 μ by 17–21.1 μ and 23.8–27.2 μ by 17–20.4 μ respectively. The former is provided with many comma-shaped microgametes. They however, noted mixed infections.

***Eimeria ahsata* Honess**

(Fig. 7B)

1942. *Eimeria ahsata* Honess, *Univ. Wyoming. Agric. Expt. Sta.*, **249**: 3; Patnaik, 1963, *Orissa Vet. J.*, **1**: 25; Singh, 1963, *Punjab Vet.*, **3**: 1; Pande, Bhatia, Dubey and Srivastava, 1964, *Indian J. Microbiol.*, **4**: 67; Jha and Subramanian, 1965, *Indian J. Anim. Hlth.*, **4**: 1; 1966, *Indian Vet. J.*, **43**: 588; Bhatia and Pande, 1970, *Orissa Vet. J.*, **5**: 123; Levine and Ivens, 1970, *Ill. Biol. Monogr.*, **44**: 129; Misra and Mohapatra, 1972, *Orissa Vet. J.*, **7**: 9; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 772.

Description.—The oocysts are ellipsoidal to ovoid in shape, measuring 37 μ –43 μ by 28 μ –29 μ in size with a mean 39 μ by 42 μ . The oocystic wall is thick measuring 1.3 μ with a light yellowish-green outer and a yellowish brown inner layers. More than one polar granules present. Oocystic residuum absent. Micropylar cap present measuring 5 μ –10 μ by 1–3 μ with a mean 8 μ by 2 μ in size. Sporocyst elongate-ovoid measuring 16 μ –21 μ by 7 μ –10 μ with a mean 19 μ by 9 μ . Stieda body absent. Sporocystic residuum present as scattered granules along the side of the sporozoites. Sporozoites banana-shaped measuring 16 μ by 4.3 μ , with one end broad and the other tapering carrying two refractile globules with the nucleus at the middle. Sporulation completed in 2 days.

Dimension of the oocysts reported by other authors are as follows:

36–44 by 22–99 μ with a mean 40 by 26 μ (Levine *et al.*, 1962); 29–37 by 17–28 μ with a mean 33 by 23 μ (Honess, 1942); 23–48 by 20–28 μ with a mean 36 by 24 μ (Kamalapur, 1961); 31–39 by 22–28 μ (Donciu, 1961); 34–37 by 22–29 μ with a mean 29.4 by 25.6 μ (Jackson, 1964); 30–39 by 18–30 μ (Chevalier, 1965); 30–34 by 18–24 μ (Vassiliades, 1965).

Type host.—Rocky mountain bighorn sheep, *Ovis canadensis*.

Other hosts.—Domestic sheep (Lamb), *Ovis* sp., and domestic goat, *Capra hircus* (= *Capra* sp.).

Distribution.—Mathura, U.P.; Bihar, Orissa and West Bengal.

Remarks.—Levine & Ivens (1970) commented that the occurrence of this species in goat may possibly have been of *E. christenseni*.

Location.—Small Intestine.

Endogenous stages.—While studying the endogenous cycle, Davis, Bowman and Smith (1963) obtained globidial schizont of 265 by 162 μ in size with thick wall of 9 μ after 15 days from the date of infection. The schizonts mainly occurred in the central portion of the mucosa of the small intestine, also in jejunum, some were in the lacteals of the villi and a very few in the muscularis mucosa. Microgametocyte measured 36.5 by 23 μ and the macrogamet being 25–46 μ in diameter.

Usually the sexual stages develop in the epithelial cells of the crypt. Davis and Bowman (1970) did some experiment with lamb infected with one million sporulated oocyst. They noted the parasites measuring 1.6–5 μ in size, in the tiny cavity of the nucleus (intra nuclear) which can be compared with *E. alabamensis* of cow. Further

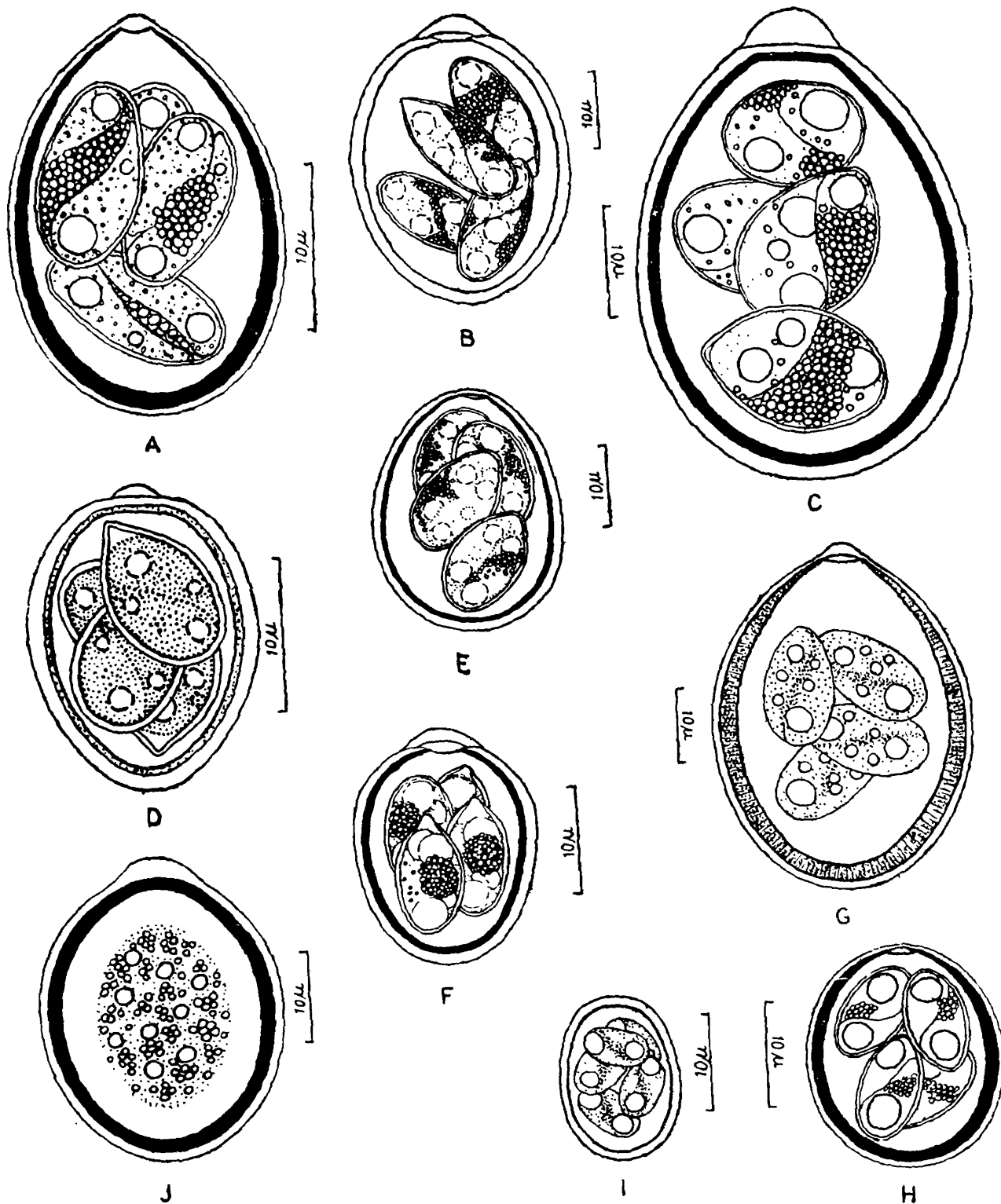


Fig. 7. (A-I). Diagrams of Sporulated oocysts of:

- A) *E. arlongi*; B) *E. ashata*; C) *E. christenseni*; D) *E. crandalis*; E) *E. faurei*;
 F) *E. granulosa*; G) *E. intricata*; H) *E. ninakohlyakimovi*; I) *E. parva*;
 J) Diagram of unsporulated oocyst of *E. tirupatiensis*.

they noticed two schizogonic processes inside the cytoplasm of epithelial cells after 15-20 days, from the date of infection which resemble to some extent with *E. bovis*. However, the largest schizont measured 52 by 39 μ .

The prepatent period was 19 days and 18-20 days observed by Smith and Davis (1965) and Smith, Davis and Bowman (1960) respectively.

Eimeria christenseni Levine, Ivens and Fritz.

(Fig. 7C)

1962. *Eimeria christenseni* Levine, Ivens and Fritz., *J. Paras.*, **48**: 225; Shah and Joshi, 1963, *J. Vet. An. Husb. Res.*, **7**: 9; Shah, 1965, *Curr. Sci.*, **34**: 564; Jha and Subramanian, 1965, *Indian J. Anim. Hlth.*, **4**: 1; *Indian Vet. J.*, **43**: 588; Pande, Bhatia, Chauhan and Kala, 1967, *Indian J. Vet. Sci.*, **37**: 58; Bhatia and Pandey, 1968, *Indian J. Microbiol.*, **8**: 183; Bhatia and Pande, 1970, *Orissa Vet. J.*, **5**: 123; Levicne and Ivens, 1970, *Ill. Biol. Monogr.*, **44**: 104; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 777.

Description.—The oocysts are ovoid, rarely ellipsoidal, and slightly flattened at the micropylar end. Sporulated oocyst measures $32\ \mu$ – $43\ \mu$ by $24\ \mu$ – $30\ \mu$ with a mean $39\ \mu$ by $26\ \mu$. Oocyst wall composed of two layers, the outer smooth, pale-yellowish about $1.0\ \mu$ thick, and the inner one brownish yellow of $0.4\ \mu$ thick; the intact oocyst often to have a colourless outermost layer of $0.3\ \mu$ thick, but no evidence of such a layer could be seen in crushed oocysts and its appearance was probably an optical illusion. Micropyle present at the narrower end of the oocyst. Micropylar cap prominent, colourless round-shaped; the micropylar cap of sporulated oocyst ranges from $2\ \mu$ – $4\ \mu$ by $5\ \mu$ – $10\ \mu$ with a mean $3\ \mu$ by $7\ \mu$. One or more oocystic polar granules present but devoid of any oocystic residuum. Sporocyst broadly ovoid with no stieda body. It measures $14\ \mu$ – $18\ \mu$ by $8\ \mu$ – $11\ \mu$ with a mean $15\ \mu$ by $10\ \mu$. Sporocystic residuum present. Sporozoites lie head to tail within the sporocyst. One large and one or two small clear globules usually present in each sporozoite.

Sporulation time.—Not known.

Type host.—Domestic goat, *Capra hircus* (= *Capra* sp.).

Distribution.—Izatnagar, U.P.; Madhya Pradesh.

Prevalence.—Shah and Joshi (1963) examined 300 goats in Madhya Pradesh of which 5% showed infection. Jha and Subramanian (1966) detected 1% infection out of 243 goats examined in Uttar Pradesh while Chevalier (1966) found the same in 9% out of 40 goats in Germany.

Location.—Small intestine, caecum and colon.

Endogenous stages.—Unknown.

Eimeria crandallis Honess

(Fig. 7D)

1942. *Eimeria crandallis* Honess, *Univ. Wyoming Agric. Expt. Sta.*, **249**: 3; Ray, 1961, *Anim. Hlth.*, **2**: 1; Patnaik, 1963, *Orissa Vet. J.*, **1**: 25; Shah and Joshi, 1963, *J. Vet. An. Husb. Res.*, **7**: 9; Singh, 1963, *Panjab Vet.*, **3**: 1; 1964, *Agra Univ. J. Res. (Sci.)*, **13**: 233; Pande, Bhatia, Dubey and Srivastava, 1964, *Indian J. Microbiol.*, **4**: 67; Jha and Subramanian, 1965, *Indian J. Anim. Hlth.*, **4**: 1; 1966, *Indian Vet. J.*, **43**: 588; Singh and Pande 1967b, *Ann. Parasit. Hum. Comp.*, **42**: 141; Pande, Bhatia, Chauhan and Kala, 1967, *Indian J. Vet. Sci.*, **37**: 58; Bhatia and Pande, 1970, *Orissa Vet. J.*, **5**: 123; Levine and Ivens, 1970, *Ill. Biol. Monogr.*, **44**: 132; Bali, 1972, *J. Res. Punjab Agric. Univ.*, **9**: 206; Bhatia, Chauhan, Arora and Agrawal, 1973, *Indian J. Anim. Sci.*, **43**: 944; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 778.

