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Coccidia (Apicomplexa: Eimeriidae)
of the Mammalian Order Insectivora

DONALD W. DUSZYNSKI AND STEVE J. UPTON

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ABSTRACT

The coccidia (protistan phylum Apicomplexa Levine, 1970) comprise a large group of obligate intracellular parasites commonly found in all classes of vertebrate hosts and in some invertebrates. This review focuses on those species within the Eimeriidae because they are among the most prevalent and speciose of all parasite groups, and there is no taxonomic summation currently available for those species that infect insectivores. All published species descriptions in the genera *Cyclospora*, *Eimeria* and *Isospora* that infect insectivores are reviewed and evaluated. Some of the named species are invalid, either because rules concerning the naming of new species (International Code of Zoological Nomenclature) were not followed and/or the original description was so incomplete as to be of little use; such names have been relegated to *species inquirendae*. The mammalian order Insectivora has seven families composed of 66 genera and 428 species. There are no coccidia described from three families: Chrysochloridae, Nesophontidae and Solenodontidae. In the Erinaceidae, only *Erinaceus*, *Hemiechinus* and *Hylomys* have valid coccidia described from them; in the Soricidae, only six genera, *Crocidura*, *Suncus* (Crocidurinae) and *Blarina*, *Cryptotis*, *Neomys*, and *Sorex* (Soricinae) have valid species described; in the Tenrecidae, only *Hemicentetes* and *Setifer* have valid species; and in the Talpidae, only *Condylura*, *Mogera*, *Neurotrichus*, *Parascalops*, *Scalopus*, *Scapanus*, *Talpa* and *Urotrichus* (Talpinae) have valid species described. In all, 75 eimeriid coccidia are known from insectivore hosts including 48 *Eimeria*, 22 *Isospora* and five *Cyclospora* species; 45 *species inquirendae* are noted.

INTRODUCTION

The mammalian order Insectivora has seven families with 66 genera and 428 species (Hutterer, 1993). Although this is not a particularly large group of mammals, it is one that has been difficult to classify (Nowak, 1991). For convenience, we use the ideas that were so well presented by Yates (1984) and generally followed by Nowak (1991) and Hutterer (1993) as the most workable taxonomy of the group. In general, insectivores are eutherian mammals that range from the size of a baby mouse to that of a small rabbit. Most have a long, narrow snout with primitive teeth that are generally rooted. Their skull has a low braincase and they have small ears and tiny eyes that sometimes lack external openings (Yates, 1984). As far as is known, all insectivores lack a cecum as a part of their digestive tract (Lipotyphla). As a group they are more or less cosmopolitan and, although many are fossorial or semi-fossorial, some may den in hollow trees. Invertebrates constitute the bulk of the diet of many species, but some are known

also to eat small vertebrates of any kind, eggs of ground-nesting birds, fruit, nuts and fungi.

Many biologists, including mammalogists and parasitologists, study these unique and interesting animals. Because of a long professional collaboration between T.L. Yates (mammals) and D.W. Duszynski (parasites) at the University of New Mexico (UNM), numerous insectivores and their coccidia parasites have been collected, identified and archived over the last two decades. Vertebrate biologists long ago learned the value of archiving voucher and type specimens in accredited museums so that they could be available for future generations to study as technologies changed and advanced. However, the concept of archiving type specimens only recently has become accepted practice among protistologists (see Bandoni and Duszynski, 1988; Duszynski, 1999), more than three decades after Corliss (1962) first scolded them for their lack of attention to submitting type specimens when they describe new species. It was at UNM that the concept of the *symbiotype* specimen first evolved through the collaboration of Yates,

Duszynski and their students (Frey et al., 1992); the symbiotype is the host animal from which a new parasite species is described. At UNM, symbiotype hosts are archived and then maintained in a separate collection. In the event there ever is a question concerning the identity of the original host animal, the actual specimen can be retrieved and the question resolved. Our symbiotype concept was supported strongly by Brooks (1993). Of the 75 valid species of coccidia detailed in this review, the symbiotype host is archived for only 40 (53%). However, 36 of the 40 (90%) known symbiotype insectivore hosts of coccidia are archived in the Mammal Division of the Museum of Southwestern Biology (MSB) at UNM. Thus, the Special Publication Series of the MSB seems the most appropriate place for this review.

Coccidia (Apicomplexa: Eimeriidae) are ubiquitous protists that are obligate intracellular parasites of vertebrates and invertebrates and represent some of the most prevalent and abundant (number of species) parasites known. However, despite their widespread distribution, there is a paucity of information regarding their occurrence in most host groups, including insectivores. The reasons for this have to do with the difficulties of working with, and isolating and preserving stages from, their complex life cycles.

The Eimeriidae are defined as coccidia with direct life cycles that include both asexual and sexual reproduction, both within the epithelial or endothelial cells of the gastrointestinal tract or related structures (bile duct, renal tubular epithelium, etc.) of their host animal. Once fertilization has occurred, the resulting stage is a resistant propagule, the oocyst, which is the only stage to leave the host, usually via the feces. In the external environment, if conditions are conducive, the oocyst produces internal spores and becomes highly resistant to environmental extremes; then, it is infective to the next appropriate host that may ingest it. The majority of the species in this family are within two genera, *Eimeria* (~1700 species) and *Isospora* (~300 species) and the majority (> 98%) of these and the other species are known only from the structures of their sporulated oocyst. The structures of the sporulated oocysts of different species, within a host lineage, often are distinct from one another, at least to some degree (Duszynski et

al., 1999). In addition, cross-infection studies have shown that coccidia from one host species generally do not infect hosts in other families or orders, although some coccidia can cross generic boundaries (Hnida and Duszynski, 1999; Upton et al., 1992).

Unfortunately, the details of the life cycles are unknown for almost all wild and exotic (zoo) animal coccidia. Their endogenous stages are intracellular, transient (each stage lasts only a few hours to a few days), difficult to collect and impossible to correlate with the appropriate oocyst stage under field conditions, and no standardized method has been developed yet to preserve sporulated oocysts long term (Duszynski and Gardner, 1991). Thus, it is the quantitative and qualitative description of all structures of the living sporulated oocyst, along with details on the host species and its geographic locality, upon which the taxonomy of most eimeriid coccidia is based. Line drawings in the published literature and photosyntypes (Duszynski, 1999) deposited into accredited museums now are required in such descriptions.

The taxonomy, generalized life cycles, and species of the known coccidia in wild mammals have been reviewed by Duszynski and Upton (2001); however, they, and Wilber et al. (1998), noted that most earlier authors who published descriptions of new species from mammals did not apply, or even loosely follow, the International Code of Zoological Nomenclature (Ride et al., 1985). Here we review all published papers on the eimeriid coccidia reported from insectivores, make qualitative decisions about their validity, standardize their descriptions, and present illustrations for all but one.

MATERIALS AND METHODS

Our methods were essentially those of Wilber et al. (1998), especially in the number of oocyst and sporocyst characters needed to validate a species and in the definition and deposition of specimens. The type host, other hosts, type locality, and any information on geographic distribution, prevalence (number infected/number examined), sporulation, prepatent and patent periods, site of infection, description of endogenous stages, deposition of specimens, and cross-transmission studies (when available) also are reviewed. Abbreviations used in the species de-

scriptions are standardized as per Wilber et al. (1998): *oocyst characters*: length (L), width (W), their ranges and ratio (L/W); micropyle (M); micropyle cap (MC); residuum (OR), polar granule (PG); *sporocyst characters*: length (L), width (W), their ranges and ratio (L/W); Stieda body (SB); substieda body (SSB); parastieda body (PSB); residuum (SR); sporozoites (SP); refractile bodies (RB) and nucleus (N) in SP. Examples of these structures are illustrated in various line drawings (Figs. 1–74). All measurements given are in μm and are for *sporulated* oocysts only. Family, genera and binomial species names of hosts are those used by Hutterer in Wilson and Reeder (1993) and most common names are those used by Nowak (1991).

Each species description was examined in its chronological order of appearance in the literature and evaluated based on all previous descriptions from that host group, if any; then, following the guidelines of the International Code, the list of minimal criteria needed to support a valid description (as per Wilber et al., 1998), and any new information that supported our decision (e.g., a redescription of an existing species), we either accepted or rejected it as a valid species. If we agreed that it was a valid species, we provided a standardized description including all of the published information to date; if certain structural features were unreported, they were not included in our standardized description.

The actual host animal from which a new parasite species is described is called the symbiotype host specimen (see Frey et al., 1992). Four symbiotype hosts are stored in the museum(s) noted in their original publication (see *Eimeria bentongi*, *E. cryptotis*, *E. globula* and *Isospora hylomysis*). All other insectivore symbiotype specimens that are known are stored in the Mammal Division of the Museum of Southwestern Biology (MSB) at The University of New Mexico (UNM), Albuquerque, New Mexico. All known photosyntype specimens (see Duszynski, 1999) of sporulated oocysts from insectivores are archived in the U.S. National Parasite Collection (USNPC), Beltsville, Maryland.

RESULTS

In the Insectivora, there are 75 valid eimeriid coccidia including 48 *Eimeria* (4 sporocysts per oocyst each with 2 sporozoites), 22 *Isospora* (2 sporocysts per oocyst each with 4 sporozoites) and 5 *Cyclospora* (2 sporocysts per oocyst each with 2 sporozoites) species. One name (*Eimeria komareki*) is considered a junior synonym and 45 published names (21 "Coccidium," 5 *Cyclospora*, 18 *Eimeria* and 1 *Isospora* spp.) are considered *species inquirendae*. Hosts are listed by order, suborder and family in the taxonomic sequence presented by Hutterer (1993); coccidia species are listed alphabetically under each host genus.

INSECTIVORA

(7 families, 66 genera, 428 species)

Family Chrysochloridae Gray, 1825 (7 genera, 18 spp.)

To our knowledge, no species in this family have ever been examined for coccidia.

Family Erinaceidae G. Fischer, 1817 (7 genera, 21 spp.)

Host Genus *Erinaceus* Linnaeus, 1758 (3 spp.)

Eimeria ostertagi Yakimoff and Gousseff, 1936 (Fig. 1)

Type host: *Erinaceus europaeus* Linnaeus, 1758, Eurasian hedgehog.

Other hosts: None reported to date.

Type locality: EUROPE: Russia, Polotzk District, Leningrad Zoo.

Geographic distribution: EUROPE: Russia.

Description of oocyst: Oocyst shape: subspheroid to ellipsoid (?); number of walls: 1; wall thickness: unknown, but probably ≤ 1.0 ; wall characteristics: outer layer apparently smooth; L x W: 33.1 x 26.5 (27–41.5 x 22–37); L/W ratio: 1.2; M: absent; OR: absent; PG: absent. Distinctive features of oocyst: large size.

Description of sporocysts and sporozoites: Sporocyst shape: spheroid to ellipsoid (?); L x W: 11–12.2 x 11–12.2; L/W ratio: 1.0 (?); SB: absent; SSB: absent; PSB: absent; SR: present; SR characteristics: diffuse, small granules be-

tween SP or large granules that surround and mostly obscure SP; SP without distinct RB (line drawing) although this was not stated in the original description. Distinctive features of sporocyst: variable shape, size and distribution of SR.

Prevalence: 1/34 (3%).

Sporulation: Unknown.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces.

