NOAA Technical Report NMFS 11

Taxonomy of North American Fish Eimeriidae

Steve J. Upton, David W. Reduker, William L. Current, and Donald W. Duszynski

August 1984
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CONTENTS

Introduction ................................................................. 1
Taxonomic description .................................................. 2
  Eimeria anguillae .................................................... 2
  Eimeria aurati ......................................................... 2
  Eimeria brevoortiana ................................................ 2
  Eimeria catostomi .................................................... 3
  Eimeria dusczynskii .................................................. 3
  Eimeria etheostoma ................................................... 3
  Eimeria fandel ....................................................... 3
  Eimeria fernandoae .................................................. 4
  Eimeria fremani ...................................................... 4
  Eimeria funduli ...................................................... 4
  Eimeria gasterostei ................................................... 4
  Eimeria glenorensis .................................................. 4
  Eimeria haneki ....................................................... 4
  Eimeria hoffmani ..................................................... 5
  Eimeria hybognathi ................................................... 5
  Eimeria icthi ...................s ........................................ 5
  Eimeria iroquoia ...................................................... 5
  Eimeria laureleus .................................................... 6
  Eimeria micropteri ................................................... 6
  Eimeria moronei ...................................................... 6
  Eimeria myxoxephal .................................................. 6
  Eimeria ojibwana .................................................... 6
  Eimeria osmeri ....................................................... 7
  Eimeria pungitii ...................................................... 7
  Eimeria salvini ....................................................... 7
  Eimeria squali ....................................................... 7
  Eimeria tedlai ....................................................... 7
  Eimeria truttae ...................................................... 8
  Eimeria sp. Davis, 1946 ................................................ 8
  Eimeria sp. Fantham and Porter, 1948 ................................. 8
  Eimeria sp. Fantham and Porter, 1948 ................................. 8
  Eimeria sp. Munson, 1974 ............................................ 8
  Eimeria sp. Orias and Noble, 1971 .................................. 8
  Goussia caseosa ..................................................... 9
  Goussia degustii ..................................................... 9
  Goussia gadi ........................................................ 9
Key to Eimeriidae of North American fishes ......................... 9
Acknowledgments .......................................................... 11
Literature cited ............................................................ 11
Figures 1-30 .................................................................. 13
Taxonomy of North American Fish Eimeriidae

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ABSTRACT

Taxonomic descriptions, line drawings, and references are given for the 30 named and 5 unnamed species of North American fish Eimeriidae. In addition, a key was developed based on available morphologic data to distinguish between similar species. Taxa are divided into two genera: Eimeria (27 species) which are tetrasporocystic with dizoic, nonbivalved sporocysts, and Goussia (3 species) which are tetrasporocystic with dizoic, bivalved sporocysts that lack Stieda bodies and have sporocyst walls composed of two longitudinal valves.

INTRODUCTION

The phylum Apicomplexa Levine, 1970, comprises about 4,000 species of totally parasitic protozoa which include the gregarines, haemogregarines, coccidia, malaria, and piroplasms (see Levine 1982 for taxonomic review). The largest family in the phylum is the Eimeriidae Minchin, 1903, which contains nearly 1,400 named species; over 75% of which belong to a single genus Eimeria.

Traditionally, genera within the Eimeriidae have been classified according to the number of sporozoites within the oocyst and the number of sporozoites within the sporocysts. The Eimeria are characterized by an oocyst which contains four sporocysts, each with two sporozoites.

Most Eimeriidae are species (or at least genus) specific and have similar life cycles. After an appropriate host ingests a sporulated oocyst, sporozoites are released into the intestinal lumen by the action of digestive enzymes and bile salts upon the oocyst and sporocysts. Sporozoites of most species enter intestinal epithelial cells where they reproduce asexually by merogony (schizogony), forming numerous merozoites by multiple fission. Usually merozoites enter new host cells and initiate one or more merogonous cycles. The number of asexual generations is believed to be genetically determined and the last generation merozoites without karyokinesis into macrogametes, while others undergo multiple fission giving rise to numerous flagellated microgametes. When released, microgametes apparently fertilize macrogametes and the resulting zygote forms an oocyst wall to protect it from adverse environmental conditions. Usually, oocysts are passed out of the host unsporulated. Under the appropriate conditions of oxygen, temperature, and moisture, sporulation will occur and the sporulated oocyst is then infective for the next host via fecal-oral contamination. Thus, most Eimeriidae develop directly (utilize one host) and produce self-limited infections.

About 130 named species and over two dozen unnamed species of fish coccidia have been reported. All of these species except three, Cryptosporidium nasoris and Ferguson, 1981, from a naso tang; Sarcocystis salvelini Fantham and Porter, 1943 from a trout; and Sarcocystis sp. Fantham and Porter, 1943 from an eel pout, have been placed within the Eimeria (Fantham and Porter 1943; Hoover et al. 1981).

Although little is known about the life cycles of fish coccidia, most developmental stages appear morphologically similar to the more well known species infecting higher vertebrates. However, two important differences can be noted for the coccidia of fish. First, about one-third of the species of fish coccidia develop and sporulate in nonintestinal sites and apparently remain in situ until the host dies. Second, whether oocysts remain in host tissues or exit via the feces, fish coccidia usually sporulate endogenously and, presumably, are immediately infective when they contact the external environment. Although the significance of these peculiarities is not known, readers are directed to a recent review by Dyková and Lom (1981) for an excellent overview of the biology of fish coccidia.

Virtually nothing is known about the incidence of fish coccidia in North America and little is known about the impact that these coccidia have on their fish hosts. Solangi and Ogle (1981) reported lower weight gains for killifish infected with the hepatic coccidium Eimeria funduli than for uninfected, control fish. Odense and Logan (1976) believed heavy swim bladder infections of Goussia gadi might interfere with the ability of haddock to spawn. In other countries, however, some fish coccidia have been shown to be economically important pathogens. Eimeria sinensis, E. subepithelialis, and Goussia carpelli may cause enteritis and death of commercially reared carp (Molnar 1979; Dyková and Lom 1981). New Zealand eels infected with E. anguillae may become emaciated and weak (Hine 1975). Sterility can result in male clupeids infected with the testicular coccidium E. sardinae (Pinto 1956). MacKenzie (1981) has reported that an unnamed species of hepatic coccidium causes blue whiting to weigh less than uninfected fish of similar age.