Description.—The oocysts are more or less spherical to oval or ellipsoidal each measuring $17\ \mu$ – $23.3\ \mu$ in length and $17\ \mu$ – $22.1\ \mu$ in width with a mean $20\ \mu$ – $4\ \mu$ by $18.4\ \mu$. The shape index ranged from 0.74–0.93. Its colour is light yellow with a greenish tinge sometimes it appears as very faint or colourless. The sporont measures $13.6\ \mu$ – $15.3\ \mu$ in diameter. Micropyle present and the very small polar cap measuring $2.6\ \mu$ in width and $0.8\ \mu$ in height is found. The oocystic residuum absent. The sporocysts are ovoid, each measuring $8.5\ \mu$ – $13.6\ \mu$ in length and $3.6\ \mu$ –

8.65 μ in width with a mean 10 μ by 7 μ having no stieda body. Sporocystic residuum usually present. The sporozoite is provided with one or two clear globules.

Sporulation time.—24–72 hours.

Dimension of oocyst recorded by others author are as follows:

Oocysts from *Capra hircus* measured 20–27 by 17–20 μ (average 23 by 19 μ) as stated by Levine, Ivens and Fritz (1962) and Kamalapur (1961). From Indian goats it measured 18–28 μ by 15–20 μ mean 22 μ by 18 μ and 19–27 μ by 14–20 μ (average 22 μ by 18 μ) according to Shah and Joshi (1963) and Singh (1964) respectively. The average dimention of oocysts from goat is 23.4 by 18.3 μ as stated by Chevalier (1966).

Type host.—Rocky Mountain bighorn Sheep, *Ovis canadensis*.

Other hosts.—(i) Domestic goat, *Capra hircus* (= *Capra* sp.), (ii) Domestic sheep, *Ovis aries* (= *Ovis* sp.), (iii) Siberian Ibex, (iv) *Capra ibex siberica*, (v) Argali, *Ovis ammon*, (vi) Moufin, *Ovis musimon*.

Distribution.—Izatnagar, U.P.; Bihar, West Bengal, Bombay, Madhya Pradesh, Orissa, Kashmir and Madras.

Prevalence.—*E. crandallis* is reported from 24% of sheep from Illinois as noted by Shah (1963); from England, Joyner *et al.* (1966) reported this species from 90% of sheep. Patyk (1965) got this species in 1% of sheep from Poland. From Turkey, Sayin (1966) got infection in 11% of goats. Wiesenhutter (1965) got 25% sheep and 22% goats infected with this species from Syria. From India, Shah and Joshi (1963) got 10% infection in goats of Madhya Pradesh, Singh (1964) found 20% and Jha and Subramanian (1966) obtained 13% of goats infected with this species while examining them from Uttar Pradesh.

Endogenous stages.—Unknown. However de Vos and Hammond (1971) found that the sporozoite could develop in Madin-Darbey bovine Kidney, embryonic lamb thyroid, lamb trachea and bovine liver cell cultures. A few refractile bodies appeared after the penetration of sporozoite around which the parasitophorous vacuole was formed. On further development along with the nuclear division the schizont appeared measuring about 150 μ in diameter with numerous merozoites inside.

***Eimeria faurei* (Moussu and Marotel)**

(Fig. 7E)

1901. *Coccidium* sp. Moussu and Marotel, *Compt. Rend. Soc. Biol. Paris*, : 1087.
1902. *Coccidium faurei* Moussu and Marotel, *Arch. Paras*, **6**: 82.
1909. *Eimeria faurei* Martin, *Rev. Vet. Toulouse*, **34**: 201, 273, 413; Ray, 1949, *Indian Fmg.*, **10**: 487; Rao and Hiregaudar, 1954, *Bombay Vet. Coll. Mag.*, **4**: 29; Ray, 1961 *Anim. Hlth.*, **2**: 1; Patnaik, 1963, *Orissa Vet. J.*, **1**: 25; Shah and Joshi, 1963, *J. Vet. Anim. Hus. Res.*, **7**: 9; Singh, 1963, *Punjab Vet.*, **3**: 1; 1964, *Agra Univ. J. Res. (Sci.)*, **13**: 233; Jha and Subramanian, 1965, *Indian J. Anim. Hlth.*, **4**: 1; 1966, *Indian Vet. J.*, **43**: 588; Jha, 1966, *Indian J. Anim. Helth.*, **5**: 33; Kudo, 1966, *Protozoology*, p. 687; Bhatia and Pande, 1970, *Orissa Vet. J.*, **5**: 123; Levine and Ivens, 1970, *Ill. Biol. Monogr.*, **44**: 106; Bhatia, Ahluwalia and Chauhan, 1972, *Curr. Sci.*, **41**: 193; Misra and Mahapatra, 1972, *Orissa Vet. J.*, **7**: 9; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 779; Krishnamurthy and Kshirsagar, 1976, *Nat. Sci. J. Marathwada Univ.*, **15** (Sci. 8): 153.
1921. ?*Coccidium caprae* Jaeger, *Beitrage zur Anreicherung der Parasiteneier im Kot der Haustiere*. Diss., Munchen,
1921. *Coccidium ovis* Jaeger, *Beilage zur Anreicherung der Parasiteneier im Kot der Haustiere*. Diss., Munchen.

Description.—The oocyst is hen egg-shaped with a brownish yellow colour which, in some, showed a greenish tinge, measured 23.8 μ –34.09 μ in length with a mean

29.53 μ and 18.8 μ –23.8 μ in breadth with a mean 22.36 μ . The prominent micropyle is found at the narrower end, measured 3.11 μ –5.1 μ in width and had no cap over it. The sporont measured 16.2 μ –20.4 μ in maximum diameter. Oocystic residuum absent, polar granules present. The ellipsoidal sporocysts, with narrow ends, measured 15 μ –17 μ by 8 μ –10 μ in size. The granular sporocystic residual body lay scattered along the sporozoites without any stieda body. Sporozoites elongated lie head to tail with one or two large globules.

Sporulation time.—24–48 hours.

Dimension of the oocysts reported by other authors are as follows:

25–36 by 19–28 μ mean 29 by 21 μ (Christensen, 1938a); 27–35 by 20–23 μ mean 31.5 by 22 μ (Balozet, 1932); 27–30 by 18–28 μ mean 28 by 23 μ (Kamalapur, 1961); 27–33 by 19–25 μ mean 29 by 22 μ (Shah and Joshi, 1963); 28–37 by 21–27 μ mean 32 by 23 (Chevalier, 1965); 28–35 by 19–25 μ mean 31.1 by 22.2 μ (Restani, 1966); 18–42 by 18–30 μ (Moussu and Marotel, 1902). 36–40 by 18–27 μ (Pellardy, 1974).

Type host.—Domestic sheep, *Ovis aries* (= *Ovis* sp.).

Other host.—From the type host: (i) Domestic goat, *Capra hircus* (= *Capra* sp.); (ii) Rocky Mountain big horn Sheep, *Ovis canadensis*; (iii) Moufflon, *Ovis ammon*; (iv) Urial or shape, *Ovis orientalis*; (v) Barbary sheep, *Ammotragus lervia*; (vi) Ibex, *Capra ibex* and (vii) Chamois, *Rapicapra rapicapra*.

Distribution.—Haryana, Punjab, Bombay, Madhya Pradesh, Uttar Pradesh, Orissa and West Bengal.

Prevalence.—Christensen (1938a) found infection in 11% of sheep from Idaho, Maryland, New York and Wyoming. From Tunisia, Balozet (1932) reported infection in 21% sheep and 2% of goats. Jacob (1943) obtained infection in 40% of sheep and 18% of goats from Germany; Svanbev (1957b) reported in 43% of Sheep and 40% of goats from Kazakhstan.

Location.—Small intestine.

Endogenous stages.—Prepatent period is 9–10 days. Endogenous cycle is still wanting. Lotze (1953) studied only giant schizont measuring 100 μ in diameter with numerous merozoites. From India, Singh and Pande (1967a, b) encountered giant schizont in the large intestine of a goat and considered it to be due to the infection of *E. faurei*. However, they were dealing with mixed infection.

***Eimeria granulosa* Christensen**

(Fig. 7F)

1938a. *Eimeria granulosa* Christensen, *J. Paras.*, **24**: 453; Shah and Joshi, 1963, *J. Vet. An. Husb. Res.*, **7**: 9; Jha and Subramanian, 1965, *Indian J. Anim. Hlth.*, **4**: 1; 1966, *Indian Vet. J.*, **43**: 588; Levine and Ivens, 1970, *Ill. Biol. Monogr.*, **44**: 119; Misra and Mohapatra, 1972, *Orissa Vet. J.*, **7**: 9; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 782; Krishnamurthy and Kshirsagar, 1976, *Nat. Sci. J. Marathwada Univ.*, **15** (Sci. 8): 153.

Description.—The oocysts are pyriform, egg or urn-shaped, each measuring 22 μ –25 μ by 17 μ –25 μ with an average 29.4 μ by 20.9 μ in size. The mature oocyst is darker, brownish-yellow or yellowish-brown colour. It is provided with a clearly visible micropyle of 3 μ –5 μ in diameter, and a polar cap measuring 5 μ with the height of 1 μ –2.5 μ . Oocystic residuum or polar granule absent. The spherical sporont measures 14 μ –23 μ with a mean 16.5 μ in diameter. Sporocysts ovoid or elongate ovoid, rounded at both ends, Stieda body faintly perceptible. It measures 13 μ –16 μ by 8 μ –9 μ with a mean 15 μ by 8 μ . Sporocystic residuum

present as loosely scattered granules. Sporozoites elongated with one end narrow than the other lying length-wise, head to tail in position with 1-3 clear globules.

Sporulation time.—3 or 4 days.

Dimension of the oocyst reported by other authors are as follows:

22-35 by 17-25 μ with a mean 29.4 by 20.9 μ , (Christensen, 1938a); 30-35 by 21-22 μ with a mean 31 by 22 μ (Shah, 1963) and 28-37 by 21-26 μ with a mean 32.5 by 24.0 μ (Jackson, 1964).

Type host.—Domestic sheep, *Ovis aries* (= *Ovis* sp.).

Other host.—(i) Rocky Mountain bighorn Sheep, *Ovis canadensis*, (ii) Domestic sheep, *Ovis* sp. and (iii) Domestic goat, *Capra* sp.

Distribution.—Haryana, Orissa, Madhya Pradesh and Uttar Pradesh.

Prevalence.—Christensen (1938a) found infection in 10% of sheep from Maryland and New York, Jacob (1943) got it in 1% of sheep from Germany.

Location.—Unknown.

Endogenous stages.—Unknown.

***Eimeria intricata* Spiegel**

(Fig. 7G)

1910. *Eimeria* (*Globidium*) *gilruthi* Chatton, *Bull. Soc. Zool. France*, **35**: 197; Reichenow and Carini, 1937, *Arch. Protistenk.*, **88**: 374.
1912. *Globidium faurei* in Henry and Masson, (*vide* Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 784.
1925. *Eimeria intricata* Spiegel, *Ztscher. Infkrankh.*, **28**: 42; Wenyon, 1926, *Protozoology*, 2 Vols., p. 843; Ray, 1949, *Indian Fmg.*, **10**: 487; Rao and Hiregaudar, 1954, *Bombay Vet. Coll. Mag.*, **4**: 29; Ray, 1961, *Anim. Helth.*, **2**: 1; Patnaik, 1963, *Orissa Vet. J.*, **1**: 25; Singh, 1963, *Punjab Vet.*, **3**: 1; Shah and Joshi, 1963, *J. Vet. Anim. Husb. Res.*, **7**: 8; Singh, 1963, *Punjab Vet.*, **3**: 1; 1964, *Agra Univ. J. Res. (Sci.)*, **13**: 233; Pande, Bhatia and Chauhan, 1966, *Indian J. Microbiol.*, **6**: 35; Jha, 1966, *Indian J. Anim. Helth.*, **5**: 33; Kudo, 1966, *Protozoology*, p. 867; Jha and Subramanian, 1965, *Indian J. Anim. Helth.*, **4**: 1; 1966, *Indian Vet.*, **43**: 588; Bhatia and Pande, 1970, *Orissa Vet. J.*, **5**: 123; Levine and Ivens, 1970, *Ill. Biol. Monogr.*, **44**: 109; Bali, 1972, *J. Res. Punjab Agric. Univ.*, **9**: 206; Bhatia, Ahluwalia and Chauhan, 1972, *Curr. Sci.*, **41**: 118; Misra and Mohapatra, 1972, *Orissa Vet. J.*, **7**: 9; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 784; Krishnamurthy and Kshirsagar, 1976, *Nat. Sci. J. Marathwada Univ.*, **15** (Sci. 8): 153.
1949. *Globidium* *Marotelia faurei* in Marotel, (*vide* Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 784).