Materials deposited: None.

Remarks: Yakimoff and Gousseff (1936) presented two line drawings of *E. ostertagi*: one was subspheroid with spheroid sporocysts that contained SR of large globules that obscured the SP (their Fig. 5) and a second oocyst that was ellipsoid with elongate-ellipsoid sporocysts that had SR of small granules located in a compact band between the sausage-shaped SP (their Fig. 6). It is likely they were dealing with two distinct species, but this possibility was not stated, nor were measurements given for the ellipsoidal sporocysts. Glebezdin and Kolodenko (1969) reported finding *E. ostertagi* in a hedgehog in Turkmenia; the oocysts they measured were 26.9 x 23.9 (23–32 x 21.5–26.5) and sporocysts were 13.7 x 8.7 (8.5–14.5 x 6.5–11.5). Thus, the form Glebezdin and Kolodenko (1969) saw is likely the unnamed form with ellipsoid sporocysts pictured by Yakimoff and Gousseff (1936, Fig. 6), but not *E. ostertagi*. Yakimoff and Gousseff (1940) said they found this species in 2/8 (25%) *Hemiechinus albulus* (?) from Kara-Kalpakistan, but based their decision on the size and shape of unsporulated oocysts only. Glebezdin (1985) also reported finding *E. ostertagi* in hedgehogs (*H. auritus* ?) from southeastern Turkmenistan, but this seems unlikely.

References: Yakimoff and Gousseff (1936, 1940); Glebezdin and Kolodenko (1969); Glebezdin (1985).

***Eimeria perardi* Yakimoff and Gousseff, 1936 (Fig. 2)**

Type host: *Erinaceus europaeus* Linnaeus, 1758, Eurasian hedgehog.

Other hosts: None reported to date.

Type locality: EUROPE: Russia, Polotzk District, Leningrad Zoo.

Geographic distribution: EUROPE: Russia; Bulgaria.

Description of oocyst: Oocyst shape: ovoid; number of walls: 1; wall thickness: unknown, but probably ≤ 1.0 ; wall characteristics: outer layer yellowish, apparently smooth; L x W: 20 x 15 (17–27 x 14.5–16); L/W ratio: 1.3; M: absent; OR: absent; PG: present. Distinctive features of oocyst: ovoid shape with PG.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid to ellipsoid (?); L x W: unknown, but line drawing suggests them to be about one-half the length of the oocyst, ~10 x 5; SB: absent; SSB: absent; PSB: absent; SR: absent; SP: without a distinct RB (line drawing) although this was not stated in the original description. Distinctive features of sporocyst: lack of SB, SR and RB.

Prevalence: 1/34 (3%).

Sporulation: Unknown.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces.

Materials deposited: None.

Remarks: The description of this species is only marginally useful; it is retained as valid only because oocyst measurements and an original line drawing were included. Glebezdin and Kolodenko (1969) said they found this species in hedgehogs in Turkmenia, but the oocysts they measured were 22.6 x 19.8 (17–26 x 14.5–24.5) and sporocysts were 10.1 x 7.0 (9–12 x 6–10) and they did not provide a line drawing or photomicrograph. Thus, the oocysts they measured, likely, were of a different species than *E. perardii*. Golemansky (1979) also reported finding this species in 1/3 *E. europaeus* from the Sreburna Reserve in Bulgaria; the oocysts he measured were 24 x 18. Finally, Glebezdin (1985) again reported finding *E. perardii* in hedgehogs (*H. auritus* ?) from southeastern Turkmenistan, but this seems unlikely.

References: Yakimoff and Gousseff (1936); Glebezdin and Kolodenko (1969); Golemansky (1979); Glebezdin (1985).

***Isospora erinacei* Yakimoff and Gousseff, 1936 (Fig. 3)**

Type host: *Erinaceus europaeus* Linnaeus, 1758, Eurasian hedgehog.

Other hosts: None reported to date.

Type locality: EUROPE: Russia, Polotzk District, Leningrad Zoo.

Geographic distribution: EUROPE: Bulgaria; Russia.

Description of oocyst: Oocyst shape: ovoid (unsporulated), cylindroid (sporoblast stage) to distinctly spheroid (sporulated); number of walls: 2; wall thickness: unknown, but probably ≤ 1.0 ; wall characteristics: outer layer colorless to yellowish, apparently smooth; L x W: 30 x 26 (28–34 x 23–27) for ovoid–cylindroid forms; no measurements given for spheroid forms; L/W ratio: 1.15; M: absent; OR: absent; PG: present. Distinctive features of oocyst: changes its shape during sporulation (?).

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 14.6 x 9.8–12.2; SB: present (?); SSB: absent; PSB: absent; SR: present (?); SP: without a distinct RB (line drawing) although this was not stated in the original description. Distinctive features of sporocyst: pointed at one end and do not fill the space within the oocyst; SP lack RB, are very short (Fig. 3, Yakimoff and Gousseff, 1936), and do not fill sporocyst.

Prevalence: 1/34 (3%).

Sporulation: Unknown.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces.

Materials deposited: None.

Remarks: The description of this species is only marginally useful; it is retained as valid only because some measurements and an original line drawing of a sporulated oocyst were included. However, the original authors reported the shape to vary greatly during sporulation from distinctly ovoid (their Fig. 1) to cylindroid (their Fig. 2) to spheroid (their Fig. 3) when sporulated, but gave no measurements for the spheroid form. It is possible that the spheroid forms represented end-on views of the ovoid/cylindroid forms or even a different species. Whichever the case, the sporulated oocyst has no mensural data. It should be noted that the original line drawing by Yakimoff and Gousseff (1936) is not drawn to the scale of the measurements they provided; thus, we have redrawn the sporulated oocyst to the scale of their measurements (our Fig. 3). Also, Yakimoff and Gousseff (1936) mentioned the presence of SR, but did not include it in their line drawing. Glebezdin and Kolodenco (1969) said they found this species in hedgehogs in

Turkmenia. The oocysts they measured were 31.9 x 27.7 (26–35 x 25.5–29) and sporocysts were 13.6 x 10.3 (9.5–14.5 x 7.5–12). Unfortunately, they did not give a line drawing or a photomicrograph. Golemansky (1979) also found this species in 1/3 *E. europaeus* from the Sreburna Reserve, Bulgaria; the oocysts measured 24 x 18. Glebezdin (1985) also reported finding *I. erinacei* in hedgehogs (*H. auritus* ?) from southeastern Turkmenistan, but, again, this seems unlikely.

References: Yakimoff and Gousseff (1936); Glebezdin and Kolodenco (1969); Golemansky (1979); Glebezdin (1985).

***Isospora rastegaievae* Yakimoff and Matikaschwili, 1933, emend. Pellérdy, 1974 (Fig. 4)**

Synonym: *Isospora rastegaiev* Yakimoff and Matikaschwili, 1933.

Type host: *Erinaceus europaeus* Linnaeus, 1758, Eurasian hedgehog.

Other hosts: None reported to date.

Type locality: EUROPE: Russia, Polotzk District, Leningrad Zoo.

Geographic distribution: EUROPE: Austria; Czechoslovakia; Germany; Russia.

Description of oocyst: Oocyst shape: subspheroid (unsporulated) to ovoid to asymmetrically cylindroid (sporulated); number of walls: 2 (?); wall thickness: unknown, but probably ~ 1.0 ; wall characteristics: outer layer colorless, apparently smooth; L x W: 19.1 x 17.4 (16–21 x 15–20); L/W ratio: 1.1; M: absent; OR: absent; PG: absent. Distinctive features of oocyst: presumably changing shape during sporulation (?) and lack of MP, OR and PG.

Description of sporocysts and sporozoites: Sporocyst shape: subspheroid to ellipsoid (line drawing); L x W: 12–14.5 x 6.9–12.1; SB: absent; SSB: absent; PSB: absent; SR: present; SR characteristics: compact mass of granules in center of sporocyst; SP: sausage-shaped, L x W: 11–12 x 2–4, without a distinct RB (line drawing), although this was not stated in the original description. Distinctive features of sporocyst: compact SR of granules and sausage-shaped SP without RB.

Prevalence: 1/2 (50%) in Russia; 1/3 (33%) in Czechoslovakia; up to 45% (38/85) in Germany.

Sporulation: 1–2 days.

Prepatent period: Unknown.

Patent period: 6–7 days.

Site of infection: Unknown. Oocysts recovered from feces.

Materials deposited: None.

Remarks: The description of this species is only marginally useful; it is retained as valid only because an original line drawing of a sporulated oocyst was included and because several later investigators have reported it and clarified some of the details. Yakimoff and Matikaschwili, (1933) reported the shape to vary greatly during sporulation from distinctly round (their Figs. 1, 2) to ovoid or subspheroid (their Figs. 3, 4) when sporulated, although this seems unlikely to us. The possibility exists that they may have been looking at more than one species. They also said the oocyst wall was double contoured, but illustrated it as a single layer. Rysávy (1957) reported this species in *E. europaeus* from Czechoslovakia and added a line drawing; the oocysts were spheroid and measured 19–23 x 17–21. Kheissin (1959) studied the fate of residual bodies of *I. rastegaievae* and other *Eimeria* and *Isospora* species when the oocysts were kept in 2% potassium dichromate ($K_2Cr_2O_7$) solution at 18–25°C and found that residual bodies (glycogen and fat) disintegrated faster in *Isospora* than in *Eimeria* species. There are several reports of *I. rastegaievae* from “hedgehogs” (host species name never stated) worth mentioning: Barutzki et al. (1987) reported the oocysts of this species to be the predominant parasite of hedgehogs maintained in animal homes (38/85, 45%) and in private homes as pets (175/542, 32%), whereas it was much less prevalent in fecal samples of wild hedgehogs living outdoors (1–13% of 127 from several areas); Saupe (1988) noted that this species was present in hedgehogs and mentioned several treatment regimes; and Löwenstein et al. (1991), reporting data from their small animal practice in Austria, found *I. rastegaievae* in 21.5% of 341 hedgehogs between 1984–1989. They also provided the following observations: 1) outer wall colorless; 2) sporulation occurs in 1–2 days; 3) patency lasts 6–7 days and results in a chronic coccidiosis; 4) this species could cause liquid feces and occasionally bloody diarrhea; and 5) that coccidiosis regularly appeared in the spring after hibernation and was less common in the fall. Finally, a

number of other authors have made occasional reference to this species (Yakimoff and Gousseff, 1940; Matuschka, 1984; Glebezdin, 1985; Epe et al., 1993; and others).

References: Yakimoff and Matikaschwili (1933); Yakimoff and Gousseff (1940); Rasávy (1957); Kheissin (1959); Pellérdy (1974); Matuschka (1984); Glebezdin (1985); Barutzki et al. (1987); Saupe (1988); Löwenstein et al. (1991); Epe et al. (1993).

***Isospora schmaltzi* Yakimoff and Gousseff, 1936 (Fig. 5)**

Type host: *Erinaceus europaeus* Linnaeus, 1758, Eurasian hedgehog.

Other hosts: None reported to date.

Type locality: EUROPE: Russia, Polotzk District, Leningrad Zoo.

Geographic distribution: EUROPE: Russia.

