

Some new *Eimeria* (Protozoa, Coccidia) from freshwater fishes in Ontario, Canada

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Twelve new species of *Eimeria* (Protozoa, Coccidia) have been described and figured from freshwater fishes in Ontario, Canada. They are *Eimeria osmeri* sp. nov., *E. glenorensis* sp. nov., *E. freemani* sp. nov., *E. degiustii* sp. nov., *E. moronei* sp. nov., *E. hybognathi* sp. nov., *E. iroquoina* sp. nov., *E. ictaluri* sp. nov., *E. laureleus* sp. nov., *E. ojbwana* sp. nov., *E. haneki* sp. nov., and *E. tedlai* sp. nov. This is the first published record on Coccidia in freshwater fishes in Canada.

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On trouvera ici la description illustrée de 12 nouvelles espèces d'*Eimeria* (Protozoa, Coccidia) provenant de poissons d'eaux douces en Ontario, Canada. Ce sont *Eimeria osmeri* sp. nov., *E. glenorensis* sp. nov., *E. freemani* sp. nov., *E. degiustii* sp. nov., *E. moronei* sp. nov., *E. hybognathi* sp. nov., *E. iroquoina* sp. nov., *E. ictaluri* sp. nov., *E. laureleus* sp. nov., *E. ojbwana* sp. nov., *E. haneki* sp. nov. et *E. tedlai* sp. nov. C'est le premier travail sur les Coccidies de poissons d'eau douce publié au Canada. [Traduit par le journal]

Introduction

Hitherto only one coccidian is known from North American freshwater fishes, namely *Eimeria aurata* by Hoffman (1965). DeGiusti and Hnath (1968) found a species of *Eimeria* from *Notropis cornutus* and *Campostoma anomalum* from North America and named it as *E. spleni*, but they did not give a description. However, over 40 species of coccidians have been described from freshwater fishes in Europe and the Asian region of the Union of Soviet Socialist Republics (Pellerdy 1965; Shulman 1962). From the rest of the world, hardly any species of coccidians of freshwater fishes are known.

We have examined 20 species of freshwater fishes from southern Ontario and found 12 new species of the genus *Eimeria* localized in the intestine, spleen, and kidney. We have described and figured these species.

Materials and Methods

The host specimens were collected from the Bay of Quinte, Ontario, in some small streams in the Bloomfield area near Picton, Ontario, and from Laurel Creek, Waterloo, Ontario. The fish were transported to the laboratory alive and examined for parasites immediately upon arrival as follows. Squash preparations were made

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of the spleen, liver, kidney, and mesenteries. Mucus and scrapings of the epithelial wall of the intestine were examined. The material, on microslides with cover slips, was examined under a high power of the microscope. Drawings and measurements were made at this stage. Positive slides were fixed in 2.5% glutaraldehyde solution by irrigation with this fixative. The cover slips were sealed with Canada balsam to prevent desiccation. Under these conditions the parasites retained their original shape and were well preserved for a period of a few weeks, during which time they could be studied in detail. Measurements (all in microns) were taken of not less than 20 oocysts for each species except for *Eimeria hybognathi* sp. nov., where only 11 oocysts were available for measurement. Sporulation of all species studied has been completed in the gut of their respective host.

Results

Eimeria osmeri sp. nov. (Fig. 1)

DESCRIPTION: Oocysts spherical, diameter 10.4-11.0. Cyst wall 0.1 thick, single layered, colorless, and of uniform thickness. Sporocysts moderately compact with a relatively narrow space separating them from the cyst wall. Oocyst residuum absent. One or two polar granules, measuring 1.5-1.7, present. Sporocysts oval, one end sharply tapered, measuring 7.1-7.8 × 4.3-4.7. Stieda body at the tapered end consists of a thickening of the sporocyst wall. Sporocyst wall in the thickened portion measures 0.35, and 0.2 in the rest. Vermiform sporozoites with one end reflexed are arranged head to tail in the sporocyst.

Sporozoite without the reflexed portion 6.0–7.1 long and 1.3–1.7 wide. Refractile globule in sporozoites absent. Sporocyst residuum rounded, compact, and refractile, measuring 1.3–1.7 in diameter.

HOST: *Osmerus mordax* (Mitchill).

LOCALITY: Bay of Quinte (1 mi E of Glenora Fisheries Research Station, Picton, Ontario).

LOCATION: Gut epithelium, feces.

HOSTS/INFECTION: 2/2.