Description.—The oocyst measures 37.4 μ –51.0 μ in length and 28.9 μ –37.4 μ in breadth with a mean 45.5 μ by 32.7 μ . The shape was ellipsoidal to ovoid and the shape index varies from 0.65–0.83. The excystic wall of the oocyst is very thick. The large micropyle, 3.4 μ –8.5 μ in size, appears as a wide gap below the crescent shaped polar cap which is colourless and 8.5 μ –13.6 μ wide and 2.6 μ –5.4 μ in height. The sporont measures in its maximum diameter, 20.0 μ –25.8 μ and is not easily visible on account of the darker nature of the excystic wall. The sporocyst is pyramidal in shape with pointed ends. At one of the ends, a colourless stieda body is present. The sporocyst measures 17 μ –20.4 μ by 10.2 μ –11.9 μ in size. A large sporocystic residuum present. Sporozoite is elongated, with one end narrower than the other, lying head to tail in position and is provided with 2-3 clear globules.

Sporulation time.—4-6 days at room temperature.

Dimension of the oocysts reported by other authors are as follows:

39-54 by 27-36 μ with a mean 47 by 32 μ (Christensen, 1938a); 46 by 33 μ (Spiegel, 1925); 47-59 by 34-47 μ with a mean 51 by 39 μ (Shah, 1963); 46-54 by 31-39 μ with a mean 50 by 35.5 μ (Restani, 1966).

Type host.—Domestic sheep, *Ovis aries* (= *Ovis* sp.).

Other host.—From the type host and (i) Rocky Mountain bighorn Sheep, *Ovis canadensis*, (ii) Moufflon, *O. musimon*, (iii) Argali, *O. ammon*, (iv) Domestic goat, *Capra hircus* (= *Capra* sp.); (v) Roe, *Capreolus capreolus* and (vi) Dama, *Dama dama*.

Distribution.—Punjab, Uttar Pradesh, West Bengal, Orissa, Madhya Pradesh and Maharashtra.

Prevalence.—Commonly found. Christensen (1938a) got infection in 14% of sheep from Maryland, New York and Wyoming; Jacob (1943) found it in 13% of sheep from Germany, Balozet (1932) got it in 3% of sheep in Tunisia and Svanbaev (1957) obtained in 4% of sheep from Kazakhstan.

Location.—Uncertain, likely to be in the abomasum and small intestine.

Endogenous stages.—Very little is known about the gametogonic stages. However, Davis and Bowman (1965) encountered the largest schizont measuring 65 μ by 45 μ in the epithelial cells lining the crypts of the small intestine and provided with large merozoite of 19.5 μ by 4 μ in size. Both gametocytes and oocysts were found in the intestinal crypts lining cells and in the caecum.

Lotz and Leek (1970) thought that there were two schizogonic processes. In one experiment they detected mature schizonts containing an eosinophilic body after 9 days from the date of infection and larger schizonts without any eosinophilic body by 11–17 days. Merozoites measuring 19.5 μ by 3.9 μ in size also gave a coarsely granular appearance. They further commented that sometimes the development did not progress beyond schizogony.

Michael and Probert (1970) traced the elongated microgametocytes, each measuring 52 by 34 μ in size. The macrogamete measured 32 by 29 μ . They reported the gametogonic stages in the crypts of Lieberkuhn of the small intestine of sheep.

Pande, Bhatia and Chauhan (1966) reported four mature schizonts measuring 32–37 by 21–25 μ with a mean 34.4 by 22.7 μ which contained 25–40 spindle shaped merozoites of 7–9 by 2 μ in size in the epithelial cells of the crypts. The microgametocytes measured 61–250 μ by 36–71 μ with a mean 113 by 52 μ and each microgamete measured 4.6–6 μ . The macrogamete measured 36–54 by 25–36 μ with a mean 42 by 30 μ in size. The gametocytes were found in the jejunum and ileum.

Prepatent period was 20–27 days, 23 days and 22–23 days according to Davis and Bowman (1965), Krylov, (1961) and Svanbaev (1967a) respectively.

***Eimeria ninakholyakimovi* Yakimoff and Rastegaieff**

(Fig. 7H)

1930. *Eimeria ninkholyakimovi* Yakimoff and Rastegaieff, *Arch. Protistenk*, **70**: 185; Ray, 1949, *India fmg.*, **10**: 487; Rao and Hiregaudar, 1954, *Bombay Vet. Coll. Mag.*, **4**: 29; Ray, 1961, *Anim. Helth.*, **2**: 1; Patnaik, 1963, *Orissa Vet. J.*, **1**: 25; Shah and Joshi, 1963, *J. Vet. Anim. Husb. Res.*, **7**: 9; Singh, 1963, *Punjab Vet.*, **3**: 1; 1964, *Agra Univ. J. Res. (Sci.)*, **13**: 233; Jha, 1966, *Indian J. Anim. Helth.*, **5**: 33; Jha and Subramanian, 1965, *Indian J. Anim. Helth.*, **4**: 1, 1966, *Indian Vet. J.*, **43**: 588; Singh and Pande, 1967, *Ann. Parasit., Hum. Comp.*, **42**: 291; Bhatia and Pande, 1970, *Orissa Vet. J.*, **5**: 123; Levine and Ivens, 1970, *Ill. Biol. Monogr.*, **44**: 99; Bali, 1972, *J. Res. Punjab Agric. Univ.*, **9**: 206; Misra and Mohapatra, 1972, *Orissa Vet. J.*, **7**: 9; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 786; Krishnamurthy and Kshirsagar, 1976, *Nat. Sci. J. Marathwada Univ.*, **15** (Sci. 8): 153.

Description.—Ovoid to sub-spherical oocyst measuring 20.4 μ –26.8 μ in length with a mean 22.2 μ and 17.0 μ –20.4 μ in width with a mean 18.08 μ . The shape-index ranges from 0.83–0.91 (mean 0.84). The very thin oocystic wall appears

from light to pale yellowish brown or even dark in colour. The micropyle was imperceptible and the sporont measures $13.6\text{ }\mu$ – $14.1\text{ }\mu$ in maximum diameter. Oocystic residuum absent. Sporocyst elongate-ovoid measuring $9\text{ }\mu$ – $14\text{ }\mu$ by $4\text{ }\mu$ – $10\text{ }\mu$ with prominent stieda body. Sporocystic residuum present as a lump. Sporozoites elongated, lying length-wise head to tail within the sporocyst, with one or two clear globules.

Dimension of the oocysts reported by other authors are as follows:

Oocysts described as oval measuring 20 – 22 by 14 – $16\text{ }\mu$ mean 20.7 by $14.8\text{ }\mu$ or egg-shaped, measuring 19 – 25 by 14 – $21\text{ }\mu$ mean 23 by $16.1\text{ }\mu$ originally described from goat; 16 – 27 by 13 – $21\text{ }\mu$ mean 19.8 by $16.5\text{ }\mu$ (Balozet, 1932) 23 – 28 by 18 – $23\text{ }\mu$ mean 25 by $21\text{ }\mu$ (Shah and Joshi, 1963); 21 – 28 by 18 – $24\text{ }\mu$ mean 24.1 by $21.1\text{ }\mu$ (Sayin, 1964); 20 – 27 by 15 – $21\text{ }\mu$ mean 23.6 by $18.2\text{ }\mu$ (Chevalier, 1965); from goat and sheep 20 – 28 by 15 – $22\text{ }\mu$ mean 23.1 by $18.3\text{ }\mu$ (Christensen, 1938a); 27 – 30 by 22 – $27\text{ }\mu$ mean 28.7 by $24.5\text{ }\mu$ (Prasad, 1960); 23.1 by $17.9\text{ }\mu$ (Chevalier, 1965); 17 – 25 by 15 – $21\text{ }\mu$ mean 22.2 by $17.6\text{ }\mu$ (Restani, 1966); from moufflon 22 – 29 by 19 – $22\text{ }\mu$ mean 25.2 by $19.5\text{ }\mu$ (Yakinoff, Gousseff and Rastegaieff, 1933); 19 – 28 by 14 – $23\text{ }\mu$ and 16 – 30 by 13 – $22\text{ }\mu$ mean 23 by $18\text{ }\mu$ from sheep and goats respectively (Levine and Ivens, 1970).

Type host.—Domestic goat, *Capra hircus* (= *Capra* sp.).

Other host.—From the type host and domestic sheep, *Ovis* sp. (i) Wild goat, *Capra aegagrus*, (ii) Siberian wild goat, *C. siberica*, (iii) Alpine ibex, *C. ibex*, (iv) Big horn sheep, *O. canadensis* and some hosts other than *Ovis* and *Capra* which Levine and Ivens (1970) expressed a doubt.

Distribution.—Punjab, Haryana, Maharashtra, Madhya Pradesh, Uttar Pradesh, Orissa & West Bengal

Location.—Small intestine specially the posterior part as well as caecum and colon.

Prevalence.—Christensen (1938) found infection in 3% of sheep from Maryland, Idaho. Jacob (1943) got infection in 5% of sheep from Germany. Balozet (1932) reported it in 35% of sheep and 34% of goats from Tunisia. Svanbaev (1957b) obtained infection in 52% of sheep and 31% of goats from Kazakhstan.

Endogenous stages: Balozet (1932) studied the endogenous cycle of this parasite in a kid and detected the schizont measuring 15 – $35\text{ }\mu$ in diameter with 40 – 200 merozoites. Microgametocyte measuring 45 – $50\text{ }\mu$ in diameter with 3 – $4\text{ }\mu$ long biflagellated microgametes was observed by the same author. Lotze (1954) studied giant schizont in lamb about $300\text{ }\mu$ in diameter with several thousand merozoites. The macrogametocytes and microgametocytes were in the ileum, caecum, and upper part of the large intestine. Sayin (1964) observed one type of schizont in Angora goat measuring 31 – 43 by 22 – $31\text{ }\mu$ with a mean $37\text{ }\mu$ by $26.5\text{ }\mu$ and located in the ileum and caecum, where the gametocytes were also established. The mature microgametocytes measured 20 – 25 by 15 – $18\text{ }\mu$ with a mean 22.6 by $16.5\text{ }\mu$ within which the microgametes formed a whorl around the central residuum.

Wacha and Hammond (1970) described two schizogonic stages. The giant schizonts or the globidia measured $290\text{ }\mu$ in diameter, with several thousand merozoites, measuring 11.9 by $2.1\text{ }\mu$ in size. The second schizonts measuring $12\text{ }\mu$ in diameter was provided with 24 merozoites, each measured 5.5 by $1.4\text{ }\mu$.

Singh and Pande (1967b) studied the endogenous cycle of the parasite in the small intestine of sheep. But they were dealing with mixed infection.

The prepatent period was 9 – 15 days on the basis of cross infection experiment on goats (Balozet 1932) and on lambs (Shumard, 1957, Krylov, 1961, Svanbaev, 1967, Hammond, Kuta and Miner, 1967). Wacha and Hammond (1970) noted the same as 11 days.

***Eimeria parva* Kotland Mocsy and Vajda**

(Fig. 7I)

1929. *Eimeria parva* Kotland, Mocsy and Vajda, *Allatorvosi Lapok.*, **52**: 304; Rao and Hiregaudar, 1954 *Bombay Vet. Coll. Mag.*, **4**: 29; Ray, 1961, *Anim. Helth.*, **2**: 1; Patnaik, 1963, *Orissa Vet. J.*, **1**: 25; Singh, 1963, *Punjab Vet.*, **3**: 1; Shah and Joshi, 1963, *J. Vet. Res. Moscow*, **7**: 9; Jha, 1966, *Indian J. Anim. Helth.*, **5**: 33; Jha and Subramanian, 1965, *Indian J. Anim. Helth.*, **4**: 1; 1966, *Indian Vet. J.*, **43**: 588; Singh and Pande, 1967b, *Ann. Parasit. Hum. Comp.*, **42**: 291; Bhatia and Pande, 1970, *Orissa Vet. J.*, **5**: 123; Levine and Ivens, 1970, *Ill. Biol. Monogr.*, **44**: 112; Bali, 1972, *J. Res. Punjab Agric. Univ.*, **9**: 206; Misra and Mohapatra, 1972, *Orissa Vet. J.*, **7**: 9; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 790; Krishnamurthy and Kshirsagar, 1976, *Nat. Sci. J. Marathwada Univ.*, **15** (Sci. 8): 153.
1930. *Eimeria galouzi* Yakimoff and Rastegaieff, *Arch. Protistenk.*, **70**: 185.
1933. *Eimeria nana* Yakimoff, *Ann. Soc. Belge. Med. Trop.*, **13**: 93.
1933. *Eimeria pallida* Christensen, *Proc. Helminth. Soc. Wash.*, **5**: 24; Jha and Subramanian, 1965, *India J. Agric. Anim. Helth.*, **4**: 1; 1966, *Indian Vet. J.*, **43**: 588.