Description of oocyst: Oocyst shape: spheroid; number of walls: 1; wall thickness: unknown, but probably ≤ 1.0 ; wall characteristics: outer layer colorless, apparently smooth; L x W: 24–28 x 24–28; L/W ratio: 1.0; M: absent; OR: present; PG: 1–2. Distinctive features of oocyst: presence of both OR and PG.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: unknown; SB: absent (?), although the original line drawing shows one end to be pointed; SSB: absent; PSB: absent; SR: present (?), original drawing shows sporocyst filled with granules and, thus, it may not have completed sporulation; SP: unknown. Distinctive features of sporocyst: SR granules that may fill it.

Prevalence: 1/34 (3%).

Sporulation: Unknown.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces.

Materials deposited: None.

Remarks: The description of this species is only marginally useful; it is retained as valid only because an original line drawing of a sporulated (?) oocyst and some oocyst measurements were included and because later authors have supplied additional information. There is no indication that Yakimoff and Gousseff (1936) ever saw completely sporulated oocysts. However, Glebezdin and Kolodenko (1969) reported finding this species in hedgehogs in Turkmenia. The

oocysts they found were round and measured 26.8 (23.5–29) and the sporocysts 11.1 x 8.6 (10.5–12 x 8.5–9); they did not provide a line drawing or photomicrograph.

References: Yakimoff and Gousseff (1936, 1940); Glebezdin and Kolodenco (1969).

**Host Genus *Hemiechinus* Fitzinger, 1866
(6 spp.)**

***Eimeria auriti* Mirza, 1970 (Fig. 6)**

Type host: *Hemiechinus auritus* (Gmelin, 1770), Long-eared desert hedgehog.

Other hosts: None reported to date.

Type locality: ASIA: Iraq, near Baghdad.

Geographic distribution: ASIA: Iraq.

Description of oocyst: Oocyst shape: subspheroid; number of walls: 2; wall thickness: ~2.0; wall characteristics: outer, pale yellow, apparently smooth, ~ $\frac{3}{4}$ of total; inner, orange; L x W: 20.4 x 18.6 (17–23.5 x 15.5–22); L/W ratio: 1.1 (1.0–1.1); M: absent; OR: absent; PG: 1. Distinctive features of oocyst: thick, smooth wall; the color of the walls might be a distinguishing feature, but it probably is due to the $K_2Cr_2O_7$ solution used to store oocysts.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 10.0 x 7.3 (8.5–13 x 6.5–8); L/W ratio: 1.35 (1.2–1.6); SB: present; SSB: absent; PSB: absent; SR: present; SR characteristics: consists of scattered coarse granules filling sporocyst; SP: elongate, one end narrower than the other, lying head to tail, RBs absent. Distinctive features of sporocyst: pointed end of sporocyst with SB.

Prevalence: 4/30 (13%).

Sporulation: Exogenous. Oocysts sporulated in 14 days in 2.5% aqueous (w/v) $K_2Cr_2O_7$ solution at ~20–22°C.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces.

Materials deposited: None.

Remarks: This species was first reported in a M.S. Thesis, University of Baghdad (Mirza, 1970). Later, Mirza (1975) published the actual description. This species has not been reported since then.

References: Mirza (1970, 1975).

***Eimeria bijlikuli* Svanbaev, 1962 (Fig. 7)**

Type host: *Hemiechinus* (= *Erinaceus*) *auritus* (Gmelin, 1770), Long-eared desert hedgehog.

Other hosts: None reported to date.

Type locality: EUROPE: Kazakhstan, in the Dzhambul Oblast, 65 km NW from Jhambo.

Geographic distribution: EUROPE: Kazakhstan.

Description of oocyst: Oocyst shape: spheroid to subspheroid; number of walls: 2; wall thickness: 1.2–2.1; wall characteristics: outer, yellow-green or yellow-brown, apparently smooth; L x W: 32.4 x 26.0 (26.5–39 x 23.5–31); L/W ratio: 1.2; M: absent; OR: present; OR characteristics: compact round mass; PG: present. Distinctive features of oocyst: color and thickness of wall and presence of both OR and PG.

Description of sporocysts and sporozoites: Sporocyst shape: subspheroid; L x W: 11.6 x 8.9 (10–13 x 8–10); L/W ratio: 1.3; SB: absent; SSB: absent; PSB: absent; SR: absent; SP: comma- or pear-shaped, one end narrower than the other, 8.0–4.1 (7–9 x 3–4.5) lying head to tail, 1 RB at broad end. Distinctive features of sporocyst: lack of SB and SR and SP do not fill sporocyst.

Prevalence: 6/35 (17%).

Sporulation: Unknown.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces.

Materials deposited: None.

Remarks: Svanbaev (1962a,b) described this species twice in two different publications; to our knowledge, it has not been reported since then.

References: Svanbaev (1962a,b).

**Host Genus *Hylomys* Müller, 1840
(3 spp.)**

***Eimeria bentongi* Colley and Mullin, 1971 (Fig. 8)**

Type host: *Hylomys suillus* Müller, 1840, Lesser gymnure.

Other hosts: None reported to date.

Type locality: ASIA: Malaysia: Pahang, Bentong, in Janda Baik.

Geographic distribution: ASIA: Malaysia.

Description of oocyst: Oocyst shape: ellipsoid to subspheroid; number of walls: 1 (?); wall thickness: 1.5; wall characteristics: smooth, pale yellow; L x W: 16.9 x 14.5 (15–18 x 14–16); L/W ratio: 1.2 (1.1–1.3); M: absent; OR: absent; PG: 1. Distinctive features of oocyst: thick, smooth oocyst wall of only 1 (?) layer.

Description of sporocysts and sporozoites: Sporocyst shape: ellipsoid to ovoid; L x W: 10.0 x 5.6 (9–11 x 5–6); L/W ratio: 1.7 (1.7–1.8); SB: present; SSB: absent (?); PSB: absent; SR: present; SR characteristics: a compact mass of irregular granules in center of sporocyst; SP: comma-shaped, one end narrower than the other, lying head to tail, without RB. Distinctive features of sporocyst: prominent SB, presence of compact SR and lack of RB.

Prevalence: 1/21 (5%).

Sporulation: Presumably exogenous. Oocysts were sporulated after 7 days in 2.5% $K_2Cr_2O_7$ solution at 30°C.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces.

Materials deposited: The symbiotype host (see Frey et al., 1992) skin and skull are in the Medical Ecology Museum, Institute of Medical Research, Kuala Lumpur, Malaysia No. 86558.

Remarks: This species has not been reported since its original description.

Reference: Colley and Mullin (1971).

***Isoospora hylomysis* Colley and Mullin, 1971 (Fig. 9)**

Type host: *Hylomys suillus* Müller, 1840, Lesser gymnure.

Other hosts: None reported to date.

Type locality: ASIA: Malaysia: Pahang, Bentong, in Janda Baik.

Geographic distribution: ASIA: Malaysia.

Description of oocyst: Oocyst shape: spheroid to subspheroid; number of walls: 1 (?); wall thickness: 1.0; wall characteristics: smooth, greenish-yellow, finely striated; L x W: 11.6 x 10.8 (11–12 x 10–12); L/W ratio: 1.1 (1.0–1.3); M: absent; OR: absent; PG: 1. Distinctive features of oocyst: thick, smooth, striated oocyst wall of only 1 layer.

Description of sporocysts and sporozoites: Sporocyst shape: ellipsoid; L x W: 6.6 x 4.8 (6–7 x 4–5); L/W ratio: 1.4 (1.3–1.5); SB: absent;

SSB: absent; PSB: absent; SR: present; SR characteristics: scattered, irregular granules; SP: club-shaped, one end narrower than the other, without RB. Distinctive features of sporocyst: ellipsoid shape without SB or RB.

Prevalence: 10/21 (48%).

Sporulation: Presumably exogenous. Oocysts were sporulated after 7 days in 2.5% $K_2Cr_2O_7$ solution at 30°C.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces.

Materials deposited: The symbiotype host (Frey et al., 1992) skin and skull are in the Medical Ecology Museum, Institute of Medical Research, Kuala Lumpur, Malaysia No. 86558.

Remarks: This species has not been reported since its original description.

Reference: Colley and Mullin (1971).

Family Nesophontidae Anthony, 1916 (1 genus, 8 spp.)

To our knowledge, all species in this family are known only from fossils.

Family Solenodontidae Gill, 1872 (1 genus, 3 spp.)

To our knowledge, no species in this family have ever been examined for coccidia.

Family Soricidae G. Fischer, 1817 (2 subfamilies, 23 genera, 311 species)

Subfamily Crocidurinae Milne-Edwards, 1872 (12 genera, 199 spp.)

Host Genus *Crocidura* Wagler, 1832 (150 spp.)

***Eimeria firestonei* Bray, 1958 (Fig. 10)**

Type host: *Crocidura poensis* (Fraser, 1843) (= *C. schweitzeri*), White-toothed shrew.

Other hosts: None reported to date.

Type locality: AFRICA: Liberia: Marshall Territory, presumably near Harbel.

Geographic distribution: AFRICA: Liberia.

Description of oocyst: Oocyst shape: ovoid; number of walls: 1; wall thickness: < 1.0; wall characteristics: smooth, thin, fracture easily; L x W: 19.1 x 16.2 (18–20 x 15–18); L/W ratio: 1.2; M: absent; OR: absent; PG: absent. Distinctive

features of oocyst: thin, smooth wall of only 1 layer that ruptures easily.

Description of sporocysts and sporozoites: Sporocyst shape: elongate ovoid; L x W: 10.5 x 7.3 (10–11 x 7–8); L/W ratio: 1.4; SB: present; SSB: absent; PSB: absent; SR: present; SR characteristics: scattered, small granules; SP: vermicular, 4 x 3, with metachromatic granules, but no obvious RB (line drawing). Distinctive features of sporocyst: pointed ovoid shape with vermicular SPs (see *Remarks*).

Prevalence: 2/6 (33%, in 2/3 adults, but 0/3 neonates).

Sporulation: Exogenous. Oocysts sporulated in 3–4 days in 2% chromic acid (?) solution.

Prepatent and patent periods: Unknown.

Site of infection: Gametocytes were (presumably) seen in epithelial cells of the ileum. Oocysts were recovered from feces in rectal contents.

Endogenous development: Bray (1958) saw a few gamonts in which the "mature female gametocytes approximate in size to the oocysts of the larger species (*E. firestonei*) and are assumed to belong to this species. Both male and female gametocysts are typical and the only point worthy of note is that the males outnumber the females 3 to 1."

Materials deposited: None.

Remarks: The measurements of the SP, and the components of the original line drawing (Bray, 1959), suggest that either the SPs were degenerate or that the RBs were confused with SPs and were the structures actually measured; he also noted (incorrectly) that sporulated oocysts of this species somewhat resemble *E. soricis* described by Henry (1932) from *Sorex ornatus californicus*. However, the oocysts of this species have a thicker wall, possess no PGs and have a mean L/W ratio of 1.2 vs. 1.3–1.4. In addition, there are differences in host genus and continent. This species has not been reported since its original description.

Reference: Bray (1958).

***Eimeria leucodontis* Musaev and Veisov, 1961 (Fig. 11)**

Type host: *Crocidura leucodon* (Hermann, 1780), Bicolor white-toothed shrew.

Other hosts: *C. suaveolens* Pall.

Type locality: EUROPE: Azerbaijan: area near the village of Kumbashi Lenkoran.