***Eimeria glenorensis* sp. nov.** (Fig. 2)

DESCRIPTION: Oocyst spherical, diameter 10.5–12.0. Oocyst wall 0.1 thick, single layered, colorless, of uniform thickness. Sporocysts compact, in contact with the oocyst wall. Oocyst residuum absent; one or two polar granules, measuring 1.0–2.0, present. Sporocysts oval, one end sharply tapered, measuring 8.0–9.5 × 5.7–6.0. Stieda body at the tapered end, and consists of a thickening of the sporocyst wall. Sporocyst wall in the thickened portion measures 0.5, and 0.3 in the rest. Two vermiform sporozoites with one end reflexed are arranged head to tail in the sporocyst. Sporozoites without the reflexed portion 5.0–5.3 long; reflexed portion 2.5–2.7 long, and 2.0–2.2 wide. Refractile globule in sporozoites absent. Sporocyst residuum rounded, compact, and refractile, measuring 2.0–2.6 in diameter.

HOST: *Morone americana* (Gmelin).

LOCALITY: Bay of Quinte (1 mi E of Glenora Fisheries Research Station, Picton, Ontario).

LOCATION: Gut epithelium, feces.

HOSTS/INFECTION: 5/5.

***Eimeria freemani* sp. nov.** (Fig. 3)

DESCRIPTION: Oocyst ellipsoidal, 22.0–24.0 long and 17.0–18.0 wide. Cyst wall 0.1 thick, single layered, colorless, and of uniform thickness. Sporocysts moderately compact with a relatively large space separating them from the walls of the oocyst. Oocyst residuum absent; polar granule, measuring 1.0–2.0, present. Sporocysts elongated, ellipsoidal, measuring 16.0–17.0 by 5.0–6.5. Sporocyst wall measures 0.2. Four sporocysts arranged lengthwise and in the same direction in the oocyst. Sporocyst with two banana-shaped sporozoites measuring 14.0–15.5

by 2.5–3.5. Each of the sporozoites has a large refractile globule (paranuclear body) at the wider end and a smaller one in the middle portion. Sporocyst residuum small (larger in young oocyst), rounded, compact, and finely granulated, measuring 2.5–5.0 in diameter.

HOST: *Notropis cornutus* (Mitchill).

LOCALITY: Laurel Creek, Waterloo, Ontario.

LOCATION: Kidney, renal parenchyma, renal tubes.

HOSTS/INFECTION: 22/1.

REMARKS: This species is similar to *E. leucisci* Shulman and Zaika but differs from it because it has the elongate form of the oocyst. It also resembles superficially *E. scardinii* Pellerdy and Molnar but differs from the latter species because it has elongate sporozoites.

This species is named after Professor R. S. Freeman, School of Hygiene, University of Toronto.