Description.—The oocyst measured 13.6 μ –18.7 μ in length and 11.9 μ –15.3 μ in breadth with a mean 16.2 μ by 13.4 μ . The shape index ranged from 0.72–0.95 with a mean 0.18. The oocyst were ellipsoidal, ovoidal or subspherical in shape. The oocystic wall, presenting a distinct double contour on account of the two dark refracted lines, measured 0.8 μ in thickness, the colour of the wall varying from a faint yellow to a dark brown or even orange. Micropyle and polar cap absent. The finely granular sporont measured 10.2 μ (mean) at its maximum diameter. The ellipsoidal sporocyst, with one end rounded and the other pointed with a definite stieda body, measured 10.2 μ by 5.0 μ in size, with large amount of sporocystic residual body.

Sporulation time.—1–3 days.

Dimension of the oocysts recorded by other authors are as follows:

12–23 by 10–19 μ (Christensen, 1938a); 11–14 by 9–12 μ (Kotland; Mocsy and Vajda, 1929); 17 by 13.5 μ (Balozet, 1932a), 18 by 15 μ , (Kamalapur, 1961); 15 by 14.5 μ (Svanbaev, 1957b); 16–23 by 14–22 μ Shah and Joshi (1963); 14–15 μ (Singh, 1964); 17 by 14.5 μ , (Chevalier, 1965).

Type host.—Domestic sheep, *Ovis aries* (= *Oirs* sp.).

Other hosts.—From the type hosts and (i) Domestic goat, *Capra hircus* (= *Capra* sp.), (ii) Muflon *Ovis musimon*, (iii) Argali, *O. ammon*, (iv) Big horn Sheep, *O. canadensis*, (v) Asian wild goat, *Capra siberica* and (vi) Alpine *ibex*, *C. ibex*. Levine and Ivens (1970) expressed a doubt about the occurrence of this species in both sheep and goats.

Distribution.—Haryana, Punjab, Madhya Pradesh, Uttar Pradesh, Orissa, Maharashtra, Bihar.

Location.—Small intestine also in caecum and colon.

Prevalence.—Christensen (1938a) obtained this species in 50% of sheep from Idaho, Maryland and Wyoming. Jacob (1943) got it in 52% sheep and 9% goats from Germany. Balozet (1932) reported it from 21% of sheep and 22% of goats in Tunisia. Svanbaev (1967b) reported this species in 9% of sheep while examining them from Kazakhstan.

Endogenous stages.—Kotlan, Pellardy and Verseny (1951 a,b) studied two types of schizonts in sheep. The giant schizonts or the globidia were whitish measured 185–256 by 128–179 μ in size. They were visible to the naked eye and laid down in the mucosa or far down upto the muscularis mucosae. Each schizont was provided with thousands of merozoites measuring 10–12 μ in length. The other one is

smaller 10–12 μ in diameter with 10–20 merozoites located in the superficial epithelial cells. However, the experiment revealed a mixed strain in which *E. intricata* and *E. ovina* were shared with *E. parva*.

Sayin (1966) encountered the giant schizont measuring 260 μ by 180 μ as whitish bodies, visible in naked eye in the epithelial cells at the middle of the small intestine. The smaller schizont measuring 15–18 by 9–12 μ was also found in the epithelial cells of the crypts of Lieberkuehn.

The microgametocytes measuring 22–25 by 15–20 μ were found in the epithelial cells of mucosa along with the oocysts. The macrogametes were also found measuring 14–14 μ in size.

In India, Singh and Pande (1967a) studied the endogeneous cycle of the parasite in a mixed infection in the large intestine of sheep.

The prepatent period was 15 days, 11–13 days and 10–13 days according to Krylov (1961), Svanbaev (1967) and Sayin (1966) respectively.

***Eimeria tirupatiensis* Sivanarayan and Venkataratnam**

(Fig. 7J)

1969. *Eimeria tirupatiensis* Sivanarayan and Venkataratnam, *Indian Vet. J.* **46**: 477; Levine and Ivens, 1970, *Ill. Bibl. Monogr.*, **44**: 270; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 793.

Description.—The oocysts are usually elongated ovoid, less often ellipsoid and 37 μ –44 μ by 25 μ –31 μ (mean 40.1 μ by 28.5 μ) in size. The oocyst wall is bilayered, with one smooth pinked outer layer about 1 μ thick and a brownish inner layer about 0.9 μ . The round-shaped micropylar cap is 1.5 μ –4 μ in height and 8.5 μ –11 μ in wide (mean 2.2 μ by 9.4 μ). Each oocyst is provided with 1–3 polar granules, but without any residuum. The ellipsoid or ovoid sporocysts have a stieda body in each and measuring 11 μ –15 μ (mean 14.1 μ by 9.6 μ). A granular sporocystic residuum is interspersed among the sporozoites; and measured 11 μ –16 μ by 4.5 μ –7 μ (mean 13.7 μ by 5 μ) with two to three refractile globules.

Sporulation time.—4 days.

Type host.—Domestic goat, *Capra hircus* (= *Capra* sp.).

Other hosts.—Not known.

Distribution.—Tirupati, Andhra Pradesh; from the type locality.

Locality.—Not known.

Remark.—Levine and Ivens (1970) in their monograph on the coccidian parasites (Protozoa, Sporozoa) of Ruminants p. 270 stated that this species resembles to some extent with *E. christenseni* and *E. ahsata* but the present one is unique due to the presence of a stieda body in the sporocyst.

COCCIDIA OF DOMESTIC PIG

***Eimeria debliciecki* Douwes**

(Fig. 8A)

1921. *Coccidium suis* Jaeger, *Basitrace zur Anreicherung der Parasiteneir im kot der Haustiere*. Diss. Munchen, p.48.
1921. *Eimeria brumpti* Cauchemez, *Bull. Soc. Path. Exot.*, **14**: 645; Wenyon, 1926, *Protozoology*, 2 Vols., p. 844.
1921. *Eimeria jalina* Kredit, *Over het voorkomen v protozoenchysten en ontwikkelingsvormen von coccid in den darm van mensch en enkele eieren* Diss., Leiden, p

1921. *Eimeria suis* Noller *Arch. Schiffs. u. Tropen. Hyg.*, **25**: 35.
1921. *Eimeria suis* Nollve (Lepsus), *Arch. Schiffs. u. Tropen. Hyg.*, **25**: 35.
1921. *Eimeria deblickei* Douwes, *Bijdrage tot de Kennis van enkele darmprotozoen der huisdieren in het bijzonder bij schape en varken*. Diss., Utrecht, p. 62; Ahluwalia, 1959, *Sci. & Cult.*, **25**: 314; Gill, 1960a, *Proc. Indian Sci. Cong.*, p. 430; Patnaik, 1963, *Orissa vet. J.*, **1**: 25; Sinha, 1963, M. V. Sc. Thesis, Magadh University (Unpublished); Vetterling, 1965, *J. Parasit.*, **51**: 897; Kudo, 1966, *Protozoology*, p. 687; Mishra, 1967a, *Indian vet. J.*, **44**: 289; 1967b, *Indian J. Anim. Health.*, **6**: 107; Shrivastav and Shah, 1968, *Indian vet. J.*, **45**: 204; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 676; Upadhyay and Ahluwalia, 1977b, *Indian J. Anim. Sci.*, **47**: 597; Upadhyay, Ahluwalia and Asthana, 1977, *Indian vet. J.*, **54**: 495.
1935. *Eimeria scrofae* Galli-Valerio, *Zbl. Bkt. Orig.*, **135**: 318.
1949. *Eimeria polita* Pellerdy, (in partim), *Acta. Vet. Acad. Sci. Hung.*, **1**, 101.
1965. *Eimeria neodeblickei* Vetterling (in partim), *J. Parasit.*, **51**: 897.
1965. *Eimeria porci* Vetterling (in partim), *J. Parasit.*, **51**: 897.

Description.—Oocysts ellipsoidal to ovoid, sporulated oocyst measured 20 μ –29 μ by 14 μ –20 μ with mean 24.2 μ by 16.8 μ ; the length width ratio ranged from 1.3 to 1.5 with a mean 1.4. Oocyst wall composed of two layers 1–2 μ in total thickness somewhat narrower at the anterior end. The inner layer appeared as yellowish brown in colour, micropyle and micropylar cap absent. One or more (maximum 3) polar granules present. Oocystic residuum absent. Sporocyst elongate-ovoid, asymmetrical one side slightly flattened; steida body present. Sporocyst measured 13 μ –15 μ by 6 μ –7 μ with a mean 14.7 μ by 6.4 μ . The length width ratio ranged from 2.1–2.3 with a mean 2.2. Sporocystic residuum present. Sporozoite elongated, lying length wise, head to tail inside the sporocyst, each containing two clear globules.

Sporulation time.—4–6 days (Kutzer, 1960), 8–13 days (Wiesenhutter, 1962b), 5–7 days (Pastuszko, 1966), 5–10 days (Vetterling, 1965), 14–16 (de Graaf 1925), 5–9 days (Henry, 1931), 8–9 days (Pellerdy, 1949), Upadhyay and Ahluwalia (1977b) noted this as 4–6 days at 26°C.

Dimension of the oocysts reported by other authors are as follows:

28–32 by 18–25 μ (Jaeger, 1921); 12–15 by 10–12 μ (Noller, 1921); 24–35 by 18–24 μ (Krediet, 1921); 12–19 by 12–20 (Henry, 1931); 15–24 by 13–18 μ (Galli-Valerio, 1935); 13–25 by 12–19 μ (Kutzer, 1960); 15–25 by 11–18 μ (Boch, Pezenburg and Rosenfeld, 1961); 12–50 by 10–30 μ (Donciu, 1961); 20–30 by 14–19 μ with the mean 24.9 by 17 μ (Vetterling, 1965); 13–23 by 13–19 μ (Pastuszko, 1966); 18–24 by 15–20 μ (Pellerdy, 1974); 16–20 by 14–18 μ (Wiesenhutter, 1962b).

Type host.—Domestic pig, *Sus scrofa domestica* [= *Sus scrofa*].

Other hosts.—From the same host.

Distribution.—Mhow, Jabalpur, Madhya Pradesh; Izatnagar, Aligarh, U.P., Karnae, Haryana.

Endogenous stages.—Douwes (1921) studied the endogenous cycles of *E. deblickei* in a mixed infection. Macrogametes measuring 10 by 8 μ in size, microgametocytes of 14 μ in diameter with microgametes of 1 μ long were noticed.

De Graff (1925) also studied the same in a mixed infection and detected schizont measuring 8–10 μ in diameter and microgametocytes of 7–22 μ in size. The microgametocytes were provided with many microgametes each measuring 3.5 μ in length.

Wiesenhutter (1962b) noted some doubtful schizont measuring 12 μ in diameter and macrogametes of 12–16 by 10–12 μ in size.

Boch and Wiesenhutter (1963) encountered the endogenous cycles in the epithelial cells of the jejunal propria and submucosa. The schizont measured 18

by 12 μ encircling 25 merozoites. Each merozoite measured 4.7 by 1.2 μ in size. The microgametocyte measured 16 by 10 μ with 70 microgametes, each of which measured 2–3 by 0.5–0.7 μ . The macrogametocyte measured 12–18 by 8–10 μ .

Vetterling (1966) encountered two schizogonic processes in the small intestine after an experimental infection of young pigs with a pure strain culture of *E. deblickei*. The first schizonts measured 8–12 μ in diameter containing 16 bent merozoites each measured 12–13 μ by 1.8 μ in size lying around a polar residuum. Another schizont of 13–16 μ in diameter was provided with 32 bent merozoites of 5–8 by 1.8 μ in size. The microgametocyte measured 9–14 μ in diameter. The microgametes measured 5–6 by 0.6 μ each with two long flagella of 2–6 μ long. The macrogametocyte measured 12–16 μ in diameter with a reticular cytoplasm and a large nucleus.

The prepatent period was about 7 days.