Geographic distribution: EUROPE: Azerbaijan; Bulgaria.

Description of oocyst: Oocyst shape: spheroid; number of walls: 2; wall thickness: 2.5; wall characteristics: outer, colorless, smooth, ~1/2 of total thickness; inner, dark yellow; L x W: 21.0 (18–24); L/W ratio: 1.0; M: absent; OR: absent; PG: absent. Distinctive features of oocyst: spheroid, with thick, double-layered wall.

Description of sporocysts and sporozoites: Sporocyst shape: subspheroid to ovoid; L x W: 8.6 x 6.4 (8–10 x 6–8); L/W ratio: 1.3; SB: absent; SSB: absent; PSB: absent; SR: present; SR characteristics: scattered, small granules; SP: bean-shaped, with a small, round RB at one end. Distinctive features of sporocyst: small size without SB.

Prevalence: 1/8 (12.5%) type host; 2/11 (18%) *C. suaveolens*.

Sporulation: Exogenous. Oocysts sporulated within 48 hours in 2.5% K₂Cr₂O₇ solution at 25–30°C.

Prepatent and patent periods: Unknown.

Site of infection: Oocysts recovered from feces.

Materials deposited: None.

Remarks: This species also was found in 2/11 *C. suaveolens* from the Arkvtino Reserve, Bulgaria (Golemansky, 1979); oocysts measured 20.3 x 18.2 (18–23 x 15–21) and sporocysts were 10–12 x 7–8.

References: Musaev and Veisov (1961); Golemansky (1979).

***Eimeria milleri* Bray, 1958 (Fig. 12)**

Type host: *Crocidura poensis* (Fraser, 1843) (= *C. schweitzeri*), White-toothed shrew.

Other hosts: None reported to date.

Type locality: AFRICA: Liberia: Marshall Territory, presumably near Harbel.

Geographic distribution: AFRICA: Liberia.

Description of oocyst: Oocyst shape: ovoid; number of walls: 1; wall thickness: < 1.0; wall characteristics: smooth, thin, but "tougher" than those of *E. firestonei*; L x W: 14.9 x 13.6 (14–16 x 12–14); L/W ratio: 1.1; M: absent; OR: absent; PG: 1, sometimes. Distinctive features of oocyst: thin, smooth wall, presumably asymmetrical (line drawing), small size.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 8.0 x 6.2 (7.5–8.5 x 6–7); L/W ratio: 1.3; SB: present; SSB: absent; PSB: absent; SR: present; SR characteristics: scattered, small granules mostly obscuring SP (line drawing); SP: vermicular, 3.5 x 2.5, but no obvious RB. Distinctive features of sporocyst: small size, pointed ovoid shape with vermicular SPs.

Prevalence: 2/6 (33%, in 2/3 adults, but 0/3 infants).

Sporulation: Exogenous. Oocysts sporulated in 4 days in 2% chromic acid (?) solution.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts were recovered from feces in rectal contents.

Materials deposited: None.

Remarks: It is likely that either the SP measurements are in error or that the RBs were being confused with the SP and were the actual structures measured by Bray (1958). This species somewhat resembles *E. chagasi* from *Sorex araneus* (Yakimoff and Gousseff, 1935) and *E. crociduræ* from *Crocidura russula* (Galli-Valerio, 1933), which we consider a *species inquirindae*; it has not been reported since its original description.

Reference: Bray (1958).

***Eimeria ropotamae* Golemansky, 1978 (Fig. 13)**

Type host: *Crocidura leucodon leucodon* (Hermann, 1780), Bicolor white-toothed shrew.

Other hosts: None reported to date.

Type locality: EUROPE: Bulgaria, near the Ropotamo River.

Geographic distribution: EUROPE: Bulgaria.

Description of oocyst: Oocyst shape: spheroid to subspheroid; number of walls: 2 (?); wall thickness: unknown, but probably ≥ 1.0 ; wall characteristics: outer, colorless, lightly sculptured, $\sim 3/4$ of total; inner, membranous, colorless; L x W: 22–25 x 20–22.5; L/W ratio: unknown; M: absent; OR: absent; PG: 1–2. Distinctive features of oocyst: sculptured outer wall.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 12 x 7.6; L/W ratio: 1.6; SB: present as a "hyaline plug" at narrow end; SSB: (?) absent; PSB: absent; SR: present; SR characteristics: diffuse, small gran-

ules; SP: with a distinct RB at one end (line drawing), although this was not stated in the original description. Distinctive features of sporocyst: the hyaline-plug like SB (which may be a SSB; this needs to be determined).

Prevalence: 1/2 (50%) in original description; 1/1 from *C. leucodon* captured in the Arkvtino Reserve, Bulgaria (Golemansky, 1979; see *Remarks* under *E. neomyi*).

Sporulation: Exogenous. Oocysts sporulated in 56 hours in 3% $K_2Cr_2O_7$ at $\sim 24^\circ C$.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Materials deposited: None.

Remarks: This species is structurally similar to *E. chagasi* from *Sorex* spp. In addition, in the original description, Golemansky (1978) also described *E. neomyi* from *Neomys anomalus* and from *N. fodiens*, and the drawings for both *E. ropotamae* and *E. neomyi* are essentially identical for both sporulated and unsporulated oocysts. Although it is known that some eimeriid coccidia in mammals seem to switch host genera easily (e.g., those in Sciuridae; see Wilber et al., 1998), the majority, apparently, cannot do this. Given the paucity of information, we do not know if host switching between genera can occur by coccidia from insectivores. Thus, we are inclined to retain this name as valid until additional evidence suggests otherwise.

References: Golemansky (1978, 1979).

Host Genus *Suncus* Ehrenberg, 1832 (16 spp.)

***Eimeria darjeelingensis* Sinha and Sinha, 1980 (Fig. 14)**

Synonym: *Eimeria* sp. Sinha and Sinha, 1979.

Type host: *Suncus murinus* (Linnaeus, 1766), House shrew.

Other hosts: None reported to date.

Type locality: ASIA: India: West Bengal, Darjeeling, alt. 2000 m.

Geographic distribution: ASIA: India.

Description of oocyst: Oocyst shape: subspheroid; number of walls: 2; wall thickness: 0.3 (?); wall characteristics: smooth, of uniform thinness; L x W: 16.7 x 14.9 (15–19 x 13–18); L/W ratio: 1.1; M: absent; OR: absent; PG: ab-

sent. Distinctive features of oocyst: very thin, smooth wall.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 8.0 x 5.6 (7–9 x 5–6.5); L/W ratio: 1.4; SB: present; SSB: absent; PSB: absent; SR: present; SR characteristics: scattered, small granules; SP: sausage-shaped (line drawing), 4.5 x 1.6 (4–5.5 x 1–2) (?), but no obvious RB (line drawing). Distinctive features of sporocyst: small size of SPs, which do not fill sporocyst.

Prevalence: 1/4 (25%).

Sporulation: Exogenous. Oocysts sporulated in 38–52 hours in 2.5% $K_2Cr_2O_7$ solution at 13–16°C.

Prepatent and patent periods: Unknown.

Site of infection: Sinha and Sinha (1980) described several endogenous stages from epithelial and subepithelial cells of the mucosa in “pieces of intestine” from the only host animal that also was passing unsporulated oocysts.

Endogenous development: Young meronts are subspheroid to ovoid, 6.4 x 5.8 (5.5–8 x 5–6) with homogeneous cytoplasm and a subcentral nucleus. Binucleate meronts are 9.3 x 6.3, while those with 12 nuclei are 13.9 x 11.9.

Young macrogamonts are ovoid with a central nucleus and measured 12.6 x 9.3, while fully developed macrogametes were 14.8 x 11 with a subcentral nucleus. Young microgamonts are spheroid, 6.3, and contain several small peripheral nuclei, whereas mature forms are subspheroid, 8.3 x 7 (7–11 x 6–9), with comma-shaped microgametes.

Materials deposited: None.

Remarks: Sinha and Sinha (1980) may actually have confused the SPs with the RBs, which may be the actual structures measured. It is possible that the asexual stages they describe represent those of a different coccidian species since development of *Eimeria* species (during light infections that probably occur in nature) often is relatively synchronous and oocysts already were being discharged in the feces. However, this cannot be verified since these tissue sections were not deposited into any known museum. This species has not been reported since its original description.

References: Sinha and Sinha (1979, 1980).

Eimeria murinus Bandyopadhyay and Das Gupta, 1985 (Fig. 15)

Type host: *Suncus murinus* (Linnaeus, 1766), House shrew.

Other hosts: None reported to date.

Type locality: ASIA: India: West Bengal.

Geographic distribution: ASIA: India.

Description of oocyst: Oocyst shape: subspheroid; number of walls: 2; wall thickness: 1.2–1.5; wall characteristics: outer, smooth, slightly yellowish; inner, same thickness as outer; L x W: 18.8 x 16.1 (15–21 x 14–16.5); L/W ratio: 1.2; M: absent; OR: absent; PG: absent. Distinctive features of oocyst: none.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 12.6 x 7.1 (8.5–13.5 x 6.5–8); L/W ratio: 1.8; SB: present; SSB: absent; PSB: absent; SR: present; SR characteristics: fine globules, scattered; SP: comma- to banana-shaped, 5.1 x 3.2 (4.5–7 x 2–3.5), with a round or ovoid RB at broad end. Distinctive features of sporocyst: pointed at one end with distinct SB.

Prevalence: 1/21 (5%).

Sporulation: Exogenous. Oocysts sporulated in 36 hours in 2.5% $K_2Cr_2O_7$ solution at 35–37°C.

Prepatent and patent periods: Unknown.

Site of infection: Endogenous stages were found in the subepithelial portion of the villi, sometimes above the submucosa at the base of the villi in “intestinal tissue pieces” from the only host animal that was passing unsporulated oocysts.

Endogenous development: Meronts were 4.9 x 3.3 (4–6.5 x 3–5) with nuclei that were ~2.0 (1.5–2). Binucleate meronts were 4.3 x 3.8 (4–6 x 3–5), while fully formed meronts with 12 merozoites were 5 x 5 (4.5–6 x 4–5). Merozoites were 3 x 1.

Gametocytes were mostly in the subepithelium, only rarely in the epithelial layer. Young microgametocytes, with numerous scattered nuclei, were 3.7 x 3 (3–4 x 2–4), whereas mature forms, with peripheral nuclei, were 4.1 x 4.0 (4–4.5 x 3.5–4.5). Young macrogametocytes were 3.8 x 2.5 (3–4.5 x 2.5–3) with a central nucleus about 0.8 in diameter. Mature macrogametocytes were 5.3 x 3.3 (4.5–6 x 3–4) with a central nucleus, ~1.0, with a clear halo around

it. Cytoplasm of the macrogametocytes was vacuolar, especially in late development.

Materials deposited: The authors stated that "type material will be deposited to the National Zoological Collection of the Zoological Survey of India, Calcutta," but no accession numbers were given nor was the kind of type material stated.

Remarks: Bandyopadhyay and Das Gupta (1985) described this species from *S. m. murinus* (Linnaeus), the house shrew. It is possible that the asexual stages they describe represent a second coccidian species since development of *Eimeria* species (in light infections that likely occur in nature) tends to be synchronous and oocysts already were being discharged in the feces. Unfortunately, it is not known if these tissue sections were deposited into the National Zoological Collection of Calcutta. This species has not been reported since its original description.