Recently, Dyková and Lom (1981) have split the Eimeria of fish into four genera based on available morphologic and life cycle data. These include: 1) Eimeria, which retains most of the species and is characterized by being tetrasporocystic with dizoic, nonbivalved sporocysts with or without Stieda bodies; 2) Goussia Labbé, 1896 containing about 20 species which are tetrasporocystic, dizoic, lack Stieda bodies, and have sporocyst walls consisting of two valves joined by a longitudinal suture (Dyková and Lom 1981; Lom and Dyková 1982a, b); 3) Cryptosporidium Labbé, 1896 contains a single species, Cryptosporidium cristaloides (Thélohan, 1893) Dyková and Lom, 1981, which is tetrasporocystic, dizoic, and has dodecahedral sporocysts composed of two...
hexagonal, pyrimidal valves joined at their bases by a suture; and 4) *Epieimeria* Dykova and Lorn, 1981 which was created for those tetrasporocytic, dizoic Eimeriidae of fish that possess Stieda bodies and undergo merogony and gametogony on the luminal surface of the intestinal tract; three species are included in this genus (Dykova and Lorn 1981; Lorn and Dykova 1982a).

Innate problems exist with portions of this classification scheme; particularly for those unfamiliar with the peculiarities of fish coccidia. *Crystallospora* has been reported only once, and only briefly, since the original description in 1893 (Dogié 1948). We believe a more accurate and up to date description is needed to retain this genus. Some species (*e.g.*, *Eimeria anguillae* Léger and Hollande, 1922 and *Eimeria hesogona* Lorn and Dykova, 1981) also appear hexagonal in cross section and, thus, the only difference between the sporocysts of *Crystallospora* and those of several other species is the location of the suture. A more detailed examination of the sporocyst, particularly in the placement of the suture, is needed before the use of the genus *Crystallospora* can be warranted.

The *Epieimeria*, which are probably not epicellular but rather develop in a parasitophorous vacuole on the luminal side of the endothelium, require histological and cytological examination to differentiate them from the *Eimeria*. Additionally, *Eimeria pigra* Léger and Bory, 1932, a coccidium infecting the intestinal epithelium of the rudd, *Scardinius erythrophthalmus*, not only develops "epicellularly," but occasionally intracellularly and lacks a Stieda body, unlike other *Epieimeria*. This genus also requires additional research to warrant proper recognition.

Pellérdy (1974) provided descriptions of most of the known fish coccidia through 1970. Since then, many new species have been reported. Because of the numerous species of fish coccidia, and because many of the original descriptions are in languages other than English, a detailed summary of each species is beyond the scope of this paper. Instead, our purpose is to provide succinct taxonomic descriptions of the known Eimeriidae from North American fish and to provide line drawings and original references that would be beneficial. These are presented below, along with literature known to us on North American fish coccidia. Taxa are divided into two genera, *Eimeria* and *Goussia*, and a taxonomic scheme is presented that we believe provides for rapid and accurate means of diagnosing fish coccidia.

**TAXONOMIC DESCRIPTION**

**Eimeriidae Minchin, 1903**

*Genus Eimeria* Schneider, 1875

Oocysts contain four sporocysts, each with two sporozoites; Stieda body may or may not be present; sporocyst wall non-bivalved.

**Eimeria anguillae** Léger and Hollande, 1922  
(Fig. 1)

**Hosts:** *Anguilla anguilla* "European eel," *A. australis* "short-finned eel," *A. dieffenbachii* "long-finned eel," *A. rostrata* "American eel" (*Anguilliformes*) (C3).

**Description:** Oocysts spherical, 9.8 (9.1-10.4) (see footnote 3). Wall smooth and colorless, composed of a single layer \( \approx 0.1 \). Micropyle, polar granule, and oocyst residuum absent. Sporocysts ovoid, hexagonal in cross section, 7.8 by 4.1 (7.5-8.0 by 3.9-4.4), in contact with oocyst wall. They are usually arranged so that parallel pairs of sporocysts cross each other. Wall thin, \( \approx 0.2 \); Stieda body present, formed by 4 papillae situated at tapered end of sporocyst. Sporocyst residuum present, spherical or ellipsoidal, compact, 2.3 by 1.6 (1.9-2.6 by 1.3-1.9). Sporozoites vermiform, reflexed at one end, 6.8 by 1.5 (6.5-7.0 by 1.3-1.8) (without reflexed portion), arranged head to tail in sporocyst. Refractile bodies absent.

**Sporulation:** Endogenous.

**Geographical locations:** Corsica; New Zealand; Quebec, Canada.

**Location in host:** Anterior intestinal epithelium; feces.

**References:** Léger and Hollande (1922); Schulman and Shtein (1962); Molnar and Hanek (1974); Hine and Boustead (1974); Hine (1975); Dykova and Lorn (1981).

**Remarks:** Merogony and gamogony occur on the luminal border of the endothelium in the anterior portion of the intestine. The description is based predominately on that given by Molnar and Hanek (1974).

**Eimeria aurati** Hoffman, 1965  
(Fig. 2)

**Host:** *Carassius auratus* “goldfish” (*Cypriniformes*) (F).

**Description:** Oocysts ovoid, occasionally spherical, 20.1 by 16.3 (16.0-24.0 by 14.0-17.0). Wall thin, \( \approx 0.3 \). Micropyle, polar granule, and oocyst residuum absent. Sporocysts ellipsoidal, 11.0-13.0 by 6.5-8.0. Stieda body and sporocyst residuum absent. Sporozoites sausage-shaped, 10.0-13.0 by 2.0-2.5, lying lengthwise and nearly filling the sporocyst entirely. Refractile bodies absent. Older oocysts may contain free sporozoites.

**Sporulation:** Exogenous.

**Geographical location:** Pennsylvania, U.S.A.

**Location in host:** Anterior intestinal epithelium; feces.

**Reference:** Hoffman (1965).

**Remarks:** Unsporulated oocysts were numerous in long, whitish, opaque fecal casts.

**Eimeria brevoortiana** Hardcastle, 1944  
(Fig. 3)

**Host:** *Brevoortia tyrannus* "Atlantic menhaden" (*Clupeiformes*) (M).

**Description:** Oocysts spherical, 25.1 (17.5-30.0), or occasionally ovoid, 26.2 by 22.7 (21.2-30.0 by 15.0-27.5). Micropyle absent; oocyst residuum described but not depicted. A polar granule is not described or depicted. Sporocysts elongate, 16.4 by 5.3.
Sporocyst residuum small; a Stieda body is not described. Sporozoites cigar-shaped, slightly curved, 15.0 by 2.5 and arranged head to tail within the sporocyst. Each sporozoite contains a large, centrally located nucleus and (possibly) a small, anterior, refractile body.

**Sporulation:** Endogenous.

**Geographical location:** Beaufort, North Carolina, U.S.A.

**Location in host:** Testes.

**Reference:** Hardcastle (1944).

**Remarks:** Hardcastle (1944) found that merogony and gamogony occurred in the endothelium of the pyloric caeca of both male and female fish, however, oocysts were only found in the testes of males. He postulated that after fertilization, a reduction division occurred involving the entire zygote resulting in two migratory ookinetes which carried the infection to the testes. Two separate species may be involved.