Remarks.—Upadhyay and Ahluwalia (1976) observed four different types of schizonts after inoculating infection-free pigs with four species viz. *E. deblickei*, *E. neodeblickei*, *E. perminuta* and *Isospora suis* after 163rd hour of infection at 1.2 and 4.8 meters level of the small intestine measured from pyloric end of the stomach.

Type I.—Schizont was subspherical measuring 8.0 μ in diameter located at the distal portion of the simple columnar epithelial cells of crypts of Lieberkhuen. The mature schizont was provided with 16 merozoites each measuring 3.2 μ by 0.2 μ in size.

Type II.—Schizont located at the same place measuring 7.2–8.0 μ by 7.6–8.0 μ and the merozoites 2.88 μ by 0.8 μ and about 8–10 in number.

Type III.—Schizont was subspherical, measuring 12.8–14.4 μ by 9.6–10.4 μ with 32 merozoites in each and measured 3.2 μ by 0.8 μ in size.

Type IV.—Schizont was subspherical measuring 7.20–9.6 μ by 5.8–8.00 μ with some residual granules after the development of 4 merozoites inside. Each merozoite measured 5.12 by 1.76 μ .

***Eimeria neodeblickei* Vetterling**

(Fig. 8B)

- 1921. *Eimeria brumpti* Cauchemez (in partim), *Bull. Soc. Path. Exot.*, **14**: 645; Wenyon, 1926, *Protozoology*, p. 844.
- 1921. *Eimeria deblickei* Douwes (in partim), *Bijdrage tot kennis van enkele darmprotozoen der huistieren in het bijzonder bij schaaap en varken*, Diss., Utrecht., p. 62.
- 1965. *Eimeria neodeblickei* Vetterling, *J. Parasit.*, **51**: 897; Shrivastav and Shah, 1968, *Indian Vet. J.*, **45**: 204; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 679; Upadhyay and Ahluwalia, 1977b, *Indian J. Anim. Sci.*, **47**: 597; Upadhyay, Ahluwalia and Asthana, 1977, *Indian Vet. J.*, **54**: 495.

Description.—Oocysts ellipsoidal, occasionally ovoid in shape, measuring 17 μ –26 μ in length and 14 μ –19 μ in width with a mean 22.1 μ by 16 μ . The length-width ratio ranged from 1.2 to 1.3 with a mean 1.25. Oocystic wall double layered, 0.9 μ –1.4 μ in thickness, outer smooth, clourless to pale yellow and the inner layer yellowish-brown. Micropyle and oocystic residuum absent. One or two polar granules occasionally present. Sporocyst broadly ovoid measuring 9 μ –13 μ by 6 μ –8 μ with a mean 10.4 μ by 6.6 μ . Stieda body and sporocystic residuum present. Sporozoites banana-shaped, usually lying length wise head to tail.

Sporulation time.—13 days (Pellerdy, 1974); 4–6 days (Upadhyay and Ahluwalia, 1977b).

Type host.—Domestic pig, *Sus scrofa scrofa* [= *Sus scrofa*].

Other hosts.—From the same host; Wild boar, *Sus scrofa scrofa*.

Distribution.—Madhya Pradesh; Aligarh, U.P.

Endogenous stages.—Unknown.

Remarks.—While discussing, Vetterling (1965) states that this species is very close to *E. deblickei* Douwes, 1921, but the sporocysts of the species dealt with is symmetrical in contrast to the assymetrical sporocyst of *E. deblickei*.

***Eimeria perminuta* Henry**

(Fig. 8C)

1931. *Eimeria perminuta* Henry, *Univ. Calif. Publ. Zool.*, **36**: 115; Gill, 1960, *Proc. Indian Sci. Congr.* p. 430; Patnaik, 1963, *Orissa Vet. J.*, **1**: 25; Sinha, 1963, M. V. Sc. Thesis, Magadh University (Unpublished); Vetterling, 1965, *J. Parasit.*, **51**: 897; Mishra, 1967a, *Indian Vet. J.*, **44**: 289; 1964b, *Indian J. Anim. Health.*, **6**: 107; Shrivastav and Shah, 1968, *Indian Vet. J.*, **45**: 204; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 679; Upadhyay and Ahluwalia, 1977b, *Indian J. Anim. Sci.*, **47**: 597; Upadhyay, Ahluwalia and Asthana, 1977, *Indian Vet. J.*, **54**: 495.
1931. *Eimeria perminuta* Henry (Lapsus), *Univ. Calif. Publ. Zool.*, **36**: 115.

Description.—Oocysts sub-spherical, sporulated oocysts measured 14 μ –15 μ by 13.0 μ with a mean 14.5 μ by 13.0 μ . The length-width ratios ranged from 1.0–1.1 with a mean 1.05. Oocyst wall composed of two layers, about 1.0 μ in total thickness, the outer layer, rough yellow and the inner one smooth, dark yellowish-brown. Micropyle and micropylar cap absent. One or two oocystic polar granules present. Oocystic residuum absent. Sporocysts broadly ovoid with the clear stieda body in each. Sporocyst measured 8 μ by 5–6 μ with a mean 8 μ by 5.5 μ . The length-width ratio ranged from 1.3–1.6 with a mean 1.4. Sporocystic residuum present and the sporozoites lie length wise head to tail inside the sporocyst, each containing 2 clear globules.

Sporulation time.—4–7 days (Upadhyay and Ahluwalia, 1977b).

Dimension of the oocysts reported by other authors are as follows:

11–16 by 9–12 μ (Yakimoff, 1933); 11–18 by 10–16 μ (Boch, Pezenburg and Rosenfeld, 1961); 11–17 by 10–16 μ (Donciu, 1961); 12–15 by 10–13 μ with the mean 13.3 by 11.7 μ (Vetterling, 1965); 11–16 by 10–13 μ (Pellerdy, 1974).

Type host.—Domestic Pig, *Sus scrofa domestica* [= *Sus scrofa*].

Other hosts.—From the same host.

Distribution.—Orissa, Bihar, U.P. and Madhya Pradesh.

Endogenous stages.—Unknown.

***Eimeria perminuta mathurai* Mishra**

(Fig. 8D)

- 1967a. *Eimeria perminuta mathurai* Mishra, *Indian Vet. J.*, **44**: 289.

Description.—Oocysts are spherical or somewhat ovoid in shape measuring 13.8 μ –19.94 μ in length and 9.2 μ –16.92 μ in width. The rough bilayered oocystic wall measured 1.0 μ –1.54 μ in thickness. The outer layer of the oocyst is yellowish or greenish yellow while the inner one is greenish or brownish coloured. Oocystic residuum absent. Polar granule present. The sporocysts are ellipsoidal in shape measuring 8.35 μ –11.97 μ in length and 5.38 μ –6.18 μ in width with the mean 10.77 μ by 6.13 μ . Stieda body absent. Sporocystic residuum present as globular mass.

Sporulation time.—7–9 days.

Type host.—Domestic pig, *Sus scrofa* Linn. (= *Sus* sp.).

Other host.—Unknown.

Locality.—Mathura, U.P.

Endogenous stages.—Unknown.

***Eimeria cordonis* Vetterling**

(Fig. 8E)

1965. *Eimeria cordonis* Vetterling, *J. Parasit.*, **51**: 897; Shrivastav and Shah, 1968, *Indian Vet. J.*, **45**: 204; Upadhyay, Ahluwalia and Asthana, 1977, *Indian Vet. J.*, **54**: 495.

Description.—Oocysts broadly ovoid, slightly flattened at the anterior end. Sporulated oocyst measured $27\ \mu$ – $29\ \mu$ by $21\ \mu$ – $23\ \mu$ with a mean $28.0\ \mu$ by $21.8\ \mu$. The length-width ratio ranged from 1.2–1.3 with a mean 1.2. Oocyst-wall two layered, about $1.5\ \mu$ in total thickness; the outer layer rough, dark yellow, devoid of striations, the inner layer smooth, dark brown. Micropyle and micropylar cap absent. Sporocyst elongated with plug-like stieda body. Sporocyst measured $16\ \mu$ – $17\ \mu$ by $7\ \mu$ – $9\ \mu$ with a mean $16.3\ \mu$ by $8.0\ \mu$. The length-width ratio is 2.0. Sporozoite banana-shaped, lying length wise, head to tail within the sporocyst. Sporozoite usually provided with 1 or 2 large globules.

Type host.—Domestic pig, *Sus scrofa domestica* [= *Sus scrofa*].

Other host.—From the same host.

Distribution.—Mhaw, Jabalpur, M.P.; Izatnagar, Aligarh, U.P.; Karnal, Haryana.

Endogenous stages.—Unknown.

Remarks.—Pellerdy (1974) is of opinion that the oocysts of *E. cordonis* and *E. polita* are identical but differ in the surface texture of the oocyst. In the former it is scabrous and in the latter both smooth and scabrous surfaces are found. Vetterling (1965) while describing *E. cordonis* did not compare this species with *E. polita* as he has synonymised *E. polita* with *E. deblickei*. He further stated that *E. cordonis* was not possible to distinguish from *E. deblickei* until a pure culture of the latter had been obtained from a single oocyst infection. Moreover, the oocyst of *E. cordonis* had yellow cast, whereas *E. deblickei* it is colourless. However, at present it is wise enough to keep *E. cordonis* as distinct species so also *E. polita*.

***Eimeria porci* Vetterling**

(Fig. 8F)

1921. *Eimeria deblickei* Douwes (in partim) *Bijdrage tot de kennis van enkele darmproto oen der huisdieren in het bij onder bij schaap en varken*. Diss., Utrecht., p. 62.
1965. *Eimeria porci* Vetterling, *J. Parasit.*, **51**: 897; Shrivastav and Shah, 1968, *Indian Vet. J.*, **45**: 204; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 683; Upadhyay, Ahluwalia and Asthana 1977, *Indian Vet. J.* **54**: 495.

Description.—Oocyst pear-shaped, distinctly narrow at the anterior end measuring $20\ \mu$ – $27\ \mu$ by $14\ \mu$ – $18\ \mu$ with a mean $23.5\ \mu$ by $16.7\ \mu$. The length-width ratio ranged from 1.4 to 1.5 with a mean 1.45. Oocystic wall double layered about $1.2\ \mu$ thick with a smooth yellowish-brown outer and smooth, dark brown inner layer. Micropyle and micropylar cap absent. Oocystic residuum absent, polar granules

present. Sporocyst broadly ovoid, measuring $9\ \mu$ – $11\ \mu$ by $7\ \mu$ – $8\ \mu$ with a mean $9.5\ \mu$ by $7.3\ \mu$. The length/width ratio ranged from 1.2 to 1.4 with a mean 1.3. Stieda body present. Sporozoites lie length-wise, head to tail in side sporocysts with one or two clear globules.

Sporulation time.—9 days.

Type host.—Domestic pig, *Sus scrofa scrofa* [= *Sus scrofa*].

Other host.—From the same host.

Distribution.—Madhya Pradesh; Aligarh, U.P.

Endogeneous stages.—Unknown.

Remarks.—This is one of the species of 'debliecki' group and the author while describing the species differentiates it from *E. debliecki* by its short, broadly ovoid sporocysts with a sparse and finely granular residuum. Pellerdy (1974) stated that the inclusion of *E. polita* as synonym of *E. porci* in his supplementum I, Catalogue of the suborder Eimeriidea published in (1969) was not valid and Vetterling (1965) did the similar mistake in synonymising the former with latter. Pellerdy (1974) further commented that the oocysts found by Shrivastav and Shah (1968) did not correspond to Vetterling's species (*E. porci*). At present *E. porci* can be treated as distinct.

***Eimeria spinosa* Henry**

(Fig. 8G)

1931. *Eimeria spinosa* Henry, *Univ. Calif. Publ. Zool.*, **36**: 115; Gill, 1960, *Proc. Indian Sci. Congr.*, p. 430; Patnaik, 1963, *Orissa Vet. J.*, **1**: 25; Vetterling, 1965; *J. Parasit.*, **51**: 897; Srivastav and Shah, 1968, *Indian Vet. J.*, **45**: 294; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 687.

Description.—The oocysts are ellipsoidal in shape and measuring $16\ \mu$ – $22.4\ \mu$ by $12.8\ \mu$ – $16\ \mu$. The wall is brown and its entire surface is covered by $1\ \mu$ high spines at $1\ \mu$ distance from one another. Following the contraction of the coarse-granulated cytoplasm to a rounded sporont a polar granule marked its appearance within the oocyst. The sporont as a rule lies asymmetrically, nearer to one of the poles. The sporocyst measured $9.1\ \mu$ – $11.7\ \mu$ by $5.2\ \mu$ – $6.5\ \mu$, but difficult to observe due to dark colour of the oocyst. Stieda body present at the narrow end. The outer residual bodies are absent. The sporocystic residual body is granular.