Reference: Bandyopadhyay and Das Gupta (1985).

***Eimeria suncus* Ahluwalia, Singh, Arora, Mandal and Sarkar, 1979 (Fig. 16)**

Type host: *Suncus murinus murinus* (Linnaeus, 1766), House shrew.

Other hosts: *S. m. soccatus* (Hodgson).

Type locality: ASIA: India: West Bengal, Mathura Veterinary College Campus.

Geographic distribution: ASIA: India.

Description of oocyst: Oocyst shape: subspheroid; number of walls: 2; wall thickness: 1.7–1.9; wall characteristics: outer, smooth, yellow, thinner than inner layer; L x W: 19.5 x 16.2 (18–22 x 15.5–17); L/W ratio: 1.2; M: absent; OR: absent; PG: reported as absent (?), but 1 is included in the line drawing. Distinctive features of oocyst: the authors state, "a clear micropylar cap is visible on the wall of the oocyst, but no distinct M is seen in any of the oocysts examined." However, they did not include a micropyle cap in their line drawing, so our conclusion is that the PG was confused for a micropylar cap.

Description of sporocysts and sporozoites: Sporocyst shape: lemon-shaped; L x W: 10.5 x 7.8 (9.5–11 x 6.5–9); L/W ratio: 1.35; SB: present; SSB: absent; PSB: absent; SR: present; SR characteristics: beaded-like globular mass, scattered; SP: comma- to banana-shaped, 4.5 x

3.5 (4–5.5 x 3–4), with a round RB at each end of SP. Distinctive features of sporocyst: nipple-like SB at thickened end of sporocyst and SPs with 2 RB.

Prevalence: 12/–100 (12%) in the type host collected from two localities in West Bengal; 1/11 (9%) of *S. m. soccatus* "collected . . . from various parts of the country" (i.e., India) (Bandyopadhyay and Das Gupta, 1984).

Sporulation: Exogenous. Oocysts sporulated in 48 hours in 2.5% $K_2Cr_2O_7$ solution at 20–22°C.

Prepatent and patent periods: Unknown.

Site of infection: "Columnar epithelial cells in sections of parts of the small intestine" (Ahluwalia et al., 1979).

Endogenous development: Bi- and multinucleate meronts were seen mostly in the subepithelium of the small intestine. Young meronts were 4.9 x 4.1 (4–6 x 3–5) with a nucleus that was 3.3 x 2.1 (3–4 x 1.5–2.3). Binucleate meronts were 3.9 x 2.9 (3.8–5 x 2–4) and multinucleate meronts, with 12 merozoites, were 6.2 x 4.8 (4–9 x 3–6).

Gametocytes also were found in the subepithelium (cell type not stated), sometimes just above the muscularis mucosa. Young microgametocytes, with numerous scattered nuclei, were 4.9 x 4.0 (4.5–5 x 3.8–4.2). Mature microgamonts, with comma-shaped microgametes arranged peripherally, were 8.0 x 5.9 (7–8.3 x 5.7–6). Young macrogametocytes were 5 x 4 (4–6 x 3–4.5) with a nucleus ~1.5. Mature macrogamonts, with a centrally located nucleus (~2) and vacuolated cytoplasm, measured 6.3 x 4.3 (5–7 x 3.5–5). Zygotes were somewhat larger, 7.2 x 6.0 (6–8 x 5–7).

Materials deposited: None. Ahluwalia et al. (1979) said, "Holotype: Z.S.I. Registration No." but did not give the number, and Bandyopadhyay and Das Gupta (1984), who made tissue sections from an infected host, did not deposit them anywhere.

Remarks: The oocyst description given above is that of Ahluwalia et al. (1979), except that we changed their mean oocyst width from 15.2 to 16.2 since the mean cannot be less than their range (15.5–17) and the description given subsequently by Bandyopadhyay and Das Gupta (1984) suggests a more subspheroid oocyst. Ahluwalia et al. (1979) stated that, "stained sec-

tions exhibit oocysts, macrogametocytes and microgametocytes inside columnar epithelial cells," but gave no drawings or photomicrographs; however, Bandyopadhyay and Das Gupta (1984) described and measured the endogenous stages from one *S. m. soccatus* they found in Darjeeling, West Bengal. The oocysts they described from fecal material were quite similar to those first described by Ahluwalia et al. (1979): subspherical oocysts were 19.6 x 18 (17–21 x 16–19.5) with a smooth, two-layered wall ~1.2–1.5; outer layer thinner than inner layer; OR absent; ovoid sporocysts were 10.2 x 6.8 (9–11 x 6–7.5) with a SB and a SR of scattered, fine globules. Bandyopadhyay and Das Gupta (1984) repeated the same error of Ahluwalia et al. (1979), mistaking a PG for a M.

Reference: Ahluwalia et al. (1979); Bandyopadhyay and Das Gupta (1984).

Subfamily Soricinae G. Fisher, 1817
(11 genera, 112 spp.)

Host Genus *Blarina* Gray, 1838
(3 spp.)

***Eimeria blarinae* Todd, French and Levine, 1986 (Fig. 17)**

Type host: *Blarina brevicauda* (Say, 1823), Short-tailed shrew.

Other hosts: None to date.

Type locality: NORTH AMERICA: U.S.A.: Illinois, Champaign County, Philo.

Geographic distribution: NORTH AMERICA: U.S.A.: Illinois.

Description of oocyst: Oocyst shape: spheroid to subspheroid; number of walls: 2; wall thickness: 1.5; wall characteristics: outer, light brown, ~ $\frac{3}{4}$ of total thickness, with indistinct striations; inner, smooth; L x W: 21.3 x 18.4 (18–23 x 15–20); L/W ratio: 1.2 (1.0–1.4); M: absent; OR: present; OR characteristics: clear homogeneous refractile globules of 2 sizes; 1 globule ~5 with 4–5 smaller globules ~1–2 each; PG: present (?). Distinctive features of oocyst: the purported presence of both OR and PG and the striated appearance of the outer wall.

Description of sporocysts and sporozoites: Sporocyst shape: elongate-piriform; L x W: 13.2 x 6.7 (12–14 x 6–8); L/W ratio: 2.0; SB: present; SSB: absent; PSB: absent; SR: present; SR char-

acteristics: numerous small granules, scattered; SP: banana-shaped, with a small anterior and a larger posterior RB. Distinctive features of sporocyst: piriform shape, strongly pointed at one end and SP with 2 RB.

Prevalence: 3/6 (50%).

Sporulation: Exogenous. Oocysts sporulated in 2.5% $K_2Cr_2O_7$ solution at 25–27°C in 10 days.

Prepatent and patent periods: Unknown.

Site of infection: Unknown, oocysts were recovered from intestinal contents.

Materials deposited: None.

Remarks: There is some confusion about the internal structure of the sporulated oocysts. Todd et al. (1986) did not tell how they distinguished the PG from the various small globules of the OR. Also, they describe two sizes of OR globules and a PG, but their line drawing (their Fig. 17) does not distinguish between them.

Reference: Todd et al. (1986).

***Eimeria brevicauda* Hertel and Duszynski, 1987a (Figs. 18, 75)**

Type host: *Blarina brevicauda* (Say, 1823), Short-tailed shrew.

Other hosts: None reported to date.

Type locality: NORTH AMERICA: U.S.A., Ohio, Ashtabula County, 4 km W, 27.4 km S, Ashtabula.

Geographic distribution: NORTH AMERICA: U.S.A., Ohio.

Description of oocyst: Oocyst shape: usually spheroid to slightly subspheroid; number of walls: 2; wall thickness: ~1.5; wall characteristics: outer, sculptured, colorless to pale yellow, ~ $\frac{2}{3}$ of total; inner, membranous, colorless; L x W: 20.3 x 19.7 (18–23 x 17–23); L/W ratio: 1.0 (1.0–1.1); M: absent; OR: absent; PG: sometimes present as 2–4 fragments of irregular size and shape. Distinctive features of oocyst: spheroid shape, sculptured outer wall, and lacking OR.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 11.3 x 7.6 (10–14 x 7–8); L/W ratio: 1.5 (1.3–1.6); SB: present; SSB: present, about same width as SB or wider; PSB: absent; SR: present; SR characteristics: occasionally composed of a large homogenous body, ~4–5, but more often of scattered spheroid globules; SP: with a distinct RB, although this was not stated in the original description.

Distinctive features of sporocyst: presence of SB and SSB.

Prevalence: 8/21 (38%).

Sporulation: Exogenous. Oocysts sporulated in 7–10 days in 2.5% aqueous (w/v) $K_2Cr_2O_7$ solution at $\sim 23^\circ C$.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Materials deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 43414 (NK 3110, female), D.W. Moore #744, 27 June 1980. Photosyntypes in the USNPC No. 86347.

Remarks: Only *Eimeria blarinae* Todd, French, and Levine, 1986, from *B. brevicauda* in Illinois, had been described from *Blarina* spp. prior to the description of this species. Although both are similar in size and shape, *E. brevicauda* differs from *E. blarinae* by lacking an OR, but having a SSB. This species has not been reported since its original description.

Reference: Hertel and Duszynski (1987a).

***Isospora brevicauda* Hertel and Duszynski, 1987a (Figs. 19, 98)**

Type host: *Blarina brevicauda* (Say, 1823), Short-tailed shrew.

Other hosts: None reported to date.

Type locality: NORTH AMERICA: U.S.A., Ohio, Ashtabula County, 4 km W, 2.7 km S, Ashtabula.

Geographic distribution: NORTH AMERICA: U.S.A.: Ohio.

Description of oocyst: Oocyst shape: spheroid to slightly subspheroid; number of walls: 2; wall thickness: ≤ 1.0 ; wall characteristics: outer, generally with a few small bumps, irregularly spaced, $\sim 1/2$ of total thickness, and with a striated appearance in optical cross section; L x W: 16.5 x 16.2 (15–18 x 15–18); L/W ratio: 1.0 (1.0–1.05); M: absent; OR: absent; PG: 4–6 fragments of irregular shape. Distinctive features of oocyst: small size, spheroid shape, with striated outer wall.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 11.6 x 7.6 (10–12 x 7–8); L/W ratio: 1.5 (1.4–1.7); SB: present; SSB: present, ~ 2 times wider than SB; PSB: absent; SR: present; SR characteristics: many lipid-

like globules that obscure SP; SP: probably have 1 large RB at rounded end, which was not reported in the original description. Distinctive features of sporocyst: lipid-like SR globules.

Prevalence: 2/21 (10%).

Sporulation: Exogenous. Oocysts sporulated in 7–10 days in 2.5% aqueous (w/v) $K_2Cr_2O_7$ solution at $\sim 23^\circ C$.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Materials deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 43415 (NK 3122, female), K. McBee #121, 29 June 1980. Photosyntypes in the USNPC No. 86356.

Remarks: This was the first *Isospora* sp. to be described from *Blarina* spp. Oocysts and sporocysts of this form are similar in size to those of *Isospora araneae* Golemansky, 1978, but differ by the striated nature of the oocyst wall and by the presence of SB and SSBs.

Reference: Hertel and Duszynski (1987a).

Host Genus *Cryptotis* Pomel, 1848 (14 spp.)