**Eimeria catostomi** Molnar and Hanek, 1974  
(Fig. 4a, b)

**Hosts:** Catostomus commersoni “white sucker,” Hypentelium nigricans “northern hog sucker” (Cypriniformes) (F).

**Description:** Oocysts spherical, 7.0 (6.5-7.5). Wall smooth, colorless, composed of a single layer ≈ 0.1. Micropyle and oocyst residuum absent. Polar granule present, centrally located, 0.8 (0.7-0.9). Sporocysts ovoid, flattened on one side, 5.5 by 3.8 (5.2-5.9 by 3.6-4.0), in contact with oocyst wall. Sporocysts arranged so that three lie in one plane with fourth overlying. Wall single layered, ≈ 0.2; Stieda body absent. Sporocyst residuum spherical, finely granular, 2.3 (2.0-2.6). Sporozoites vermiform, slightly curved with one end reflected, 4.6 by 1.4 (4.4-4.8 by 1.3-1.6) and lie head to tail within the sporocyst. Refractile bodies absent.

**Sporulation:** Endogenous.

**Geographical location:** Ontario, Canada.

**Location in host:** Anterior intestinal epithelium; feces.

**Reference:** Molnar and Hanek (1974).

**Eimeria duszynskii** Conder, Oberndorfer, and Heckmann, 1980  
(Fig. 5)

**Host:** Cottus bairdi “mottled sculpin” (Perciformes) (F).

**Description:** Oocysts irregular in shape, 12.2 (11.6-12.9). Wall very thin, adhering closely to sporocysts. Micropyle, polar granule, and oocyst residuum absent. Sporocysts ovoid, 9.1 by 6.0 (8.4-10.0 by 5.2-6.3), with one side slightly flattened. Stieda and subsieda bodies absent. Sporocyst residuum present, compact and coarsely granular, occasionally dispersed. Sporozoites 2.1 wide, lying head to tail in sporocyst with one end reflected. Each sporozoite contains a large, oblong, refractile body near one end. A spherical nucleus and transverse banding occur at the end opposite from the refractile body.

**Sporulation:** Endogenous.

**Geographical location:** Provo river, Utah, U.S.A.

**Location in host:** Intestinal epithelium; feces.

**Reference:** Conder et al. (1980).

**Eimeria etheostomae** Molnar and Hanek, 1974  
(Fig. 6)

**Hosts:** Etheostoma exile “Iowa darter,” E. nigrum “Johnny darter” (Perciformes) (F).

**Description:** Oocysts spherical, 9.4 (9.1-10.4). Wall smooth and colorless, composed of a single layer ≈ 0.1. Micropyle, polar granule, and oocyst residuum absent. Sporocysts coffee-bean shaped, 8.5 by 5.0 (7.8-9.1 by 4.5-5.4), in contact with oocyst wall. Sporocysts usually arranged so that three lie in one plane with fourth overlying. Stieda body absent. Sporocyst residuum present, spherical, and finely granular, 3.6 (3.1-3.9). Sporozoites banana-shaped, 8.4 by 1.6 (7.8-9.0 by 1.4-1.8), arranged head to tail in sporocyst. Rarely, one end of the sporozoite may be reflexed. Each sporozoite has a spherical refractile body.

**Sporulation:** About one-half of the oocysts sporulate endogenously; the rest exit semisporulated.

**Geographical location:** Ontario, Canada.

**Location in host:** Anterior intestinal epithelium; feces.

**Reference:** Molnar and Hanek (1974).

**Eimeria fernandoae** Molnar and Hanek, 1974  
(Fig. 7)

**Hosts:** Catostomus commersoni “white sucker,” Hypentelium nigricans “northern hog sucker” (Cypriniformes) (F).

**Description:** Oocysts ellipsoid, 8.3 by 6.6 (7.8-9.0 by 6.5-7.0). Wall smooth and colorless, composed of a single layer ≈ 0.1. Micropyle, polar granule, and oocyst residuum absent. Sporocysts ellipsoid, 7.2 by 3.0 (6.8-7.5 by 2.6-3.4), in contact with oocyst wall. All four sporocysts lie parallel in oocyst. Wall 0.2; Stieda body absent. Sporocyst residuum spherical and finely granular, 2.6 (2.3-3.2). Sporozoites banana-shaped, 5.8 by 1.2 (5.2-6.5 by 1.0-1.3), arranged head to tail in sporocyst. Each sporozoite has a spherical refractile body.

**Sporulation:** Endogenous.

**Geographical location:** Ontario, Canada.

**Location in host:** Anterior intestinal epithelium; feces.

**Reference:** Molnar and Hanek (1974).
**Eimeria freemani** Molnar and Fernando, 1974  
(Fig. 8)

Host: *Notropis cornutus* “common shiner” (Cypriniformes) (F).

Description: Oocysts ellipsoid, 22.0-24.0 by 17.0-18.0. Wall smooth and colorless, composed of a single layer ∼ 0.1. Oocyst residuum absent, a micropyle is not described. Polar granule present, 1.0-2.0. Sporocysts ellipsoid, 16.0-17.0 by 5.0-6.5, arranged parallel within oocyst. Wall ∼ 0.2; a Stieda body is not described. Sporocyst residuum spherical, compact, and finely granular, 2.5-5.0. Sporozoites banana-shaped, 14.0-15.5 by 2.5-3.5. Each sporozoite has a large, posterior, refractile body and a smaller refractile body more centrally located.

Sporulation: Endogenous.

Geographical location: Ontario, Canada.

Location in host: Kidney, renal parenchyma, renal tubules.


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**Eimeria funduli** Duszynski, Solangi, and Overstreet, 1979  
(Fig. 9)


Description: Oocysts spherical, 24.5 (20.0-31.0). Wall smooth and colorless, ∼ 1.0, composed of two layers of equal thickness. Outer layer transparent; inner layer opaque. Micropyle, polar granule, and oocyst residuum absent. Sporocysts ovoid, 10.0 by 6.0 (9.0-11.0 by 5.0-7.0). Shape index 1.68 (1.45-2.02). Stieda and substieda bodies present. Thin membrane encloses sporocysts completely forming a transparent matrix, 1.7 (1.0-3.0) wide. Membrane supported by 15 (10-25) footlike structures termed sporopodia attached to outer surface of sporocysts. Sporocyst residuum present, consisting of 1 to 4 refractile granules between the sporozoites. Each sporozoite contains a single refractile body near the posterior end.

Sporulation: Endogenous.