Sporulation time.—At room temperature it begins on the 10th day and is completed on 15th day.

Dimension of the oocyst reported by other authors are as follows:

14 – $26\ \mu$ by 14 – $21\ \mu$ (Boch, Pezenburg and Rosenfeld, 1961); 11 – 22 by 10 – $13\ \mu$ (Wiesenhutter, 1962a); 16 – 22 by 13 – $16\ \mu$ (Pellerdy, 1974).

Type host.—Domestic pig, *Sus scrofa*.

Distribution.—Madhya Pradesh, Orissa, West Bengal.

Other hosts.—From the same host.

Endogenous stages.—Wiesenhutter (1962a) reported the schizogonic stages of *E. spinosa* from the small intestine of the host. He described the mature schizont measuring 8 – $10\ \mu$ in diameter producing about 20 merozoites. Each merozoite measured 4 – 6 by 1 – $1.5\ \mu$. The microgametocyte measured 6 – $8\ \mu$ in diameter producing $3\ \mu$ long microgamete. The macrogametocyte measured 7 – $9\ \mu$ in diameter, with centrally or eccentrically placed nucleus.

***Eimeria scabra* Henry**

(Fig. 8H)

1931. *Eimeria scabra* Henry, *Univ. Calif. Publ. Zool.*, **36**: 115; Gill, 1960, *Proc. Indian Sci. Congr.*, p. 430; Patnaik, 1963, *Orissa Vet. J.*, **1**: 25; Sinha, 1963, *M. V. Sc. Thesis*, Magadh University (unpublished); Vetterling, 1965, *J. Parasit.*, **51**: 897; Mishra, 1967a, *Indian Vet. J.*, **44**: 289; 1967b, *Indian J. Anim. Health.*, **6**: 107; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 684; Upadhyay, Ahluwalia and Asthana, 1977, *Indian Vet. J.*, **54**: 495.
1931. *Eimeria scarba* Henry (lapsus), *Univ. Calif. Publ. Zool.*, **36**: 115.
1961. *Eimeria romaniae* Donciu, *Cercentari asupra Coccidiilor la animalele domestice in R. P. R. Bucuresti*, p. 89.

Description.—Oocysts ellipsoidal to somewhat ovoid, slightly flattened at the micropylar end. Sporulated oocyst measured $27\ \mu$ – $32\ \mu$ by $19\ \mu$ – $24\ \mu$ with a mean $28.2\ \mu$ by $20.3\ \mu$; the length/width ratio ranged from 1.3–1.4 with a mean 1.3. Oocyst wall composed of two layers about $1.5\ \mu$ in total thickness, with a rough pigmented brown outer layer, having radial striations and a smooth, brownish yellow one. Micropyle present measuring $3.5\ \mu$ – $4.5\ \mu$. Micropylar cap absent. One or two polar granules present but oocystic residuum absent. Sporocysts ovoid, with a stieda body in each. Sporocyst measured $14\ \mu$ – $18\ \mu$ by $7\ \mu$ – $8\ \mu$ with a mean $15.2\ \mu$ by $8\ \mu$. The length/width ratio ranged from 2.0–2.5 with a mean 2.2. Sporocystic residuum present. Sporozoite elongated lying head to tail inside the sporocyst, each was provided with 2 clear globules.

Dimension of the oocysts reported by other authors are as follows:

25–36 by 17–25 μ (Kutzer, 1960); 24–42 by 20–24 μ with the mean 31.9 by 22.5 μ (Vetterling, 1965); 22–36 by 16–26 μ (Pellerdy, 1974).

Type host.—Domestic pig, *Sus scrofa* [= *Sus scrofa*].

Other hosts.—From the same host.

Distribution.—Mhow, Madhya Pradesh; Izatnagar, Aligarh, U.P.; Orissa and Bihar.

Remarks.—Though Pellerdy (1965, 1969) retained *E. romaniae* as valid species but Vetterling (1965) synonymised it with the species dealt with. The present author is of same opinion to synonymise *E. romaniae* with *E. scabra* Henry.

Endogenous stages.—Rommel and Ipczynski (1967) described 3 schizogonic processes. The first schizont occurred in the jejunum after 3rd day from the date of infection measured 12–19 μ by 11–17 μ , each containing 16–24 merozoites of 11–15 μ by 1.5–2 μ in size. The second schizont having 14–22 merozoites each measuring 9–17 μ by 2–4 μ in size with a large polar residuum. The third one also located in the ileum and measured 16–27 μ by 13–27 μ in size producing 14–28 merozoites with a large residuum. Each merozoite measured 12–19 μ by 2–4 μ in size. The microgametocytes measured 17–34 μ by 14–22 μ with many microgametes measuring 5–4.4 by 0.6–1 μ in size with two flagella. The macrogametes measured 14.23 μ by 9–16 μ with a large nucleus and cytoplasmic granules.

***Eimeria polita* Pellerdy**

(Fig. 8I)

1921. *Eimeria deblickei* Douwes (in partim), *Bijdrage tot de Kennis van enkele darmprotozoen der hllisdieren in het bijzonder bij schaap en varken*. Diss., Utrecht. p. 62; Vetterling, 1965, *J. Parasit.*, **51**: 897.
1949. *Eimeria polita* Pellerdy, *Acta. Vet. Acad. Sci. Hung.*, **1**: 101; Gill, 1960, *Proc. Indian Sci. Congr.*, p. 430; Mishra, 1967a, *Indian Vet. J.*, **44**: 289; Pellerdy, 1974, *Coccidia and Coccidiosis*, p. 680.

Description.—Oocysts ellipsoidal or badly ovoid measuring 22 μ –31 μ by 17 μ –22 μ sometimes a little more. Oocystic residuum absent. The sporocysts are

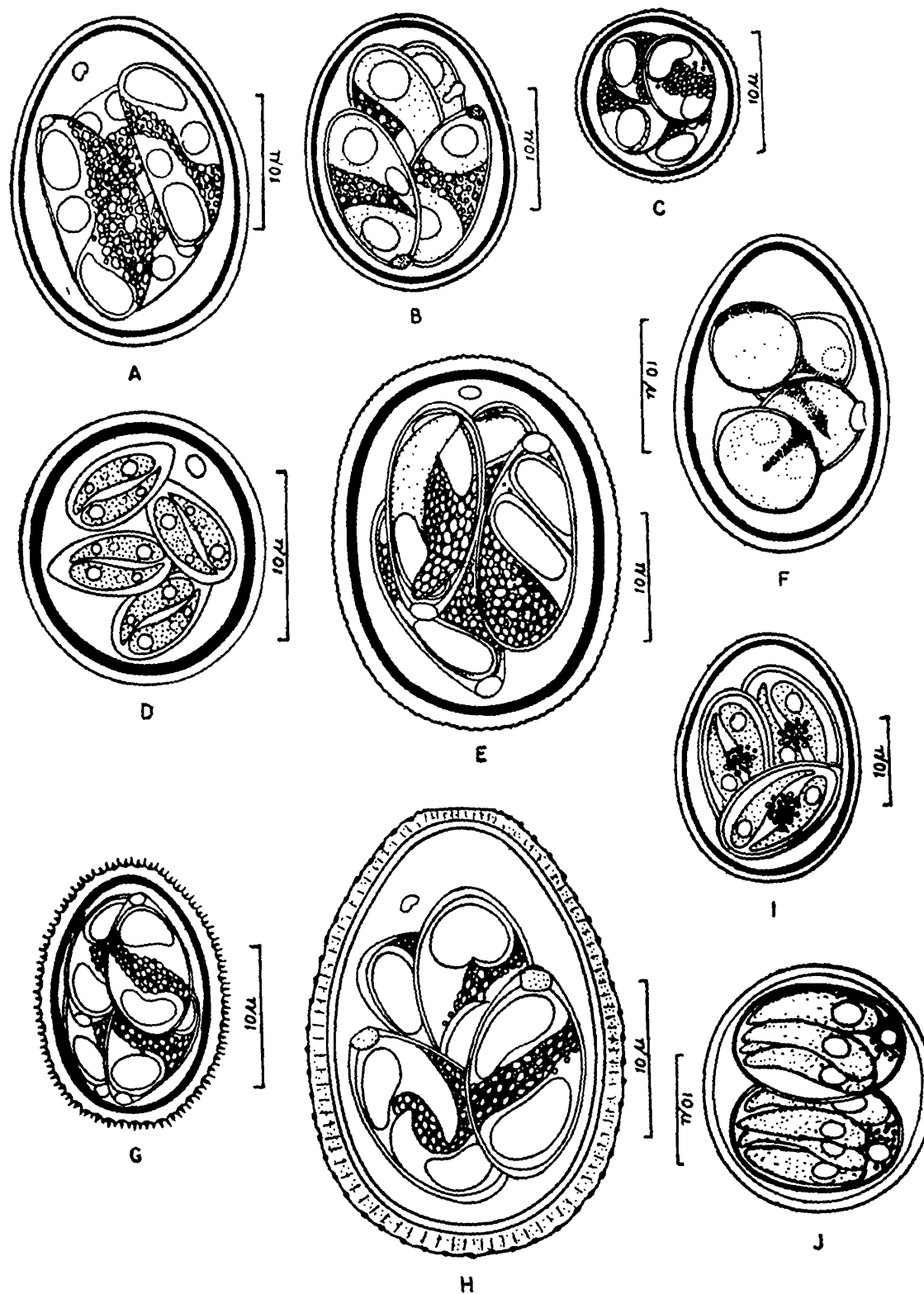


Fig. 8. (A-J). Diagrams of sporulated oocysts of:

- A) *E. deleiecki*; B) *E. neodebliecki*; C) *E. perminuta*; D) *E. perminuta mathurai*;
 E) *E. cerdonis*; F) *E. porci*; G) *E. spinosa*; H) *E. scabra*; I) *E. polita*;
 J) *Isospora suis*.

ellipsoidal in shape each measuring 13–19 μ in length with a mean 16.3 μ and 6 μ –9 μ in width with a mean 7.6 μ . Sporocystic residuum present. The sporozoites are long measuring 17 μ –18 μ .

Sporulation time.—8–9 days. (Pellerdy, 1974), 7.5 days (Vetterling, 1964), 6–9 days (Pastuszko, 1966).

Dimension of the oocysts reported by other authors are as follows:

24–40 by 20–27 μ and 29–34 by 17–22 μ (Boch, Pezenburg and Rosenfeld, 1961); 21–31 by 15–20 (Vetterling, 1964); 22–39 by 17–26 with the mean 26.8 by 20.5 μ (Rommel, 1970); 22–31 by 17–22 and 23–27 by 18–21 μ (Pellerdy, 1974).

Type host.—Domestic pig, *Sus scrofa domestica* [= *Sus scrofa*].

Other host.—From the same host.

Distribution.—Izatnagar, U.P.

Endogenous stages.—Vetterling (1964) studied the endogenous stages of *E. polita* with pure strain culture and observed the first schizont measured 8–12 μ in diameter with 16 merozoites and a polar residuum. The merozoite measure 8–12 μ in length. The first schizont developed in the jejunum and matured after 3 days from the date of infection while the second schizont matured after 5 days. The schizont were measured 15–20 μ in diameter with 32 merozoites each measuring 12 μ but without any residuum. The microgametocyte measured 11–12 μ in diameter producing many microgametes of 1.5 μ long. The macrogamet measured 17–22 μ in diameter.

Centurier (1970) made some experiment with pure strain culture and reported two schizogonic processes in *E. polita*. The first schizont appeared after 3 days from date of infection. It measured 14–24 by 11–25 μ with the mean 17.2 μ by 14.5 μ and enclosed 16–30 sickle-shaped merozoites of 9–22 μ by 1.5–3 μ with a mean 14 μ by 2.3 μ in size but without any residuum. The second schizonts appeared after 5–6 days from the date of infection and measured 14–23 by 12–30 μ containing 15–30 merozoites of 10–15 μ by 1.5–3 μ in size with a residuum. There was no morphological difference between the two schizonts. Microgametocyte measured 16–29 by 13–29 μ producing 60–150 microgametes of 2.2–by 0.6 μ in size. The microgametocytes also provided with a residuum of 9.5 by 7 μ in size. The macrogametocyte measuring 14 by 11.5 μ produced macrogamet of 16–29 by 15–25 μ in size and the gametocytic nucleus measured 3.2 μ in diameter.