***Eimeria degiustii* sp. nov.** (Fig. 4)

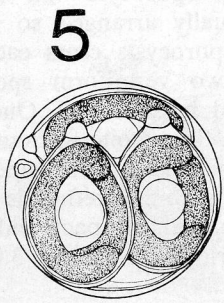
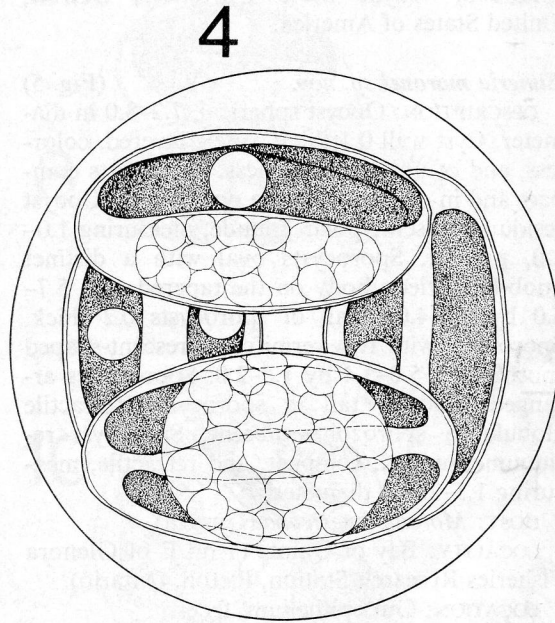
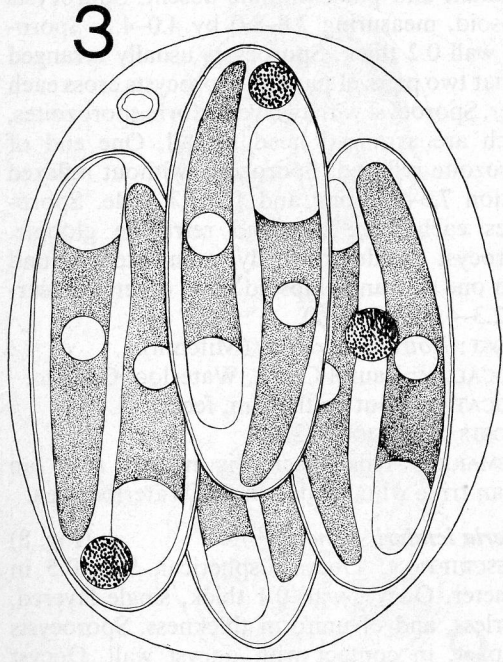
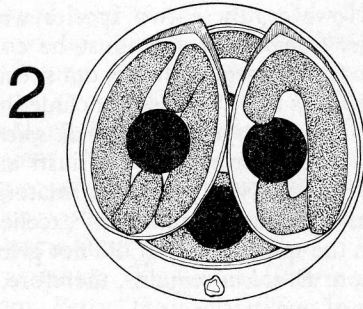
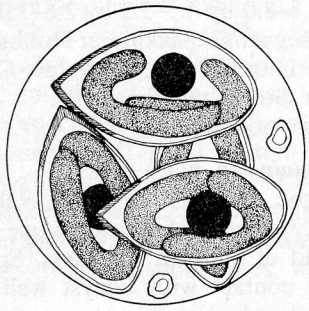
DESCRIPTION: Oocysts spherical, 19.0–22.0 in diameter. Cyst wall 0.1 thick, single layered, colorless, and of uniform thickness. Sporocysts moderately compact with a relatively narrow space separating them from the wall of the oocyst. Oocyst residuum absent; one or two polar granules, measuring 1.0–2.0, present. Sporocysts ellipsoidal, measuring 13.0–14.5 by 6.5–8.5. Width of sporocyst wall 0.2. Two banana-shaped sporozoites, 10.5–12.0 by 2.5–2.8, are arranged head to tail in the sporocyst. A round refractile globule present in each of sporozoites. Sporocyst residuum large, coarsely granulated, compact, and 9.0–10.0 long, 7.0–8.0 wide, and 4.5–5.5 in depth.

HOST: *Notropis cornutus* (Mitchill), *Pimephales notatus* (Rafinesque), *P. promelas* Rafinesque.

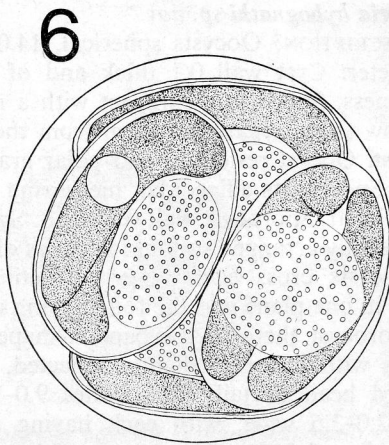
LOCATION: Spleen.

HOSTS/INFECTION: 22/17, 3/1, 6/2.

REMARKS: The above description is for oocysts from *Notropis cornutus*. Oocysts from *Pimephales* spp. were within the range of variability for this species. This species can not be morphologically distinguished from *E. metschnikovi* Laveran and *E. macroresidualis* Schulman and Zaika, which were recorded from Europe and Asian U.S.S.R.,



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respectively. However, these two species were found in genus *Gobio* only and must be considered specific for this genus. Hence, our species can be considered as new. We also conclude that *E. degiustii* sp. nov. is a synonym with *E. spleni*, mentioned but not described by DeGiusti and Hnath (1968). Lom (1971) studied material obtained from DeGiusti, made an excellent photograph on the sporocysts, but did not give a valid description. *E. spleni* remains, therefore, a nomen nudum of our species.

This species is named after Professor D. DeGiusti, Wayne State University, Detroit, United States of America.

Eimeria moronei sp. nov. (Fig. 5)

DESCRIPTION: Oocysts spherical, 7.2–8.0 in diameter. Cyst wall 0.1 thick, single layered, colorless, and of uniform thickness. Sporocysts compact and in contact with the oocyst wall. Oocyst residuum absent; polar granule, measuring 1.0–2.0, present. Sporocysts oval with a distinct knob-like Stieda body on the tapered end, 5.7–6.0 by 3.9–4.0. Wall of sporocysts 0.2 thick. Sporocysts with two vermiform crescent-shaped sporozoites, 5.0–5.4 by 1.5–2.0. Sporozoites arranged head to tail in sporocyst. Refractile globule in sporozoites absent. Sporocyst residuum rounded, compact, and refractile, measuring 1.5–2.0 in diameter.