Geographical locations: Estuaries of Mississippi, Alabama, and Louisiana, U.S.A.

Location in host: Liver (rarely intestinal mucosa and submucosa, ovary, testes, caudal peduncle).

References: Duszynski et al. (1979); life-cycle, Solangi and Overstreet (1980), Upton and Duszynski (1982), Fournie and Overstreet (1983); Hawkins, Fournie, and Overstreet (1983b); effect of temperature, Solangi et al. (1982); prevalence, Fournie and Solangi (1980); effects on fish, Solangi and Ogle (1981), Hawkins et al. (1981); transmission studies, Fournie and Overstreet (1982); ultrastructure of sexual stages, Hawkins, Solangi, and Overstreet (1983a, b); ultrastructure of oocysts, Hawkins, Fournie, and Overstreet (1983a).

**Eimeria gasterostei** (Thélohan, 1890) Dolfin, 1909  
(Fig. 10)

Synonym: *Coccidium gasterostei* Thélohan, 1890

Hosts: *Gasterosteus aculeatus* “threespine stickleback” (Gasterosteiformes) (F, M).

Description: Oocysts spherical, 16.0-18.0, with smooth thin wall. Oocyst wall greatly separated from sporocysts. Oocyst residuum absent; micropyle and polar granule not described. Sporocysts elongate, narrowing at poles, 10.0-14.3 by 4.0-6.5. Sporocyst residuum large and coarsely granular. Sporozoites botuliform, each with a large refractile body.

Sporulation: Endogenous.

Geographical locations: Vancouver, British Columbia; Kamchatka, Paratunka river basin.

Location in host: Liver.

References: Thélohan (1890); Schulman and Shtein (1962); Lester (1974).

Remarks: Description is based on that given by Thélohan (1890), Schulman and Shtein (1962), and Lester (1974).

**Eimeria glnorensis** Molnar and Fernando, 1974  
(Fig. 11)

Host: *Morone americana* “white perch” (Perciformes) (F).

Description: Oocysts spherical, 10.5-12.0. Wall smooth and colorless, ∼ 0.1, composed of a single layer ∼ 0.1. Oocyst residuum absent; a micropyle is not described. One or two polar granules present, 1.0-2.0. Sporocysts ovoid, 8.0-9.5 by 5.7-6.0, in contact with oocyst wall. Stieda body present, consisting of a thickening of the sporocyst wall at tapered end, ∼ 0.5 high; rest of wall ∼ 0.3. Sporocyst residuum spherical and compact, refractile, 2.0-2.6. Sporozoites vermiform, one end reflexed, 5.0-5.3 by 2.0-2.2 (without reflexed portion). Reflexed portion 2.5-2.7 long. Sporozoites arranged head to tail in sporocyst. Refractile bodies absent.

Sporulation: Endogenous.

Geographical location: Ontario, Canada.

Location in host: Intestinal epithelium; feces.


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**Eimeria haneki** Molnar and Fernando, 1974  
(Fig. 12)

Host: *Culaea inconstans* “brook stickleback” (Gasterosteiformes) (F).

References: Duszynski et al. (1979); life-cycle, Solangi and Overstreet (1980), Upton and Duszynski (1982), Fournie and Overstreet (1983); Hawkins, Fournie, and Overstreet (1983b); effect of temperature, Solangi et al. (1982); prevalence, Fournie and Solangi (1980); effects on fish, Solangi and Ogle (1981), Hawkins et al. (1981); transmission studies, Fournie and Overstreet (1982); ultrastructure of sexual stages, Hawkins, Solangi, and Overstreet (1983a, b); ultrastructure of oocysts, Hawkins, Fournie, and Overstreet (1983a).
Granular, 5.8-8.0 by 4.5-5.2. Sporozoites banana-shaped, one end of parallel sporocysts cross each other. Wall: 0.2. A Stieda body contacts with oocyst wall. Sporocysts usually arranged so that pairs of parallel sporocysts cross each other. Wall: 0.2. A Stieda body is not described. Sporocyst residuum spherical and compact, nongranular, refractile, 1.3-1.5. Sporozoites vermiciform, one end reflexed, 5.6-6.0 by 1.3-2.0 (without reflexed portion), arranged head to tail in sporocyst. Each sporozoite has a spherical refractile body.

Sporulation: Endogenous.

Geographical location: Ontario, Canada.

Location in host: Intestinal epithelium; feces.


**Eimeria hoffmani** Molnar and Hanek, 1974 (Fig. 13)

*Host:* Umbra limi “central mudminnow” (Salmoniformes) (F).

*Description:* Oocysts ellipsoid, 11.5 by 9.2 (11.0-12.2 by 9.1-9.6). Wall smooth and colorless, composed of a single layer ≥ 0.1. Micropyle and oocyst residuum absent. Polar granule present, 0.8 (0.7-0.9). Sporocysts ellipsoid, 10.0 by 3.6 (9.6-10.4 by 3.4-3.9), arranged lengthwise and parallel in oocyst. Wall: 0.2; A Stieda body absent. Sporocyst residuum ellipsoid and finely granular, 6.4 by 2.0 (6.2-6.6 by 1.8-2.2). In older oocysts the residuum is either less elongate or dispersed. Sporozoites vermiciform, one end reflexed, 8.6 by 1.4 (8.4-8.7 by 1.3-1.5), (without reflexed portion), arranged head to tail in sporocyst. Refractile bodies absent.

Sporulation: Endogenous.

Geographical location: Ontario, Canada.

Location in host: Anterior intestinal epithelium; feces.


**Eimeria hybognathi** Molnar and Fernando, 1974 (Fig. 14)

*Host:* Hybognathus hankinsoni “brassy minnow” (Cypriniformes) (F).

*Description:* Oocysts spherical, 14.0-14.5. Wall of uniform thickness, composed of a single layer ≥ 0.1. Polar granule and oocyst residuum absent. A micropyle is not described. Sporocysts ellipsoid, 9.5-10.0 by 5.7-6.0, with a narrow space separating them from oocyst wall. They are usually arranged so that pairs of parallel sporocysts cross each other. Sometimes three lie in one plane with the fourth overlying. Wall: 0.2. A Stieda body is not described. Sporocyst residuum ovoid, compact, and finely granular, 5.8-8.0 by 4.5-5.2. Sporozoites banana-shaped, one end slightly reflected, 9.0-9.2 by 2.0-2.6, lying head to tail in sporocyst. A single spherical refractile body is present in each sporozoite.

Sporulation: Endogenous.

Geographical location: Ontario, Canada.

Location in host: Intestinal epithelium; feces.


**Eimeria ictaluri** Molnar and Fernando, 1974 (Fig. 15)

*Host:* Ictalurus nebulosus “brown bullhead” (Siluriformes) (F).