***Eimeria cryptotis* McAllister and Upton, 1989 (Figs. 20, 76)**

Type host: *Cryptotis parva parva* (Say, 1823), Least shrew.

Other hosts: None reported to date.

Type locality: NORTH AMERICA: U.S.A., Texas, Dallas County, 2.4 km W of DeSoto off FM 1382 on Ellerson Road.

Geographic distribution: NORTH AMERICA: U.S.A.: Texas.

Description of oocyst: Oocyst shape: subspheroid; number of walls: 2; wall thickness: 1.2; wall characteristics: outer, apparently smooth, $\sim 2/3$ of total thickness; L x W: 16.4 x 15.3 (14–18 x 13–17); L/W ratio: 1.1 (1.0–1.2); M: absent; OR: absent; PG: 1, always attached to inner surface of oocyst wall. Distinctive features of oocyst: attachment of PG to inner surface of wall.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 10.6 x 7.0 (9–11 x 6–8) with a smooth, thin, single-layered wall ~ 0.4 ; L/W ratio: 1.5 (1.4–1.8); SB: present as a

thickened end of the sporocyst; SSB: present, ~1.6 high x 3.2 wide; PSB: absent; SR: present; SR characteristics: a large, diffuse mass of granules filling sporocyst, ~5.7 x 4.9 (5–8 x 4–6); SP: 9–11 x 2.4, arranged head-to-tail with posterior ends recurved around one end of sporocyst, each with a centrally located N, but without RB. Distinctive features of sporocyst: large SSB and the curved SP without RB.

Prevalence: 1/14 (7%).

Sporulation: Exogenous. Oocysts sporulated in 7 days in 2.5% aqueous (w/v) $K_2Cr_2O_7$ solution at ~23°C.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Materials deposited: Symbiotype host is preserved in the Arkansas State University Museum of Zoology, ASUMZ No. 17740 (male), C.T. McAllister #91, 29 May 1987. Photosyntypes in the USNPC No. 87395.

Remarks: No other eimerian from shrews has a PG that has been reported to stick to the inner wall of the oocyst along with sporocysts with a SSB.

Reference: McAllister and Upton (1989).

***Eimeria whitakeri* Upton and McAllister, 1991 (Fig. 21, 77)**

Type host: *Cryptotis parva parva* (Say, 1823), Least shrew.

Other hosts: None reported to date.

Type locality: NORTH AMERICA: U.S.A., Texas, Johnson County.

Geographic distribution: NORTH AMERICA: U.S.A.: Texas.

Description of oocyst: Oocyst shape: spheroid to subspheroid; number of walls: 2; wall thickness: 1.2; wall characteristics: outer, smooth to lightly pitted, ~2/3 of total thickness; L x W: 17.4 x 16.4 (15–19 x 13–18.5); L/W ratio: 1.1 (1.0–1.2); M: absent; OR: absent; PG: 1, rather large and highly refractile. Distinctive features of oocyst: large, highly refractile PG.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 11.2 x 7.5 (9.5–12 x 6.5–8) with a smooth, thin, single-layered wall ~0.4; L/W ratio: 1.5 (1.4–1.6); SB: present as a thickened end of the sporocyst; SSB: convex, twice as wide as SB; PSB: absent; SR: present; SR characteristics: cluster of globules,

6.7 x 3.6 (5.5–8 x 2–5.5), either between SP or pressed tightly against sporocyst wall; SP: elongate, 13.6 x 3.2 (12–16 x 3–3.5), arranged head-to-tail, each with a spheroid anterior refractile body 2.2 (2–2.5) and ellipsoid posterior refractile body 5.6 x 3.0 (4–6.5 x 2.5–3.5) and a centrally located N between RBs. Distinctive features of sporocyst: combination of convex SSB, SR and SP with 2 RB.

Prevalence: 2/9 (22%) from Johnson County, but 0/1 from Denton County, 0/4 from Dallas County and 0/5 from Hood County.

Sporulation: Exogenous. Oocysts sporulated in 7 days in 2.5% aqueous (w/v) $K_2Cr_2O_7$ solution at ~23°C.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Materials deposited: Symbiotype host was not preserved, but syntypes (oocysts in 10% neutral buffered formalin) are in USNPC, No. 81476.

Remarks: This is only the second *Eimeria* species described from *Cryptotis*. Its oocysts differ from those of *E. cryptotis* by being slightly smaller (as are the sporocysts), by having a larger SR, and by having SP with RBs; this species has not been reported since its original description.

Reference: Upton and McAllister (1991).

Host Genus *Neomys* Kaup, 1829 (3 spp.)

***Eimeria neomyi* Golemansky, 1978 (Fig. 22)**

Synonym: *Eimeria komareki sensu* Černá (1961).

Type host: *Neomys anomalus* Cabrera, 1907, Southern water shrew.

Other hosts: *Neomys fodiens* (Pennant, 1771), Northern water shrew.

Type locality: EUROPE: Bulgaria, area of the Rila Mountain.

Geographic distribution: EUROPE: Bulgaria.

Description of oocyst: Oocyst shape: spheroid to subspheroid; number of walls: 2; wall thickness: unknown, but probably ≥ 1.0 ; wall characteristics: outer, colorless, smooth, ~2/3 of total; inner, membranous, colorless; L x W: 18–20 x 18–20 (spheroid oocysts) and 18.3 x 16.5 (16–20.5 x 15.2–17.8, subspheroid oocysts); L/W ratio: 1.0 (spheroid), 1.1 (subspheroid); M:

absent; OR: absent; PG: 1. Distinctive features of oocyst: 1 PG always present.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 12 x 7.5; L/W ratio: 1.6; SB: present as a "hyaline plug" at narrow end; SSB: absent (? , see below); PSB: absent; SR: present; SR characteristics: diffuse, small granules between the SP; SP: with a distinct RB at one end (line drawing), although this was not stated in the original description. Distinctive features of sporocyst: the hyaline-plug like SB (which may be a SSB; this needs to be determined).

Prevalence: 5/8 (63%) type host; 1/3 (33%) *N. fodiens*; 5/8 *N. anomalus* from Parangalista Reserve in Bulgaria (see *Remarks* and Golemansky, 1979).

Sporulation: Exogenous. Oocysts sporulated in 56 hours in 3% $K_2Cr_2O_7$ at $\sim 24^\circ C$.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Materials deposited: None.

Remarks: Černá (1961) found oocysts in *N. fodiens* that she called *E. komareki*, which she and Daniel (1956) had described earlier from *S. araneus*. Although some groups of mammalian coccidia do switch host genera (Wilber et al., 1998), most apparently do not. With so little known about insectivore coccidia, it is not possible to generalize about the host-parasite relationship in this group. Thus, we conclude that this species named by Golemansky (1978) actually describes oocysts similar to those first seen by Černá (1961) in this host genus. This is the only *Eimeria* species known from *Neomys*. It is of interest to note that in the original description, Golemansky (1978) also described *E. ropotamae* from *C. l. leucodon* and the drawings for both *E. ropotamae* and *E. neomyi* are essentially identical for both sporulated and unsporulated oocysts, with the exception that in the former the outermost wall is "lightly sculptured." For both *E. neomyi* and *E. ropotamae*, Golemansky (1978) stated that a typical SB either was not observed or was absent and that it was replaced by a structure he called a hyaline plug ("bouchon hyalin"). The pointed nature of the end of the sporocyst in both species (line drawings) indicates the presence of a SB and the hyaline plug may actually be a SSB.

In 1979, Golemansky reported on the coccidia of small mammals from four "reserves" in Bulgaria (Arkvitino, Parangalitsa, Ropotamo, Sreburna) and listed 1 *Cyclospora*, 3 *Isospora* and 8 *Eimeria* spp. from insectivores collected in these reserves. Six of the species he listed (1979) he also described in 1978 and, in most instances, the number of host animals collected and infected was identical or nearly identical for these six species in both papers; only the locality is different. For example, 1978: 5/8 *N. anomalus* and 1/3 *N. fodiens* from the Rila Mountains (Montagne de Rila) had *E. neomyi*; 1979: 5/8 *N. anomalus* from the Parangalista reserve had *E. neomyi*. It seems an odd coincidence that the number of hosts caught, and their prevalence of infection with the same parasites (*E. flexilis*, *E. neomyi*, *E. ropotamae*, *I. araneae*, *I. neomyi*, *I. talpae*), would be identical in different years from different localities. Measurements given for sporulated oocysts also were identical in both papers.

References: Černá (1961); Golemansky (1978, 1979); Wilber et al. (1998).

Isospora neomyi Golemansky, 1978 (Fig. 23)

Type host: *Neomys anomalus* Cabrera, 1907, Southern water shrew.

Other hosts: *Neomys fodiens* (Pennant, 1771), Northern water shrew.

Type locality: EUROPE: Bulgaria, area of the Rila Mountain.

Geographic distribution: EUROPE: Bulgaria.

Description of oocyst: Oocyst shape: spheroid; number of walls: 2; wall thickness: unknown, but probably ~ 1.0 ; wall characteristics: outer, colorless, smooth, $\sim 2/3$ of total; inner, membranous, colorless; L x W: 12–16 x 12–16; L/W ratio: 1.0; M: absent; OR: absent; PG: 1. Distinctive features of oocyst: small size, spheroid, 1 PG always present.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 8–11 x 5–6.5; L/W ratio: unknown; SB: absent; SSB: absent; PSB: absent; SR: present; SR characteristics: diffuse, small granules between the SP; SP: with a distinct RB at one end (line drawing), although this was not stated in the original description. Distinctive features of sporocyst: ovoid shape, without a SB.

Prevalence: 1/6 (17%) *N. anomalus*; 1/3 (33%) *N. fodiens*; Golemansky (1979) also reported this species in 1/6 *N. anomalus* and 1/2 *N. fodiens* from the Parangalista Reserve in Bulgaria. However, it is not clear if his 1979 paper uses the same or different animals than were cited in his 1978 paper (see *Remarks* under *E. neomyi*).

Sporulation: Unknown.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Materials deposited: None.

Remarks: This is the only *Isospora* species described from *Neomys* to date.

References: Golemansky (1978, 1979).

Host Genus *Sorex* Linnaeus, 1758 (70 spp.)

Eimeria chagasi Yakimoff and Gousseff, 1935a (Fig. 24)

Synonyms: *Eimeria komareki* Černá and Daniel, 1956; *E. komareki* of Arnastauskienė and Maldžiūnaitė, 1979; *E. komareki* of Arnastauskienė, 1980.

Type host: *Sorex araneus* Linnaeus, 1758, Eurasian common (Gomel) shrew.

Other hosts: *Sorex arcticus* Kerr, 1792, Arctic shrew; *Sorex minutus* Linnaeus, 1766, Pygmy shrew.

Type locality: EUROPE: Russia, Gomel District.

Geographic distribution: EUROPE: Bulgaria; Czechoslovakia; Lithuania; Russia.

Description of oocyst: Oocyst shape: spheroid to slightly subspheroid; number of walls: 1; wall thickness: ≤ 1.0 ; wall characteristics: smooth, thin, colorless; L x W: 14.5 (13–19 x 12–15); L/W ratio: 1.0–1.1; M: absent; OR: absent; PG: 1. Distinctive features of oocyst: small, spheroid shape and without OR.