The prepatent period was 8–9 days according to Pellerdy (1949) and 9–11 days according to Centurier (1970).

***Isospora suis* Biester and Murray.**

(Fig. 8J)

1934. *Isospora suis* Biester and Murray, *J. Amer. Vet. Med. Assoc.*, **85**: 207; Gill, 1960, *Proc. Indian Sci. Congr.*, p. 430; Patnaik, 1963, *Orissa Vet. J.*, **1**: 25; Vetterling, 1965, *J. Parasit.*, **51**: 897; Kudo, 1966, *Protozoology*, 0. 698; Mishra, 1967a, *Indian Vet. J.*, **44**: 289; Pellerdy, 1974; *Coccidia and Coccidiosis*, p. 689; Upadhyay and Ahluwalia, 1977b, *Indian J. Anim. Sci.*, **47**: 597; Upadhyay, Ahluwalia and Asthana, 1977, *Indian Vet. J.*, **54**: 495.

Description.—Oocysts subspherical measuring 20 μ –24 μ in length and 18 μ –21 μ in width with a mean 22 μ by 19.5 μ . The shape index is 1.1. The oocystic wall is double layered 1.5 μ in thickness light yellow in colour with a brown shed in it. No micropyle is visible. Two sporonts are usually round in shape each measuring 16.5 μ in diameter and occupy the central position of the oocyst. Oocystic residuum absent. Sporocysts are elliptical to cylindrical in shape measuring 16 μ –19.6 μ in length and 10 μ –12 μ width with a mean 18 μ by 11 μ . The sporocystic

wall is very distinct and $0.66\ \mu$ in thickness. Sporozoites are four in number in each sporocysts.

Sporulation time.—74–95 hours; 4–5 days (Uphadhyay and Ahluwalia, 1977b), 3–5 days (Pellerdy, 1974).

Dimension of the oocyst reported by other authors are as follows:

19–25 by 16–31 μ (Boch, Pezenburg and Rosenfeld, 1961); 17–22 by 17–19 with the mean 19.5 by 17.5 μ . (Vetterling, 1965).

Type host.—Domestic pig, *Sus scrofa*.

Other host.—(i) From the same host; (ii) Wild bore, *Sus scrofa scrofa*.

Distribution.—Orissa, Uttar Pradesh.

Endogenous stages.—Little is known about the endogeneous stages. It is found in the ileum of the intestine. The discharge of oocysts begins 6–8 days after experimental inoculation (Pellerdy, 1974). Vetterling (1965) is of opinion that the same begins after 5 days.

Remarks.—Pellerdy (1974) expressed a doubt about the validity of *I. suis* and of opinion that this *Isospora* resembles *I. lacazei* (Labbe) of sparrow. Some cross transmission experiments are needed to clarify the position of this species.

E. tenella						
E. necatrix						
E. brunetti						
E. maximma						
E. acervulina						
E. mivati						
	Duodenum	Jejunum	Ileum	Caeca	Rectum	Cloaca

Fig. 9. Table showing the site preference of the pathogenic chicken coccidia belonging to the genus *Eimeria*.

***Isospora* sp.**

1968. *Isospora* sp. Shrivastav and Shah, *Indian J. Vet.*, **45**: 204;

Description.—Oocysts were subspherical to spherical in shape, measuring 25 μ –26 μ by 25 μ in diameter with a mean 25.5 μ . The wall composed of two layers, 1.2 μ in total thickness; outer layer smooth, yellowish to pale brown, the inner layer dark brownish-yellow. Micropyle and micropylar cap absent. Oocystic polar granule and residuum are absent. Sporocysts lemon-shaped measured 14 by 9 μ . Stieda body present, with dependent hyaline mass extending into the interior of the sporocyst. Sporozoite more or less sausage-shaped, with a clear large globule at broad end; without definite arrangement in side sporocyst. Sporocystic residuum present as fine granules scattered inside the sporocyst.

Type host.—Domestic pig, *Sus scrofa domestica* [= *Sus scrofa*].

Other hosts.—From the same hosts.

Distribution.—Jabalpur, Madhya Pradesh.

Endogenous stages.—Unknown.

Remarks.—It is very likely that the present authors were dealing with the *Isospora lacazei* commonly found in sparrow. They have vividly analysed this occurrence of *Isospora* sp. and probably correct not to designate this species but to call as pseudo-parasite.

COCCIDIOSIS IN POULTRY AND FARM ANIMALS

In establishing animal farms and poultry, the coccidiosis, a disease caused by coccidia poses a great problem. It is highly responsible for morbidity and mortality in vertebrates particularly in birds and mammals. The coccidial infections are easily acquired in poultry and livestock as this parasite has a direct life cycle inside the host. Moreover, unhygienic and insanitary conditions accelerate the spread of this disease. The younger stock of the flock generally suffers a lot. Older counterpart sometimes shows clinical symptoms and acts simply as carrier, but in chronic cases, it becomes emaciated causing a dip in over all production. This disease, causes a loss of body weight, reduction in milk yield and production of inferior wool fibres. In addition, the toxic role of coccidia and relationship of the disease with paralysis and nervous system are generally encountered. In this connection the cases of 'Coccidiosis' with clinical symptoms are to be distinguished from 'Coccidiasis' which is nothing but a symptomatic condition of the infected animals of all age groups. In order to make the things more clear, Levine (1961) stated that after being recovered from a coccidial infection an animal became relatively immune to reinfection with the same species. But this immunity may not be so solid as to check reinfection completely with the same species or to cause low graded infection. Of course, low grade infection is extremely common i.e. the animals have 'Coccidiasis' rather than 'Coccidiosis'. Both the conditions are equally important for adapting any control measure.

Sometimes it is very difficult to diagnose the disease. Mere presence of the oocyst in the faeces of an animal, even for highly pathogenic species of coccidia, does not necessarily mean that the animal has clinical coccidiosis (Levine, 1961). On the other hand, coccidia may cause severe symptoms and even death early in their life cycle before the liberation of any oocyst. The only authentic way of diagnosing coccidiosis is to find out lesions containing coccidia at necropsy. The characteristic endogenous stages located in the smear or histological preparations should also be taken into consideration for confirming coccidiosis.

Now-a-days, various sulfa drugs and other chemical compounds are in use both as prophylactic and therapeutic measure and experimental assessment of their actions on the different stages of the parasite.

Levine P. P. (1939) first introduced sulfanilamide as anticoccidial drug but Herrick and Holmes (1936) brought sulfar as effective drug in coccidia. Many drugs like the derivatives of phenylarsonic acid, diphenylmethane diphenyldisulfide, introfuram, triazine, carbanilide, imidazole and benzamide are being used as coccidiostat. However, Levine (1961) stated that no drug would be effective, if the same is used after the appearance of symptoms of the disease. He further suggested that most of the drugs are prophylactic and must be administered at the time of exposure or soon thereafter in order to be effective.

The real effective therapy depends upon correct time at which the remedies exert their optimal effect against the endogenous phase of the different species of

coccidia. The treatment of the disease depends somehow on the endogenous stage particularly during the asexual phase. If it is not controlled after repeated infections, the therapeutic measure alone may not check the outbreaks.

Before adopting any control measure one should be aware of different types of coccidia and coccidiosis in various livestock and poultry. They are treated below groupwise, along with the symptoms.

DOMESTIC FOWL

According to Pellerdy (1969, 1974) nine valid species of *Eimeria*, 2 species of *Isospora* and 1 species of *Wenyonella* are occurring in domestic fowl of which India shares 9 species of *Eimeria*, 1 species of *Wenyonella* and one *Isospora* species. In chicken, 6 species of *Eimeria* viz. *E. tenella*, *E. necatrix*, *E. brunetti*, *E. mivati*, *E. acervulina* and *E. maxima* are found pathogenic. Amongst them, *E. necatrix*, *E. maxima*, *E. acervulina* and *E. mivati* affect the region of the small intestine, *E. tenella* infects caeca, *E. necatrix* attacks both caeca and colon and *E. brunetti* is found in the rectum and colon. The lesions due to coccidiosis in poultry frequently comes from mixed infection. Sometimes the specific differentiation from the examination of gross lesions becomes difficult due to their severity and other associated character. In the infection of *E. acervulina*, the well-marked thickening is found on the duodenal mucosa with extreme reddening. In case of *E. maxima* infection it follows by the thickening of mucosa particularly in the upper half of the small intestine with an almost orange-coloured intestinal contents and streak of blood. Due to the infection of *E. necatrix*, milky to milkwhite spots or small areas like pin-heads due to deep seated aggregations of colonies of asexual stages are noticed in the surface of the small intestine Bhatia and Pande (1968a). In *E. tenella*, a severe congestion with greatly enlarged caeca containing mass of dark red or dark brown core are found. The caecal wall has become almost membranous. The droppings of ailing chicks often contain blood or mucus or both. While observing the *E. necatrix* infection, Misra, Enigk and Dey Hazra (1976) noticed gross changes in the jejunum with the disquamation of epithelial cells. The villi were found stumpy with holes at the tip from where the blood was seen to come out. The epithelial cells become loose. The site preference of the pathogenic chicken coccidia belonging to the genus *Eimeria* is shown in Fig. 9.

DOMESTIC TURKEY

Seven species of *Eimeria* viz. *E. meleagridis*, *E. meleagritidis*, *E. gallopavonis*, *E. adenoides*, *E. dispersa*, *E. innocua* and *E. subrotunda*, 1 species of *Isospora* viz. *I. heissini* and 1 species of *Cryptosporidium* viz. *C. meleagridis* are found in domestic Turkey. Of which 6 species of *Eimeria* (except *E. subrotunda*) have been reported from our domestic counterpart. The jejunal wall of the infected bird becomes thick with much fluid in the jejunum and the duodenum. Sometimes the duodenum is plugged with roset coloured fragmentary material in case of the infection of *E. meleagridis*.

DOMESTIC DUCK

Very little work has been done on duck coccidiosis in India. So far two species of *Eimeria* viz. *E. anatis* and *E. battakhi* and two species of *Wenyonella* viz. *W. anatis* and *W. gagari* have been reported from domestic duck of our country. The mortality is quite high due to coccidiosis in ducks. Frequently the inflammatory changes along with haemorrhagic spots are found in the small intestine. Dubey and Pande (1963a) detected the eimerian Schizonts in the domestic duck from our country.

CATTLE

Coccidiosis in cattle causes a profuse economic loss in our country. In India, outbreak of red dysentery in dairy cattle due to bovine and bubaline coccidiosis have been reported from time to time. High percentage of mortality in calves or leading to morbid conditions are frequently marked. It is predominant in calves particularly below one year of age. The adult one is practically symptomless although it carries coccidia and passes oocysts continuously. More than 15 species (Pellerdy 1965, 1974) of *Eimeria* and one species of *Isospora* are found in cattle of which buffalo and cow of this country harbour 13 species of *Eimeria*. They are *E. auburnensis*, *E. bovis*, *E. ellipsoidalis*, *E. zuernii*, *E. subspherica*, *E. cylindrica*, *E. canadensis*, *E. alabamensis*, *E. bukidoninensis*, *E. pellita*, *E. brasiliensis*, *E. wyomingensis* and *E. bareillyi*. The last 3 species occur less frequently as stated by Bhatia, Pande, Chauhan and Arora (1968). A foul smelling reddish diarrhoeic stool due to haemorrhage in the intestine are generally found in acute cases. Sometimes the stool may be just soft or watery. The victim occasionally shows recovery but there may be a sudden flare up of the symptoms associated with recurrent diarrhoea, anorexia, tenesmus, inability to rise on legs, debility, fever etc. Young calves, in acute condition, die within a few days particularly when the stools carry large quantities of blood.

It has been sometimes observed that the mesenteric blood vessels are distended and the intestinal coils appear to be extensively congested. The catarrhal enteritis with reddening of the mucosa and excess mucus are also seen with watery intestinal contents. A general swelling and punctiform haemorrhage are found spread over large areas. The lesions are mainly traced in the junction of jejunum and ileum. Mature giant schizonts which look like white pin points to pin-heads are found superficially or deep in the mucosa. Large epithelial schizonts with irregularly marginated milky-white superficial areas of about 1-2 mm size are also observed. In addition, a congregation of gametocytes and oocysts inside the slightly raised whitish patches known as epithelial schizont are frequently marked. The caecum and colon also show severe catarrhal enteritis filled with fluid contaminated with blood.