*Description:* Oocysts spherical, 9.0-10.5. Wall colorless and of uniform thickness, composed of a single layer ≥ 0.1. Polar granule and oocyst residuum absent; a micropyle is not described. Sporocysts ellipsoid, rarely coffee-bean shaped, 7.8-8.4 by 3.6-4.2, in contact with oocyst wall. Sporocysts usually arranged so that pairs of parallel sporocysts cross each other. Wall: 0.2; A Stieda body is not described. Sporocyst residuum ovoid, compact, and coarsely granular, 5.0-5.3 by 3.0-3.3. Sporozoites vermiciform, one end reflexed, 7.1-7.8 by 1.5-1.8, without reflexed portion, arranged head to tail in sporocyst. Each sporozoite has a spherical refractile body.

Sporulation: Endogenous.

Geographical location: Ontario, Canada.

Location in host: Intestinal epithelium; feces.


**Eimeria iroquoina** Molnar and Fernando, 1974 (Fig. 16)


*Description:* Oocysts spherical, 9.0-11.0. Wall colorless and of uniform thickness, composed of a single layer ≥ 0.1. Polar granule and oocyst residuum absent; a micropyle is not described. Sporocysts ellipsoid, 7.8-8.0 by 4.0-4.5, in contact with oocyst wall. Sporocysts usually arranged so that pairs of parallel sporocysts cross each other. Wall: 0.2; A Stieda body is not described. Sporocyst residuum ovoid, finely granular, 2.3-4.0 by 2.2-3.0. Sporozoites vermiciform, one end reflexed, 7.5-7.7 by 1.5-1.7 (without reflexed portion), arranged head to tail in sporocyst. Each sporozoite has a spherical refractile body.

Sporulation: Endogenous.

Geographical location: Ontario, Canada.

Location in host: Intestinal epithelium; feces.
References: Molnar and Fernando (1974); Molnar and Hanek (1974); Paterson and Desser (1981a, b, c, 1982).

**Eimeria laureleus** Molnar and Fernando, 1974 (Fig. 17)

*Host*: *Perca flavescens* “yellow perch” (Perciformes) (F).

*Description*: Oocysts spherical, 11.0-12.0. Wall colorless and of uniform thickness, composed of a single layer ≈ 0.1. Polar granule and oocyst residuum absent; a micropyle is not described. Sporocysts coffee-bean shaped, 9.2-11.0 by 5.0-5.8, in contact with oocyst wall. Sporocysts usually arranged so that pairs of parallel sporocysts cross each other. A Stieda body is not described. Sporocyst residuum finely granular and dispersed. Sporozoites vermiform, one end reflexed, 9.0-10.0 by 1.5-2.0, without reflexed portion, arranged head to tail in sporocyst. Each sporozoite has a spherical refractile body.

*Sporulation*: Endogenous.

*Geographical location*: Ontario, Canada.

*Location in host*: Intestinal epithelium; feces.


**Eimeria micropteri** Molnar and Hanek, 1974 (Fig. 18)

*Host*: *Micropterus dolomieui* “smallmouth bass,” *M. salmoides* “largemouth bass” (Perciformes) (F).

*Description*: Oocysts spherical, 12.0 (11.7-12.5). Wall smooth and colorless, composed of a single layer ≈ 0.1. Micropyle, polar granule, and oocyst residuum absent. Sporocysts ellipsoid, 11.4 by 6.2 (11.0-11.7 by 6.0-6.5), in contact with oocyst wall. Sporocysts arranged three in one plane with fourth overlying. Wall ≈ 0.2; Stieda body absent. Sporocyst residuum finely granular, dispersed. Sporozoites vermiform, one end reflexed, 9.1 by 2.1 (8.9-9.3 by 2.0-2.2), (without reflexed portion), arranged head to tail in sporocyst. Each sporozoite has a spherical refractile body.

*Sporulation*: About 90% leave the gut semisporulated; the rest exit fully sporulated.

*Geographical location*: Ontario, Canada.

*Location in host*: Anterior intestinal mucosa; feces.


**Eimeria moronei** Molnar and Fernando, 1974 (Fig. 19)

*Host*: *Morone americana* “white perch” (Perciformes) (F).

*Description*: Oocysts spherical, 7.2-8.0. Wall colorless and of uniform thickness, composed of a single layer ≈ 0.1. Oocyst residuum absent; a micropyle is not described. Polar granule present, 1.0-2.0. Sporocysts ovoid, 5.7-6.0 by 3.9-4.0, in contact with oocyst wall. Sporocysts arranged three in one plane with fourth overlying. Wall ≈ 0.2; Stieda body present, consisting of a distinct knoblike thickening at tapered end. Sporocyst residuum spherical, compact, refractile, 1.5-2.0. Sporozoites vermiform, 5.0-5.4 by 1.5-2.0, arranged head to tail in sporocyst. Refractile bodies absent.

*Sporulation*: Endogenous.

*Geographical location*: Ontario, Canada.

*Location in host*: Intestinal epithelium; feces.


**Eimeria myoxocephali** Fitzgerald, 1975 (Fig. 20)

*Host*: *Myoxocephalus polyacanthocephalus* “great sculpin” (Perciformes) (M).

*Description*: Oocysts spherical, 37.2 (34.0-40.0). Wall bilayered and smooth, ≈ 2.0. Micropyle and oocyst residuum absent; a polar granule is not described or depicted. Sporocysts composed of a thin membrane stretched tightly around the sporozoites. Sporocyst residuum present, small, and spherical. Sporozoites elongate, 16.7 by 3.7, twisted around each other and arranged head to tail in sporocyst membrane. A single refractile body is present in each sporozoite.

*Sporulation*: Endogenous.

*Geographical location*: Puget Sound, Washington, U.S.A.

*Location in host*: Anterior intestinal epithelium; feces.


**Eimeria ojibwana** Molnar and Fernando, 1974 (Fig. 21)

*Host*: *Cottus bairdi* “mottled sculpin” (Perciformes) (F).

*Description*: Oocysts spherical, 10.4-11.0. Wall colorless and of uniform thickness, composed of a single layer ≈ 0.1. Micropyle, polar granule, and oocyst residuum absent; a micropyle is not described. Sporocysts coffee-bean shaped, 9.0-9.2 by 5.0-5.8, in contact with oocyst wall. Sporocysts usually arranged so that pairs of parallel sporocysts cross each other. Wall ≈ 0.2; a Stieda body is not described. Sporocyst residuum composed of irregularly sized granules, dispersed. Sporozoites vermiform, reflexed on one end, 8.4-8.7 by 2.0-2.5 (without reflexed portion), arranged head to tail in sporocyst. Each sporozoite has a spherical refractile body.