Description of sporocysts and sporozoites: Sporocyst shape: ellipsoid; L x W: 8–9 x 4–5; SB: absent; SSB: absent; PSB: absent; SR: present; SR characteristics: mass of small granules in center of sporocyst between the SP (line drawings); SP: sausage-shaped without RB (line drawings of both Yakimoff and Gousseff, 1935a and Černá and Daniel, 1956). Distinctive features of sporocyst: nondescript, without SB.

Prevalence: 1/26 (4%) in the type host from the Gomel district and 0/10 from the Polotsk District of Russia; 1/17 (6%) in Bulgaria.

Sporulation: Exogenous. According to Černá and Daniel (1956), oocysts sporulated in 1–2 days at room temperature in 1.5% potassium “bichromate” solution.

Prepatent and patent periods: Unknown.

Site of infection: Oocysts in original description recovered from feces and intestinal contents, but gamogony, according to Černá (1961), occurs in the small intestine.

Endogenous stages: Černá (1961) found gamonts in the mucosal cells of the small intestine, but rarely the large intestine. She described microgamonts as broadly ovoid, 8–10 x 6–8 when mature and as producing many elongate, drop-shaped microgametes $\sim 2 \times 0.5$. Macrogamonts were described as broadly ovoid ~ 7 –9 x 6–7.

Materials deposited: None.

Remarks: Little information on oocyst structure was given in the original description. Yakimoff and Gousseff (1935a) described the oocysts as spheroid, 14.5 in diameter, without an OR, but with a PG; they did provide a line drawing. Černá and Daniel (1956) described similar oocysts from *S. araneus* in Czechoslovakia, but called it *E. komareki*. Both descriptions are incomplete, but their descriptions and respective line drawings are virtually identical; thus, we believe they saw the same species. Černá and Daniel (1956) also noted, “. . . in the sporozoits (sic) the light-refracting bodies are visible,” but they did not include RB in their line drawing. Černá (1961) described the micro- and macrogamonts (which she still called *E. komareki*) from *S. araneus* collected from Šárka near Prague, Czechoslovakia. The structural and biological information given (above) is a synthesis from these three papers. Černá (1961) also said she saw *E. komareki* in *Neomys fodiens*, but Golemansky (1978) named the form Černá saw as *E. neomyi*. In the same paper, Golemansky (1978) described *E. ropotamae* from *Crocidura leucodon*; the description he gave shows only a small size difference between the sporulated oocysts of *E. neomyi* and *E. ropotamae*, and drawings of both are indistinguishable. It is possible that the difference in oocyst size may be attributed to the variability in host species dis-

cussed by Reduker et al. (1985) or to inherent individual variability in oocyst size over patency (Duszynski, 1971), or both. If true, *E. komareki*, *E. neomyi* and *E. ropotamae* may all be synonyms of *E. chagasi*. However, since we do not know if some *Eimeria* spp. of insectivores can transfer easily between host genera (as occurs with some sciurid coccidia; see Wilber et al., 1998), we will assume, for the present, that species from different insectivore genera are distinct. This is an area that needs additional study.

Golemanski and Yankova (1973) reported this species (as *E. komareki*) in the same host species in Bulgaria. Golemanski (1979) again reported it (as *E. komareki*) from *S. araneus* from the Parangalista and Sreburna Reserves and from *S. minutus* from the Parangalista Reserve in Bulgaria. Finally, Arnastauskienė and Maldžiūnaitė (1979) found this species (reported as *E. komareki*) in both *S. araneus* and *S. minutus* from the Žagarė Botanical and Zoological Preserve and Arnastauskienė (1979) reported it, again as *E. komareki*, from *S. arcticus* collected from the Taimyr Peninsula, Lithuania.

References: Yakimoff and Gousseff (1935a,b); Černá and Daniel (1956); Černá (1961); Golemanski and Yankova (1973); Arnastauskienė and Maldžiūnaitė (1979); Golemanski (1979); Arnastauskienė (1980).

***Eimeria dissimilis* Yakimoff and Gousseff, 1935a (Fig. 25)**

Type host: *Sorex araneus* Linnaeus, 1758, Eurasian common (Gomel) shrew.

Other hosts: *Sorex minutus* Linnaeus, 1766, Pygmy shrew.

Type locality: EUROPE: Russia, Gomel District.

Geographic distribution: EUROPE: Bulgaria; Lithuania; Russia.

Description of oocyst: Oocyst shape: ovoid with both ends either rounded or pointed; number of walls: 1; wall thickness: ~1.0; wall characteristics: smooth, yellow; L x W: 28.0 x 19.4 (18–33 x 13–24); L/W ratio: 1.4; M: absent; OR: absent; PG: 1. Distinctive features of oocyst: elongate, ovoid shape with pointed ends (line drawing).

Description of sporocysts and sporozoites: Sporocyst shape: ellipsoid (line drawing); L x W: 15 x 10 (from Golemanski, 1979); SB: ab-

sent; SSB: absent; PSB: absent; SR: presence or absence could not be determined by the authors, but none is shown in their line drawing; SP: sausage-shaped without RB (line drawing). Distinctive features of sporocyst: nondescript, without SB.

Prevalence: 1/26 (4%) from the Gomel District and 0/10 from the Polotsk District, Russia; 1/2 (50%) in *S. minutus* from Bulgaria (Golemanski, 1979).

Sporulation: Unknown.

Prepatent and patent periods: Unknown.

Site of infection: Oocysts recovered from feces and intestinal contents.

Materials deposited: None.

Remarks: No information on sporocyst structure was given in the original description by Yakimoff and Gousseff (1935a), although they did provide two line drawings that are quite different. The first drawing (their Fig. 1) shows an oocyst with rounded ends and four sporoblasts, while the second (their Fig. 2) is 25% larger and shows an oocyst with pointed ends. Either the oocysts increase in size during sporulation or during patency, or they were dealing with two different species, or most likely, the oocysts were not drawn to scale relative to each other. This species was reported for the second time in *S. minutus* by Golemanski (1979) from the Parangalista Reserve in Bulgaria; the oocysts he saw were 27–29 x 23–25 and sporocysts were 15 x 10. It also was reported from *S. araneus* from the Žagarė Botanical and Zoological Preserve, Lithuania, by Arnastauskienė and Maldžiūnaitė (1979).

References: Yakimoff and Gousseff (1935a); Arnastauskienė and Maldžiūnaitė (1979); Golemanski (1979).

***Eimeria fumeus* Hertel and Duszynski, 1987a (Fig. 26, 78)**

Type host: *Sorex fumeus* Miller, 1895, Smokey shrew.

Other hosts: *Sorex monticolus* Merriam, 1890, Montane shrew (previously thought to be *S. vagrans*); *Sorex pacificus* Coues, 1877, Pacific shrew; *Sorex unguiculatus* Dobson, 1890, Long-clawed shrew.

Type locality: NORTH AMERICA: U.S.A., Vermont, Lamoille County, 6.4 km E, 3.2 km S, Morrisville.

Geographic distribution: NORTH AMERICA: U.S.A., Massachusetts, New Mexico, Oregon, Vermont; ASIA: Japan, Hokkaido.

Description of oocyst: Oocyst shape: ellipsoid; number of walls: 2; wall thickness: ~1.0; wall characteristics: outer, rough, yellow, ~2/3 of total thickness; L x W: 27.6 x 22.4 (25–32 x 20–25); L/W ratio: 1.2 (1.1–1.5); M: absent; OR: absent; PG: usually 1, but occasionally up to 4 fragments. Distinctive features of oocyst: none.

Description of sporocysts and sporozoites: Sporocyst shape: football-shaped, being slightly pointed at both ends; L x W: 15.1 x 8.8 (13–17 x 8–12); L/W ratio: 1.7 (1.3–2.3); SB: present; SSB: present, about same width as SB; PSB: present at pointed end of sporocyst opposite SB; SR: present; SR characteristics: 1 large globule, ~4.0, or composed of several globules; SP: with distinct RB at one end, although this was not stated in the original description. Distinctive features of sporocyst: football-shape and presence of SB, SSB and PSB.

Prevalence: 4/16 (25%) *S. fumeus*; 1/112 (< 1%) *S. monticolus*; 1/12 (8%) *S. pacificus*; 2/48 (4%) *S. unguiculatus*.

Sporulation: Exogenous. Oocysts sporulated in 7–10 days in 2.5% aqueous (w/v) $K_2Cr_2O_7$ solution at ~23°C.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Materials deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 43318 (NK 3032, sex undetermined), R.M. Sullivan #484, 14 June 1980. Photosyntypes in the USNPC No. 86348.

Remarks: Oocysts of this species are distinctive among those from insectivores being one of only two, thus far, to have sporocysts with a PSB.

Reference: Hertel and Duszynski (1987a).

***Eimeria inyoni* Hertel and Duszynski, 1987a (Fig. 27, 79)**

Type host: *Sorex tenellus* Merriam, 1895, Inyo shrew.

Other hosts: None reported to date.

Type locality: NORTH AMERICA: U.S.A., California, Mono County, 22.5 km N, 4 km W, Bridgeport.

Geographic distribution: NORTH AMERICA: U.S.A., California.

Description of oocyst: Oocyst shape: subspheroid; number of walls: only 1 obvious layer; wall thickness: ≤1.0; wall characteristics: smooth; L x W: 21.6 x 19.3 (19–24 x 17–23); L/W ratio: 1.1 (1.0–1.3); M: absent; OR: absent; PG: usually 1–2, but occasionally up to 7 highly refractile fragments. Distinctive features of oocyst: highly refractile nature of PGs.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 11.9 x 7.4 (10–14 x 6–9); L/W ratio: 1.6 (1.3–1.9); SB: present; SSB: present, slightly wider than SB; PSB: absent; SR: present; SR characteristics: dispersed granules; SP: appear to be highly granular, with a distinct RB at one end. Distinctive features of sporocyst: highly granular appearance of SP.

Prevalence: 1/2 (50%).

Sporulation: Exogenous. Oocysts sporulated in 7–10 days in 2.5% aqueous (w/v) $K_2Cr_2O_7$ solution at ~23°C.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Materials deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 53229 (NK 7991, female), S.B. George #1059, 13 August 1983. Photosyntypes in the USNPC No. 86350.

Remarks: This species most closely resembles *Eimeria suncus* Ahluwalia, Singh, Arora, Mandel and Sarkar, 1979, from the common house shrew (*Suncus murinus*) from India, but differs by having larger oocysts (22 x 19 vs. 20 x 15) and by the presence of a SSB, which *E. suncus* lacks.

Reference: Hertel and Duszynski (1987a).

***Eimeria longirostris* Hertel and Duszynski, 1987b (Fig. 28, 80)**

Synonym: *Eimeria palustris* Hertel and Duszynski, 1987a, *nomen preocc*; non *Eimeria palustris* Barnard, Ernst and Stevens, 1971.

Type host: *Sorex tenellus* Merriam, 1895, Inyo shrew.

Other hosts: *Sorex cinereus* Kerr, 1792, Masked shrew; *Sorex fontinalis* Hollister, 1911, Maryland shrew; *Sorex fumeus* Miller, 1895, Smoky shrew; *Sorex haydeni* Baird, 1858, Hayden's shrew; *Sorex longirostris* Bachman, 1837, Southeastern shrew; *Sorex monticolus* Merriam, 1890, Montane shrew (previously thought to be *S. vagrans*); *Sorex ornatus* Merriam, 1895, Ornate shrew; *Sorex pacificus* Coues, 1877, Pacific shrew; *Sorex palustris* Richardson, 1828, Northern water shrew; *Sorex trowbridgii* Baird, 1858, Trowbridge shrew.