HOST: *Morone americana* (Gmelin).

LOCALITY: Bay of Quinte (1 mi E of Glenora Fisheries Research Station, Picton, Ontario).

LOCATION: Gut epithelium, feces.

HOSTS/INFECTION: 5/1.

Eimeria hybognathi sp. nov. (Fig. 6)

DESCRIPTION: Oocysts spherical, 14.0–14.5 in diameter. Cyst wall 0.1 thick and of uniform thickness. Sporocysts compact with a relatively narrow space separating them from the wall of oocyst. Oocyst residuum and polar granule absent. Sporocysts ellipsoidal, measuring 9.5–10.0 by 5.7–6.0. Sporocyst wall 0.2 thick. Sporocysts are usually arranged so that two pairs of parallel sporocysts cross each other, sometimes with three in one plane and the fourth lying on them. In sporocyst, there are two banana-shaped sporozoites with one end slightly reflected, and arranged head to tail. Sporozoites 9.0–9.2 long and 2.0–2.6 wide, with each having a round refractile globule. Sporocyst residuum large,

finely granulated, usually compact, and oval, measuring 5.8–8.0 by 4.5–5.2 by 2.6–3.0.

HOST: *Hybognathus hankinsoni* Hubbs.

LOCALITY: Laurel Creek, Waterloo, Ontario.

LOCATION: Gut epithelium, feces.

HOSTS/INFECTION: 8/1.

Eimeria iroquoina sp. nov. (Fig. 7)

DESCRIPTION: Oocysts spherical, 9.0–11.0 in diameter. Cyst wall 0.1 thick, single layered, colorless, and of uniform thickness. Sporocysts compact, in contact with oocyst wall. Oocyst residuum and polar granule absent. Sporocysts ellipsoid, measuring 7.8–8.0 by 4.0–4.5. Sporocyst wall 0.2 thick. Sporocysts usually arranged so that two pairs of parallel sporocysts cross each other. Sporocyst with two vermiform sporozoites, which are arranged head to tail. One end of sporozoite reflexed. Sporozoite without reflexed portion 7.5–7.7 long and 1.5–1.7 wide. Sporozoites each have a round refractile globule. Sporocyst residuum finely granulated, round from one side and ellipsoid from other; measuring 2.3–4.0 by 2.2–3.0.

HOST: *Notropis cornutus* (Mitchill).

LOCALITY: Laurel Creek, Waterloo, Ontario.

LOCATION: Gut epithelium, feces.

HOSTS/INFECTION: 22/3.

REMARKS: This species is named after an Indian tribe who resided in the Waterloo area.

Eimeria ictaluri sp. nov. (Fig. 8)

DESCRIPTION: Oocysts spherical, 9.0–10.5 in diameter. Oocyst wall 0.1 thick, single layered, colorless, and of uniform thickness. Sporocysts compact, in contact with oocyst wall. Oocyst residuum and polar granule absent. Sporocysts ellipsoid, rarely coffee bean-shaped, measuring 7.8–8.4 by 3.6–4.2. Sporocyst wall 0.2 thick. Sporocysts are usually arranged so that two pairs of parallel sporocysts cross each other. Sporocysts with two vermiform sporozoites, which are arranged head to tail. One end of sporozoite reflexed. Sporozoite without reflexed portion 7.1–7.8 long and 1.5–1.8 wide. Sporozoites each have a round refractile globule. Sporocyst residuum oval, compact, and coarsely granulated, measuring 5.0–5.3 by 3.0–3.3 by 2.0–2.2.

HOST: *Ictalurus nebulosus* (Lesueur).

LOCALITY: Laurel Creek, Waterloo, Ontario.

LOCATION: Gut epithelium, feces.

HOSTS/INFECTION: 5/2.

Eimeria laureleus sp. nov.