*Sporulation*: Endogenous.

*Geographical location*: Ontario, Canada.

*Location in host*: Intestinal epithelium; feces.

**Eimeria osmeri** Molnar and Fernando, 1974 (Fig. 22)

*Host: Osmerus mordax* "rainbow smelt" (Salmoniformes) (F).

*Description:* Oocysts spherical, 10.4-11.0. Wall colorless and of uniform thickness, composed of a single layer \( \approx 0.1 \). Oocyst residuum absent; a micropyle is not described. One or two polar granules present, 1.5-1.7. Sporocysts ovoid, 7.1-7.8 by 4.3-4.7, with a narrow space separating them from oocyst wall. Stieda body present, consisting of thickening of sporocyst wall at tapered end, \( \approx 0.4 \) high; rest of sporocyst wall \( \approx 0.2 \). Sporocyst residuum spherical and compact, refractile, 1.3-1.7. Sporozoites vermiform, reflexed on one end, 6.0-7.1 by 1.3-1.7 (without reflexed portion), arranged head to tail in sporocyst. Refractile bodies absent.

*Sporulation:* Endogenous.

*Geographical location:* Ontario, Canada.

*Location in host:* Intestinal epithelium; feces.


**Eimeria pungitii** Molnar and Hanek, 1974 (Fig. 23)

*Host: Pungitius pungitius* "nine-spine stickleback" (Gasterosteiformes) (F).

*Description:* Oocysts ellipsoid, 12.5 by 9.8 (12.1-13.0 by 8.6-10.4). Wall smooth and colorless, composed of a single layer \( \approx 0.1 \). Micropyle, polar granule, and oocyst residuum absent. Sporocysts ellipsoid, 10.0 by 3.6 (9.1-10.4 by 3.4-3.9), in contact with oocyst wall. All four sporocysts arranged lengthwise and parallel in oocyst. Wall \( \approx 0.2 \); Stieda body absent. Sporocyst residuum granular, dispersed, completely filling sporocyst. Sporozoites banana-shaped, 8.7 by 2.3 (8.4-9.1 by 2.1-2.4), arranged head to tail in sporocyst. Each sporozoite contains a spherical refractile body.

*Sporulation:* Most oocysts leave the host unsporulated.

*Geographical location:* Quebec, Canada.

*Location in host:* Anterior intestinal epithelium; feces.


**Eimeria salvelini** Molnar and Hanek, 1974 (Fig. 24)

*Host: Salvelinus fontinalis* "brook trout" (Salmoniformes) (F).

*Description:* Oocysts spherical, 12.0 (11.7-12.5). Wall smooth and colorless, composed of a single layer \( \approx 0.1 \). Micropyle, polar granule, and oocyst residuum absent. Sporocysts ovoid, 9.2 by 5.1 (9.0-9.4 by 5.0-5.3), in contact with oocyst wall. Caplike Stieda body present at tapered end, 1.1 (0.9-1.3) high; rest of wall \( \approx 0.2 \). Sporocysts arranged three in one plane with fourth overlying. Sporocyst residuum spherical and compact, 1.8 (1.5-2.1).

*Sporulation:* Endogenous.

*Geographical location:* Ontario, Canada.

*Location in host:* Intestinal epithelium; feces.

**Eimeria tedlai** Molnar and Fernando, 1974 (Fig. 26)

*Host: Perca flavescens* "yellow perch" (Perciformes) (F).

*Description:* Oocysts spherical, 9.5-10.0. Wall colorless and of uniform thickness, consisting of a single layer \( \approx 0.1 \). Oocyst residuum absent; a micropyle is not described. Polar granule present, refractile, 1.0-1.5. Sporocysts ovoid, 8.4-8.7 by 4.5-4.7, in contact with oocyst wall. Sporocysts usually arranged so that pairs of parallel sporocysts cross each other. Caplike Stieda body at tapered end, 1.5-2.0 high; rest of wall \( \approx 0.3 \). Sporocyst residuum spherical or ellipsoid, refractile, 1.5-2.6 by 1.5-2.0. Sporozoites vermiform, one end reflexed, 6.0-6.5 by 1.6-2.1 (without reflexed portion), arranged head to tail in sporocyst. Refractile bodies absent.

*Sporulation:* Endogenous.

*Geographical location:* Ontario, Canada.

*Location in host:* Intestinal epithelium; feces.

**Eimeria squali** Fitzgerald, 1975 (Fig. 25)

*Host: Squalus acanthias* "spiny dogfish shark" (Chondrichthyes) (M).

*Description:* Oocysts ovoid or ellipsoid, 24.0-36.0 by 20.0-29.0. Wall brownish lavender, pitted, with the bottoms of the pits light green or grey. Sporont spherical, 19.9 (16.0-28.0). Micropyle absent; a polar granule is not described. Oocyst residuum \( \approx 12.4 \). Sporocysts ellipsoid, 19.6 by 5.9. Several fibers extend from pointed ends of sporocysts when forced from oocysts, disappearing shortly after leaving oocyst. A Stieda body is not described. Sporocyst residuum consisting of several small, spherical granules in each sporocyst. Sporozoites slender, spindle-shaped, 13.6 by 2.2, slightly twisted in a head to tail arrangement. Each sporozoite has weakly visible cross striations while still in the sporocyst extending for about one-fifth of its length at the larger end. Refractile body not described but depicted at end opposite to striations in sporozoite.

*Sporulation:* Exogenous.

*Geographical location:* Puget Sound, Washington, U.S.A.

*Location in host:* Mucosa of spiral valve; feces.


**Eimeria truttae** (Léger and Hesse, 1919)  
Stankovitch, 1924  
(Fig. 27)

**Synonym:** Goussia truttae Léger and Hesse, 1919.

**Hosts:** Salvelinus fontinalis “brook trout,” Salmo trutta fario “German brown trout” (Salmoniformes) (F).

**Description:** Oocysts spherical, 12.8 (12.3-13.0). Wall smooth and colorless, composed of a single layer = 0.1. Micropyle and oocyst residuum absent. Polar granule present, 0.9 (0.7-1.0). Sporocysts ovoid, 10.1 by 6.0 (9.3-11.0 by 5.0-6.5), in contact with oocyst wall. Sporocysts arranged parallel in oocyst. Disc-like Stieda body present at tapered end of sporocyst, 2.7 (2.6-2.8). Sporocyst residuum spherical and finely granular, 2.8 (2.6-3.0). Sporozoites vermiform, one end reflexed, 8.5 by 1.6 (7.8-9.0 by 1.3-2.0), (without reflexed portion), arranged head to tail in sporocyst. Refractile bodies absent.