Pellerdy (1974) divides bovine coccidiosis into three periods (i) the first one lasts for 5-7 days characterised by debility, diarrhoea with few oocysts and loss of milk; (ii) the second period also has the same duration showing anorexia, a raised respiration rate, loss of weight with no milk and clots of blood with mucus present in the fluid faeces, partial paralysis of the anal sphincter resulting in its mostly wide open condition; (iii) duration of the third period varies to some extent. During this period the victim is unable to stand on its legs and cannot take food and water and often displays more or less extensive transverse haemorrhagic streaks on the exposed rectal mucosa through the permanently opened anus with fairly high mortality rate. The detailed knowledge of the pathogenic species of *Eimeria* is very less except for *E. bovis*, *E. zuernii*, *E. auburnensis*, *E. ellipsoidalis*, *E. bukidoninensis* and *E. alabamensis* in cattle from abroad. In our country, various endogenous stages of bubaline and bovine coccidia may be had from Bhatia and Pande (1967), Pande *et al.* (1971) particularly for *E. bareillyi* from *Babulus bubalis*. Shastri *et al.* (1973) noted that the infection of 50,000 to 100,000 oocysts of *E. bareillyi* produced clinical disease while feeding of 300,000 oocysts caused remarkable illness and death. The same authors (1974) recorded that the infection due to *E. bareillyi* leads to diarrhoea and noted 20% mortality in buffalo calves. The pathogenicity of this species has been noted by Shastri and Krishnamurthy (1975) leading to the distention of the mesenteric blood vessels, tortuous with swollen intestinal wall, alongwith the accumulation of fluid inside the intestine. The presence of circular growth of 2-6 mm diameter in the mucosa of the jejunum has also been observed as already detected by Pande *et al.* (1971).

SHEEP AND GOATS

So far 16 species of *Eimeria* have been reported from sheep and goats and these species are interchangeable to some extent in between these two hosts. From India, 10 species of *Eimeria* viz. *E. arloingi*, *E. intricata*, *E. crandallis*, *E. ahsata*, *E. faurei*, *E. ninakohlyakimovae*, *E. parva*, *E. granulosa*, *E. christenseni* and *E. tirupatiensis* have been reported, of which, the latter two are recorded only from goat. Single infection is rare. The symptom of the disease initiates with the discharge of diarrhoeaic stool of foul smell with or without streaks of blood. It may persist for more than a week and sometimes preceded by heavy constipation.

A severe abdominal pain, anaemia, inappetence unthriftiness, loss of weight and sometime paralysis also appear out of coccidiosis. In acute cases, the entire small intestine is found thickened, congested, oedematous and even haemorrhagic. Some white plaques at the serosal surface, white or greyish white papillomata areas throughout the length of the small intestine are also seen due to the aggregation of gametocytes and developing oocysts. Well developed mature schizonts resembling pin-head sized white cysts are found scattered throughout the small intestine. These are sometimes regarded as developing and mature giant schizonts. Bhatia and Pande (1966) observed these bodies in the caecum of a kid and concluded that this stage is more pathogenic than the sexual phase. It leads to the destruction of villi and areas of the small intestine became oedematous and thickened. These cystic bodies are also frequently marked in the mucosa of the abomasum. They are considered as abomasal giant or globidial schizonts as noted by Pande and Bhatia (1966). In acute cases of coccidiosis in goat, Bhatia and Pande (1967) observed large schizonts in the enlarged mesenteric lymph nodes. Pande, Singh and Kala (1964) observed a small schizont in the colon of a kid. A heavy concentration of male and female gametocytes along with the oocysts at different developmental stages are found in the enlarged epithelial cells of the villi, superficially and deep inside the crypts end. Developing and mature giant schizonts of multinucleated mass with thick schizont wall fully compact with hundred to thousand elongated merozoites of different shapes and sizes have been reported. Such giant schizonts have also been noticed in different parts of the mesenteric lymph nodes. Matta and Pande (1966) made a histological study on sheep-stomach and observed globidial schizonts in the abomasum. Though the actual casualty due to coccidiosis has not been estimated but a high percentage of the population of sheep and goats particularly the younger ones are being died every year.

DOMESTIC PIG

Pellerdy (1969, 1974) listed 10 species of *Eimeria* and 2 species of *Isospora* in Swine. Vetterling (1965) opined that there are 8 valid species of *Eimeria* and 2 species of *Isospora* occurring in domestic pig. However, in India we have 7 species of *Eimeria* and 1 species of *Isospora*. An *Isospora* sp. has also been reported from domestic pig in our country. The swine-coccidia in our country has been paid a little attention. The information regarding coccidiosis given below are mainly based on the findings of the workers from abroad. It has been found on post mortem examination that there is catarrhal-inflammatory lesions on the mucus membrane of the large intestine. In severe infections, the epithelium was found to become deducted from the mucous membrane. Wiesenhutter (1962a, b) and Boch and Wiesenhutter (1963) found inflammatory lesions in the small intestine of the domestic pig.

A few slaughter houses and piggeries have been visited by the present author and come across 6 species of *Eimeria* viz. *E. dobliecki*, *E. scabra*, *E. spinosa*, *E. perminuta*, *E. suis* and *E. neodebliecki* from swine. However in India, Upadhyay and Ahluwalia, (1976) after performing the experiments with *E. deblickei*, *E. neodebliecki*, *E. perminuta*

and *I. suis* found four types of schizonts in the different parts of the intestine of pigs. But they could not trace any stages in the section of stomach, caecum, colon and mesenteric lymph glands. The same authors (1977a) reported that on swine coccidia 'Amprolsol' was found very effective, if administered after 2nd day of infection of *E. deblickei*, *E. neodeblickei* and *E. perminuta*.

HOST-PARASITE RELATIONSHIP

The relationship between the host and the parasite has an important role in the survival of the host and the parasite. It is an intricate process of adaptation and depends upon the compatibility between the host and the parasite. When a parasite invades a host, various factors start to exercise their role and determine the acceptance. A well adapted parasite must be able to maintain a condition of equilibrium when neither host nor parasite hampers each other's interest to a fatal degree.

In coccidia, the affinity of a parasite to a particular host species is very common. By nature they are mostly host specific. *Eimeria tenella*, a very common coccidium in the caecum of *Gallus gallus*, under experimental inoculation did not complete its life cycle in several closely phylogenetic relations of *Gallus gullus* (Vetterling, 1976). An extreme case of organ specificity has been shown by Leathem (1969) who did some experiment on caeca-ectomised chicken and found that the schizogonic and gametogonic stages developed close to the caecal orifice. While conducting experiment with *E. ovoidalis*, Ray and Mandal (1961, 62) failed to infect this buffalo-coccidium in cow-calf. Anyway, the same species of *Eimeria* are shared both by bovine and bubaline group of animals. Subramaniam and Jha (1966) did some experiments with *E. fauveli* and *E. ninakholyaki mowi* and were successful in transmitting them from goat to lamb. Levine and Ivens (1970) have reviewed the literature of cross-transmission studies of ruminant coccidia. Out of 158 attempts 11 were found successful in transmitting coccidian species between the cow and the buffalo. Kenneth *et al.* (1977) expressed the validity of this result because the adequate controls and coccidia-free animals were not used while conducting the experiment. The specificity with the species of other Coccidian genera has not been significantly studied. However, they are as a whole limited to a narrow host species range and exhibit some organ system specificity, being limited to a particular type of cell or prefer particular location within the cell.

Many workers have contributed much about the effect of parasites on hosts pertaining to the poultry and farm animals. In India authors like Cooper (1924, 26, 27) Biswal (1948) Gill (1956a) Bhatia and Pande (1967), Pande *et al.* (1968) Pande *et al.* (1971) Shastri *et al.* (1973, 74) and Shastri and Krishnamurthy (1975) reported some incidence of bovine Coccidiosis. Sharma (1951-52), Munjrahar (1954), Ray (1961), Shah (1963) Pande *et al.* (1964) Sivdas *et al.* (1965), Bhatia and Pande 1966, 67, Misra and Goutam (1970) and Bali (1972) mainly dealt with coccidiosis of sheep and goats. Recently Upadhyay and Ahluwalia (1976, 1977b) reported some incidence of swine coccidiosis. Gill and Ray (1957), Gill (1955, 1956b and 1958) Sharma and Reid (1962) Sharma and Foster (1964) Das (1963), Prasad (1963), Mishra (1964), Sharma (1964), Gill *et al.* (1962, 1963) Patnaik (1966b), Rahman and Anantaraman (1970), Bhatia (1971, 1972) Gill and Grewall (1972, 1974) and Bhatia *et al.* (1974) described a great deal about poultry coccidiosis. The clinical symptoms and the course of infection vary from species to species and also within the same species. The disease, however, is highly responsible for morbidity and mortality of the livestock, in general. The younger stock generally suffers a lot, while the older ones may act simply as carrier. But in chronic cases, the host becomes emaciated and results in a loss of body weight, reduction in milk yield, paralysis, etc. The pathological effects depend upon a number of factors viz. the severity of infection,

the species concern, the age and other condition of the host, the size and location of the parasite in the tissue.

The immunity for protecting the host by a particular parasite develops after the initial subclinical infection. It is specific for the species of *Coccidium* to which the animal is exposed. For a long time it was believed that the Coccidiosis was a disease of young animals and attributed to the factor of age resistance. The younger animal is exposed to infection and develops immunity due to which the chances of reinfection decrease in the particular host. However, the younger nonimmune animals are more severely affected by the disease than the older animals already having immunity.

Kenneth *et al.* (1977) discussed about the immunity in *Coccidia* and quite justified in saying that little is known about the mechanism of immunity in the group. Two major factors viz. humoral and cellular factor play the important role. The authors have cited many works in favour of humoral antibodies to *Coccidia* in calves, rabbits and mice, while on the other hand blood or serum from immune host inoculated to susceptible hosts did not give any response against infection. While dealing with rat *Coccidia*, protection by cell or cell reaction has been given very satisfactory result as mentioned by Rommel and Heydon (1971) and Liburd *et al.* (1973). Klesius *et al.* (1975) also supported that the cellular factor (lymphocyte suspension and cell free transfer) was responsible for immunity to Coccidiosis in *E. stiedai* infection. While discussing about the stages affected by the immune response, Fitzgerald (1965, 1968) did some studies with *E. bovis* by exposing the oocysts for radiation and found that irradiated unsporulated oocysts were more resistant to the effect of gamma radiation than the oocysts irradiated in the sporulated state. Some sporulated oocysts completed sporulation and produce mild infection in calves. There are some other records of producing immunity after irradiation of oocysts and subsequent inoculation to the host. Kheysin (=Cheissin 1972) stated that sporulated oocyst of *E. tenella* after being irradiated with 45000 or could infect 12 days old chicks and resulted with a light infection. However, Reid (1975) stated that none of the investigations could not succeed to produce immunogenicity by irradiating the oocysts.

While discussing about the stages affected by the immune response, Ruff and Reid (1977) stated that the entry of the epithelial cells might be blocked partially or the sporozoites if entered inside could not undergo further development. Rose (1973) was of opinion that the infection acted as boosting antigenic stimulus in that partially immunized host which generally affect the life cycle of the parasite and resulted with the shortening of patent period. Moreover, numerous serum antibodies recovered from chicken might play an important role in immobilizing the invasive stages of the parasite. The antibodies found in the alimentary tract (copro-antibodies) may be more important for immunological defense against the infection of coccidia. The main object of the parasite is to survive successfully within the host without causing any fatal injury. In order to achieve this goal, some biological, immunological and physiological factors play most important role and also responsible to develop the host specificity.

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SUMMARY

Coccidia include a group of parasitic protozoa which cause extensive epidemics in poultry and farm animals with a result of serious economic loss in the country. In India 13 species of *Eimeria* are known from cattle and 10 species from sheep and goats. Swine coccidia in our country have received little attention. In total seven species of *Eimeria* and one named and one unnamed species of *Isospora* have been recorded from Indian pigs. Pellerdy (1974) listed nine valid species of *Eimeria* two species of *Isospora* and one species of *Wenyonella* from domestic fowl, of which all the nine species of *Eimeria*, one species of *Wenyonella* and one species of *Isospora* have been reported from our country. In our domestic turkey, six species of *Eimeria* have been reported. Of these, *E. meleagridis*, *E. adenoides* and *E. dispersa* are quite common. The pathogenicity of some of the species occurring in poultry and farm animals has been discussed along with some comments on host — parasite relationship.

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