(Fig. 9)

DESCRIPTION: Oocyst spherical, 11.0–12.0 in diameter. Cyst wall 0.1 thick, single layered, colorless, and of uniform thickness. Sporocysts compact, in contact with oocyst wall. Oocyst residuum and polar granule absent. Sporocysts coffee bean-shaped; from certain angles they appear oval, and measure 9.2–11.0 by 5.0–5.8. Sporocysts are usually arranged so that two pairs of parallel sporocysts cross each other. Sporocyst with two vermiform sporozoites, which are ar-

ranged head to tail. One end of sporozoite reflexed. Sporozoite without reflexed portion 9.0–10.0 long and 1.5–2.0 wide. Sporozoites have each a round refractile globule. Sporocyst residuum finely granulated and dispersed.

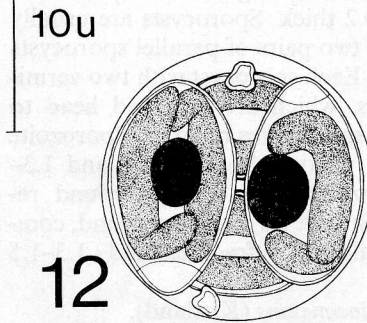
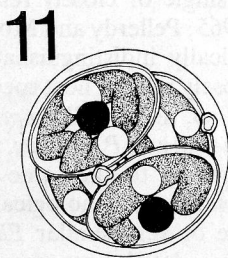
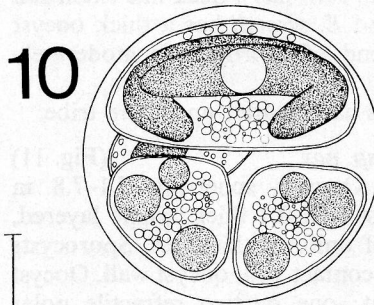
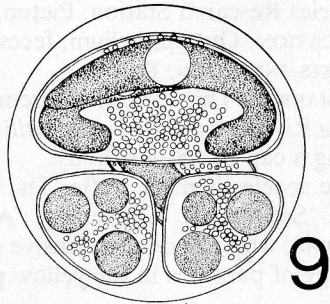
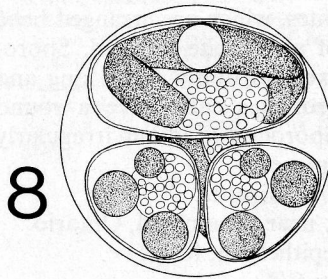
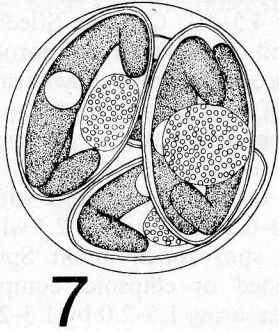
HOST: *Perca flavescens* (Mitchill).

LOCALITY: Laurel Creek, Waterloo, Ontario.

LOCATION: Gut epithelium, feces.

HOSTS/INFECTION: 17/12.

REMARKS: Oocysts of *Eimeria percae* Riviere from *Perca fluviatilis* differ from the above



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FIGS. 7-12. Fig. 7. *Eimeria iroquoiana* sp. nov. Fig. 8. *Eimeria ictaluri* sp. nov. Fig. 9. *Eimeria laureleus* sp. nov. Fig. 10. *Eimeria ojobwana* sp. nov. Fig. 11. *Eimeria haneki* sp. nov. Fig. 12. *Eimeria tedlai* sp. nov.

species in having banana-shaped sporozoites and a knob-like Stieda body.

***Eimeria ojibwana* sp. nov.** (Fig. 10)

DESCRIPTION: Oocysts spherical, 10.4–11.0 in diameter. Cyst wall 0.1 thick, single layered, colorless, and of uniform thickness. Sporocysts compact and in contact with oocyst wall. Oocyst residuum and polar granule absent. Sporocysts coffee bean-shaped, measuring 9.0–9.2 by 5.0–5.8. Sporocyst wall 0.2 thick. Sporocysts are usually arranged so that two pairs of parallel sporocysts cross each other. Sporocyst with two vermiform sporozoites, which are arranged head to tail. One end of sporozoite reflexed. Sporozoite without reflexed portion 8.4–8.7 long and 2.0–2.5 wide. Sporozoites each have a round refractile globule. Sporocyst residuum irregularly granulated and dispersed.

HOST: *Cottus bairdi* Girard.

LOCALITY: Creek near Bloomfield, Ontario.

LOCATION: Gut epithelium, feces.

HOSTS/INFECTION: 6/3.