**Sporulation:** Endogenous.

**Geographical locations:** Quebec, Canada; France.

**Location in host:** Anterior intestinal epithelium; feces.

**References:** Léger and Hesse (1919); Molnar and Hanek (1974).

**Remarks:** Description is based predominately on that of Molnar and Hanek (1974).

In addition to those species listed previously, a number of incidental findings of *Eimeria* from North American fishes occur in the literature. Listed below are those which we have located. Others undoubtedly exist.

**Eimeria sp. Davis, 1946**

**Host:** Salvelinus fontinalis “brook trout” (Salmoniformes) (F).

**Description:** None given.

**Sporulation:** Endogenous.

**Geographical location:** Rutland, Vermont, U.S.A.

**Location in host:** Intestinal epithelium of pyloric caeca; feces.

**Reference:** Davis (1946).

**Remarks:** Various developmental stages of an eimerian were found in the epithelium of the pyloric caeca and, to a lesser extent, in the epithelium proximal to the caeca. This species may be *E. salvelini* or *E. truttae*, which occur in *S. fontinalis* in Ontario, Canada.

**Eimeria sp. Fantham and Porter, 1948**

**Host:** Fundulus heteroclitus “mummichog” (Atheriniformes) (B).

**Description:** None given.

**Sporulation:** Endogenous (?).

**Geographical location:** Halifax, Nova Scotia.

**Location in host:** Unknown.

**Reference:** Fantham and Porter (1948).

**Remarks:** This species may be *E. funduli* (Duszynski et al. 1979).

**Eimeria sp. Munson, 1974**

**Host:** Liparis atlanticus “seasnail” (Perciformes) (M).

**Description:** None given.

**Sporulation:** Endogenous.

**Geographical location:** New Hampshire, U.S.A.

**Location in host:** Intestinal epithelium; heaviest infections in posterior intestine.

**Reference:** Munson (1974).

**Remarks:** This species was found in 128/128 (100%) of all fish examined and caused serious histopathological damage. It probably represents an undescribed new species.

**Eimeria sp. Orías and Noble, 1971**

**Host:** Nezumia bairdi “marlin-spike” or “common grenadier” (Gadiformes) (M).

**Description:** Sporocysts averaged 9.5 by 5.5.

**Sporulation:** Endogenous.

**Geographical location:** Off coast of Greenland.

**Location in host:** Stomach epithelium.
**Reference:** Orias and Noble (1971).

**Remarks:** This eimerian probably represents an undescribed new species.

Genus *Goussia* Labbé. 1896

Oocysts contain four sporocysts, each with two sporozoites; Stieda body absent; sporocyst wall bivalved.

*Goussia caseosa* Lorn and Dykova, 1982

(Fig. 28, sporocyst only)

**Host:** Macrourus berglax “roughhead grenadier” (Gadiformes) (M).

**Description:** Oocysts irregular in shape, 42.0 (40.0-47.0). Wall thin, membranelike, easily ruptured, and coated with fine granules. Micropyle and polar granule not mentioned or depicted. Oocyst residuum absent. Sporocysts ellipsoid, 19.2 by 13.6 (18.0-20.3 by 12.0-15.5), with thick sporocyst wall. Sporocyst residuum absent. Sporozoites 26.0 by 7.0, arranged head to tail in sporocyst and partially curled around one another. Anterior ends of sporozoites with transverse striations, disappearing when sporozoites excyst. Sporozoite refractile bodies not mentioned but clearly depicted.

**Sporulation:** Endogenous.

**Geographical location:** Grand Banks, Newfoundland.

**Location in host:** Swim bladder, gas gland, gall bladder, intestinal contents, mesenteric blood vessels.

**Reference:** Lorn and Dykova (1982a).

*Goussia degiustii* (Molnar and Fernando, 1974) Dykova and Lorn, 1981

(Fig. 29)

**Synonyms:** Eimeria spleni DeGiusti and Hnath, 1968; Eimeria degiusti Molnar and Fernando, 1974.

**Hosts:** Notropis cornutus “common shiner,” Pimephales notatus “blunt nose minnow,” P. promelas “fathead minnow,” Campostoma anomalum “central stoneroller” (Cypriniformes) (F).

**Description:** Oocysts spherical, 19.0-22.0. Wall colorless and of uniform thickness, consisting of a single layer \( \approx 0.1 \). Oocyst residuum absent; a micropyle is not described. One or two polar granules present, 1.0-2.0. Sporocysts ellipsoid, 13.0-15.0 by 6.5-8.5, with a relatively narrow space separating them from oocyst wall. Wall \( \approx 0.2 \). A thin membranelike collar, apparently visible only with electron microscopy, girdles the sporocyst at the suture. Sporocyst residuum compact and coarsely granular, 9.0-10.0 by 7.0-8.0. Sporozoites banana-shaped, 10.5-12.0 by 2.5-2.8, arranged head to tail in sporocyst. A spherical refractile body is present in each sporozoite.

**Sporulation:** Endogenous.

**Geographical location:** Ontario, Canada.

**Location in host:** Spleen.

**References:** DeGiusti and Hnath (1968); Lorn (1971); Molnar and Fernando (1974); Dykova and Lorn (1981); Paterson and Desser (1982).

**Remarks:** *Eimeria spleni* was mentioned, but not described, by DeGiusti and Hnath (1968) and later examined ultrastructurally by Lorn (1971). However, Molnar and Fernando (1974) described the morphology of the species and, thus, *E. spleni* is a nomen nudum.

*Goussia gadi* (Fiebiger, 1913) Dykova and Lorn, 1981

(Fig. 30)

**Synonym:** Eimeria gadi Fiebiger, 1913.

**Hosts:** Gadus (=Melanogrammus) aeglefinus “haddock,” G. morrhua “common cod” or “codfish,” G. virid “coal-fish,” Enchelyopus cimbrius “fourbeard rockling,” Molva vulgaris “ling” (Gadiformes) (M).

**Description:** Oocysts spherical, 26.0-28.0, with a smooth thin wall. Micropyle and polar granule not described. Oocyst residuum sometimes present. Sporocysts ovoid, 11.0-15.0 by 7.5-10.0, with apical pore and longitudinal ridges extending length of sporocyst (not visible with light microscopy). Sporocyst residuum present. Sporozoites 16.0 by 4.0, and contain one or more refractile bodies.

**Sporulation:** Endogenous.

**Geographical location:** North Atlantic Ocean.

**Location in host:** Swim bladder.

**References:** Fiebiger (1913); Odense and Logan (1976); Scott (1981); Schulman and Shein (1962); Dykova and Lorn (1981).