REMARKS: Oocysts of *Eimeria cotti* Gauthier and *E. piraudi* Gauthier from *Cottus gobio* are of about the same size as those of *E. ojibwana* sp. nov. However, *E. cotti* has a neck-like extension in sporocysts and *E. piraudi* has a thick oocyst wall and one end of sporocyst is moderately tapered.

This species is named after an Indian tribe.

***Eimeria haneki* sp. nov.** (Fig. 11)

DESCRIPTION: Oocysts spherical, 7.1–7.8 in diameter. Oocyst wall 0.1 thick, single layered, colorless, and of uniform thickness. Sporocysts compact and in contact with oocyst wall. Oocyst residuum absent; one or two refractile polar granules present, measuring 1.0–1.5. Sporocysts shortly ellipsoid, measuring 5.6–6.5 by 3.9–4.5. Sporocyst wall 0.2 thick. Sporocysts are usually arranged so that two pairs of parallel sporocysts cross each other. Each sporocyst with two vermiform sporozoites, which are arranged head to tail. One end of sporozoites reflexed. Sporozoite without reflexed portion 5.6–6.0 long and 1.3–2.0 wide. Sporozoites have each a round refractile globule. Sporocyst residuum round, compact, non-granulated, refractile, and 1.3–1.5 in diameter.

HOST: *Culaea inconstans* (Kirtland).

LOCALITY: Creek near Bloomfield, Ontario.

LOCATION: Gut epithelium, feces.

HOSTS/INFECTION: 9/3.

REMARKS: This species is named after Dr. George Hanek, Department of Biology, University of Waterloo, who has made extensive studies on parasites of this fish species.

***Eimeria tedlai* sp. nov.** (Fig. 12)

DESCRIPTION: Oocyst spherical, 9.5–10.0 in diameter. Oocyst wall 0.1 thick, single layered, colorless, and of uniform thickness. Sporocysts compact and in contact with oocyst wall. Oocyst residuum absent. Refractile polar granule 1.0–1.5 in diameter. Sporocysts oval, measuring 8.4–8.7 by 4.5–4.7. Cap-like Stieda body at its tapered end, 1.5–2.0 long. Sporocyst wall 0.3 thick. Sporocysts are usually arranged so that two pairs of parallel sporocysts cross each other. Each sporocyst with two vermiform sporozoites, which are arranged head to tail. One end of sporozoite reflexed. Sporozoite without reflexed portion 6.0–6.5 long and 1.6–2.1 wide. Refractile globule in sporozoites absent. Sporocyst residuum rounded or ellipsoid, compact, and refractile, measuring 1.5–2.0 by 1.5–2.6.

HOST: *Perca flavescens* (Mitchill).

LOCALITY: Bay of Quinte (1 mi E of Glenora Fisheries Research Station, Picton, Ontario).

LOCATION: Gut epithelium, feces.

HOSTS/INFECTION: 8/2.

REMARKS: This species resembles *Eimeria percae* Riviere from *Perca fluviatilis* but differs in having a cap-like Stieda body.

The species is named after Dr. Shibru Tedla, Haile Selassie II University, Addis Ababa, Ethiopia, who has done extensive studies on the ecology of parasites in the yellow perch.

Discussion

It is well known that *Eimeria* spp. are highly specific to single or closely related host species (Pellerdy 1965; Pellerdy and Molnar 1968). When morphologically indistinguishable *Eimeria* spp. occur in closely related host species, for example, *E. degiustii* sp. nov. in *Notropis cornutus*, *Pimephales promelas*, and *P. notatus*, we consider these forms to belong to the same parasite species. However, when morphologically almost indistinguishable or very similar *Eimeria* spp. occur in distantly related host species, we consider these parasites as distinct species, as we have done in case of *Eimeria osmeri* sp. nov. from *Osmerus mordax* and *E. glenorensis* sp. nov. from *Morone*

americana, and in case of *E. iroquoiana* sp. nov. from *Notropis cornutus* and *E. ictaluri* sp. nov. from *Ictalurus nebulosus*.

We have described the oocysts as spherical or ellipsoid. It has been noted, however, that since the oocyst wall is not rigid, pressure by a cover slip can alter the shape. The sporocyst wall of the species described in this paper is a relatively thin wall as compared with *Eimeria* spp. in general (Pellerdy 1965; Kheysin 1972). However, two of the species described, namely *Eimeria glenorensis* sp. nov. and *E. tedlai* sp. nov., have slightly thicker walls than our other species.

Acknowledgment

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the species. The work was supported by funds from NRCC grant 3748 to C.H.F.

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