**Remarks:** This description is based on that given by Fiebiger (1913) and Odense and Logan (1976).

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**KEY TO EIMERIIDAE OF NORTH AMERICAN FISHES**

1a. Sporocysts nonbivalved; with or without Stieda body (*Eimeria*) .......................... 2
1b. Sporocysts bivalved; without Stieda body (*Goussia*) .......................... 28

*All tetrasporocystic oocysts which have dizoic sporocysts and lack Stieda bodies may eventually prove to be *Goussia*. The suture is often difficult or impossible to see with light microscopy. However, both Odense and Logan (1976) and Lorn and Dykova (1982a) have published photomicrographs which suggest that crushing sporocysts between slide and coverglass can separate the valves at the suture; this making electron microscopy unnecessary for diagnosis.*
| 2a. | Stieda body present; oocysts spherical; oocyst residuum absent | 3 |
| 2b. | Stieda body absent; oocysts vary in shape | 10 |
| 3a. | Oocysts > 20 μm with wall = 1.0 μm thick; sporocysts with sporopodia; sporulation endogenous, in liver of Atheriniformes | E. fundali |
| 3b. | Oocysts < 15 μm with wall = 1.0 μm; sporocysts without sporopodia | 4 |
| 4a. | One or more polar granules present | 5 |
| 4b. | Polar granules absent | 9 |
| 5a. | Stieda body disc-shaped; sporulation endogenous, in anterior intestinal epithelium of Salmoniformes | E. truttae |
| 5b. | Stieda body not as above | 6 |
| 6a. | Stieda body caplike at tapered end of sporocyst; sporulation endogenous, in intestinal epithelium of Perciformes | E. tedlai |
| 6b. | Stieda body a knoblike thickening at tapered end of sporocyst | 7 |
| 7a. | Oocyst small, < 10 μm in greatest diameter; sporulation endogenous, in intestinal epithelium of Perciformes | E. moronei |
| 7b. | Oocyst > 10 μm in diameter | 8 |
| 8a. | Sporocysts 8-10 μm long and in contact with oocyst wall; sporulation endogenous, in intestinal epithelium of Perciformes | E. glenorensis |
| 8b. | Sporocysts < 8 μm long leaving space separating them from oocyst wall; sporulation endogenous, in intestinal epithelium of Salmoniformes | E. osmeri |
| 9a. | Stieda body formed by 4 papillae, sporocysts hexagonal in cross-section; sporulation endogenous, in anterior intestinal epithelium of Anguilliformes | E. anguillae |
| 9b. | Stieda body caplike, sporocyst round in cross-section; sporulation endogenous, in anterior intestinal epithelium of Salmoniformes | E. salvelini |
| 10a. | Oocyst residuum present | 11 |
| 10b. | Oocyst residuum absent | 12 |
| 11a. | Oocyst spheroid to ovoid, outer wall smooth; sporulation endogenous, oocysts in testes of Clupeiformes | E. brevoortiana |
| 11b. | Oocyst ellipsoid to ovoid, outer wall pitted, brown; sporulation exogenous, merogony in spiral valve mucosa of Chondrich-thyes | E. squali |
| 12a. | Oocyst spheroid, > 30 μm in diameter, with thick (3 μm) wall; sporulation endogenous, in anterior intestinal mucosa of Scorpaeiformes | E. myoxocephali |
| 12b. | Oocyst spherical or otherwise, < 30 μm in any dimension, with thin (< 0.1 μm) wall | 13 |
| 13a. | One or more polar granules present | 14 |
| 13b. | Polar granule absent | 17 |
| 14a. | Oocyst spheroid, < 10 μm in diameter | 15 |
| 14b. | Oocyst ellipsoid | 16 |
| 15a. | Sporocysts ovloid, flat on one side; sporozoites without refractile body; sporulation endogenous, in anterior intestinal epithelium of Cypriniformes | E. catostomi |
| 15b. | Sporocysts ellipsoid, not flat on one side, sporozoites with refractile body; sporulation endogenous, in intestinal epithelium of Gasterosteiformes | E. hanki |
| 16a. | Oocyst small, greatest length < 20 μm; sporulation endogenous, in anterior intestinal epithelium of Salmoniformes | E. hoffmani |
| 16b. | Oocyst large, smallest length > 20 μm; sporulation endogenous, in kidneys and renal parenchyma of Cypriniformes | E. freemani |
| 17a. | Sporocyst residuum absent; sporulation exogenous, merogony in anterior intestinal epithelium of Cypriniformes | E. aurati |
| 17b. | Sporocyst residuum present | 18 |
| 18a. | Oocyst irregular in shape with wall tightly adhering to sporocysts; sporulation endogenous, in intestinal epithelium of Scorpaeiformes | E. duszynskii |
| 18b. | Oocyst spherical or ellipsoid | 19 |
| 19a. | Oocyst ellipsoid | 20 |
| 19b. | Oocyst spheroid | 21 |
| 20a. | Oocyst 7.5-9 × 6-7 μm, sporocysts 6-8 × 2-3.5 μm; sporulation endogenous, in anterior intestinal epithelium of Cyprini-formes | E. fernandoae |
| 20b. | Oocyst 12-13 × 8-10.5 μm, sporocysts 9-10.5 × 3-4 μm; sporulation mostly exogenous; merogony in anterior intestinal epithelium of Gasterosteiformes | E. pungitii |
| 21a. | Oocyst smallest diameter > 15 μm; sporulation endogenous in liver of Gasterosteiformes | E. gasterosti |
| 21b. | Oocyst largest diameter ≤ 15 μm; sporocysts elongate; sporulation endogenous in gut epithelium | 22 |
| 22a. | Sporocysts appear triangular in cross section, with granular residuum | 23 |
| 22b. | Sporocysts not triangular in cross section | 25 |
| 23a. | Sporocyst residuum dispersed | 24 |
| 23b. | Sporocyst residuum compact, coarsely granular; ellipsoid sporocysts always < 9.0 μm long; sporulation endogenous in intestinal epithelium of Siluriformes | E. ictaluri |

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1. Oocysts of these "species" are nearly identical and, in fact, may represent the same species. In their original description, Molnar and Fernando (1974) argued, "It is well known that Eimeria spp. are highly specific to single or closely related host species" and "... when morphologically almost indistinguishable or very similar Eimeria spp. occur in distantly related host species, we consider these parasites as distinct species..." This assumption may prove invalid with time, but our knowledge of the life cycles of fish eimerians is too incomplete to refute it at this time.

2. Oocysts of these "species" are nearly identical and may represent a single species. See footnote 5.
29a. One or more polar granules present; sporulation endogenous, in spleen of Cypriniformes ................................................................. G. degiustii

29b. Polar granule absent; sporulation endogenous, in swim bladder of Gadiformes ................................................................. G. gadi

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