Type locality: NORTH AMERICA: U.S.A.: New Mexico, Santa Fe County, 8 km N, 12.9 km E, Santa Fe.

Geographic distribution: NORTH AMERICA: Canada: Manitoba, Ontario; U.S.A.: Arizona, California, Colorado, Florida, Massachusetts, Minnesota, New Mexico, Oregon, Pennsylvania, Vermont, Virginia, Washington.

Description of oocyst: Oocyst shape: spheroid to slightly subspheroid; number of walls: only 1 obvious layer; wall thickness: ≤ 1.0 ; wall characteristics: yellow, slightly sculptured, and gives striated appearance in optical cross section; L x W: 17.1 x 16.6 (12–22 x 12–21); L/W ratio: 1.0 (1.0–1.3); M: absent; OR: absent; PG: usually 1–2. Distinctive features of oocyst: striated appearance of wall when viewed in cross section.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 10.8 x 6.5 (6–14 x 4–8); L/W ratio: 1.7 (1.1–2.6); SB: present; SSB: absent; PSB: absent; SR: present; SR characteristics: dispersed granules; SP: with 1–2 distinct RBs. Distinctive features of sporocyst: small size with high L/W ratio.

Prevalence: 12/63 (19%) *S. cinereus*; 2/7 (29%) *S. fontinalis*; 5/16 (31%) *S. fumeus*; 1/4 *S. haydeni*; 5/8 (63%) *S. longirostris*; 14/112 (12.5%) *S. monticolus*; 1/2 (50%) *S. ornatus*; 1/12 (8%) *S. pacificus*; 8/41 (20%) *S. palustris*; 1/2 (50%) *S. tenellus*; 4/105 (4%) *S. trowbridgii*.

Sporulation: Exogenous. Oocysts sporulated in 7–10 days in 2.5% aqueous (w/v) $K_2Cr_2O_7$ solution at $\sim 23^\circ C$.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Materials deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM:

MSB No. 41120 (NK 1027, female), J.M. Evans #010, 8 July 1979. Photosyntypes in the USNPC No. 86351.

Remarks: Sporulated oocysts of *E. longirostris* somewhat resemble those of *Eimeria suncus* Ahluwalia, Singh, Arora, Mandal and Sarkar, 1979 from the common house shrew (*Suncus murinus*) in India. They differ from oocysts of *E. suncus* by having a single-layered, rough oocyst wall (vs. bilayered, smooth), in L/W ratio (1.0 vs. 1.3), by lacking a micropyle cap, and by the presence of PBs.

References: Hertel and Duszynski (1987a,b).

Eimeria soricis Henry, 1932 (Fig. 29)

Type host: *Sorex ornatus* Merriam, 1895 (= *S. californicus*), Ornate shrew.

Other hosts: *Sorex araneus* Linnaeus, 1758, Eurasian common shrew; *Sorex minutus* Linnaeus, 1766, Pygmy shrew.

Type locality: NORTH AMERICA: U.S.A., California, near Berkeley.

Geographic distribution: NORTH AMERICA: U.S.A., California; EUROPE: Lithuania; Russia.

Description of oocyst: Oocyst shape: subspheroid to ovoid to ellipsoid (?); number of walls: 1; wall thickness: ≤ 1.0 ; wall characteristics: thin, of uniform thickness, colorless; L x W: 19 x 14 (19–22 x 13–14); L/W ratio: 1.4; M: absent; OR: absent; PG: 1. Distinctive features of oocyst: none.

Description of sporocysts and sporozoites: Sporocyst shape: elongate–ellipsoid (line drawing of Yakimoff and Gousseff, 1935); L x W: unknown; L/W ratio: unknown; SB: absent; SSB: absent; PSB: absent; SR: present (?); SR characteristics: “residual material in the sporocyst” (not shown in line drawing); SP: with a distinct RB at one end (in the line drawing). Distinctive features of sporocyst: elongate–ellipsoid shape.

Prevalence: 1/1 *S. ornatus*; 1/10 (10%) *S. araneus*.

Sporulation: Exogenous. Oocysts sporulated in 7–8 days.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Materials deposited: None.

Remarks: Henry (1932) said the oocysts she saw were "ovoidal." However, her photomicrograph (her Fig. 10) showed an oocyst that was subspheroid, but the measurements she gave (L:W 1.4) indicate the oocyst could be ellipsoid. Yakimoff and Gousseff (1935a), who gave oocysts measurements similar to those of Henry (1932), had a line drawing that clearly was ellipsoid. Neither Henry (1932) nor Yakimoff and Gousseff (1935a) measured sporocysts, but the latter authors drew them as elongate-ellipsoid structures and showed that each SP had a RB at one end. Although a SR is mentioned by both authors as being present, it is not easily seen in the photomicrograph (Henry, 1932) or in the line drawing (Yakimoff and Gousseff, 1935a). The oocysts measured by Yakimoff and Gousseff (1935a) were 20.8 x 14.6 (16–22 x 12–18), but we are unable to determine if the oocysts they measured actually were *E. soricis* or a morphologically similar species. The oocysts found in the pygmy shrew from Lithuania measured 18.5–19.5 x 14–15 (Arnastauskienė and Maldžiūnaitė, 1979).

References: Henry (1932); Yakimoff and Gousseff (1935a); Arnastauskienė and Maldžiūnaitė (1979).

***Eimeria vagrantis* Hertel and Duszynski, 1987a (Fig. 30, 81)**

Type host: *Sorex monticolus* Merriam, 1890, Montane shrew (previously thought to be *S. vagrans*).

Other hosts: *Sorex fumeus* Miller, 1895, Smoky shrew; *Sorex trowbridgii* Baird, 1858, Trowbridge shrew.

Type locality: NORTH AMERICA: U.S.A., New Mexico, Otero County, 8.8 km NE Cloudcroft.

Geographic distribution: NORTH AMERICA: U.S.A., Arizona, New Mexico, Oregon, Vermont, Washington.

Description of oocyst: Oocyst shape: ellipsoid; number of walls: 2; wall thickness: ~1.0; wall characteristics: outer, golden yellow, rough, ~3/4 of total thickness; L x W: 26.6 x 21.8 (24–32 x 20–35); L/W ratio: 1.2 (1.1–1.5); M: absent; OR: absent (?); PG (?): 5–10 dispersed granules. Distinctive features of oocyst: relatively large size with many dispersed PGs.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 15.9 x 9.0 (13–17 x 7–10); L/W ratio: 1.8 (1.5–2.2); SB: present; SSB: present, ~2 times wider than SB; PSB: absent; SR: present; SR characteristics: a cluster of 10–15 globules; SP: with a distinct RB at one end. Distinctive features of sporocyst: high L/W ratio and SSB 2 times wider than SB.

Prevalence: 1/16 (6%) *S. fumeus*; 5/112 (4%) *S. monticolus*; 1/105 (<1%) *S. trowbridgii*.

Sporulation: Exogenous. Oocysts sporulated in 7–10 days in 2.5% aqueous (w/v) K₂Cr₂O₇ solution at ~23°C.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Materials deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 40945 (NK 1589, female), D.J. Hafner #1671, 17 August 1979. Photosyntypes in the USNPC No. 86354.

Remarks: This species resembles *Eimeria dissimilis* Yakimoff and Gousseff, 1935a from the Eurasian common shrew (*S. araneus*) and *E. fumeus* from the Smoky shrew (*S. fumeus*). It differs from *E. dissimilis* in oocyst L/W ratio (1.2 vs. 1.5) and by having a coarse, granular SR, SB and SSBs that *E. dissimilis* apparently lacks. It differs from *E. fumeus* by lacking a PSB and by the size and shape of the SSB.

Reference: Hertel and Duszynski (1987a).

***Isospora aranae* Golemansky, 1978 (Fig. 31)**

Type host: *Sorex araneus* Linnaeus, 1758, Eurasian common shrew.

Other hosts: None to date.

Type locality: EUROPE: Bulgaria, area of the Rila Mountain.

Geographic distribution: EUROPE: Bulgaria.

Description of oocyst: Oocyst shape: spheroid to subspheroid; number of walls: 2; wall thickness: unknown, but probably ~1.0; wall characteristics: outer, colorless, smooth, ~2/3 of total; inner, darker than outer; L x W: 17 x 17 (spheroid) and 16–18.5 x 15–18 (subspheroid); L/W ratio: 1.0 (spheroid); M: absent; OR: absent; PG: 1–2. Distinctive features of oocyst: none.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 12.5 x 9.5; L/W ratio: 1.3; SB: present (?); SSB: absent; PSB: absent; SR: present; SR characteristics: diffuse, small granules between the SP; SP: with a distinct RB at one end (line drawing), although this was not stated in the original description. Distinctive features of sporocyst: ovoid shape without a SB.

Prevalence: 2/52 (4%).

Sporulation: Oocysts sporulated in 48 hours at 24°C in 3% K₂Cr₂O₇.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Materials deposited: None.

Remarks: Golemansky's (1978) original description did not mention the presence of a SB on the sporocyst; however, his line drawing showed that one end of the sporocyst is distinctly pointed, a structural feature that usually indicates a SB is present. This species was reported again by Golemansky (1979) from *S. araneus* from the Parangalista Reserve, Bulgaria; it is not clear if these are the same host animals used in the original description (see *Remarks* under *E. neomyi*).

References: Golemansky (1978, 1979).

***Isoospora palustris* Hertel and Duszynski, 1987a (Fig. 32, 99)**

Type host: *Sorex palustris* Richardson, 1828, Northern water shrew.

Other hosts: *Sorex monticolus* Merriam, 1890, Montane shrew (previously thought to be *S. vagrans*); *Sorex pacificus* Coues, 1877, Pacific shrew; *Sorex trowbridgii* Baird, 1858, Trowbridge shrew; *Sorex unguiculatus* Dobson, 1890, Long-clawed shrew.

Type locality: NORTH AMERICA: U.S.A., New Mexico, Santa Fe County, 8 km N, 12.9 km E, Santa Fe.

Geographic distribution: ASIA: Japan: Hokkaido; NORTH AMERICA: U.S.A.: California, New Mexico, Oregon, Washington.

Description of oocyst: Oocyst shape: subspheroid; number of walls: 2; wall thickness: ≤1.0; wall characteristics: outer, generally with a few small bumps, irregularly spaced, ~½ of total thickness, and with a striated appearance in optical cross section; L x W: 17.6 x 16.7 (16–19 x 16–18); L/W ratio: 1.1 (1.0–1.2); M: ab-

sent; OR: absent; PG: usually 1, but sometimes (30%) as 2–4 fragments of irregular size and shape. Distinctive features of oocyst: subspheroid shape, with striated outer wall.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 12.8 x 8.3 (12–14 x 8–10); L/W ratio: 1.6 (1.25–1.8); SB: present; SSB: almost spheroid, about same width as SB; PSB: absent; SR: present; SR characteristics: many small granules; SP: probably have 1 large RB at rounded end, which was not reported in the original description. Distinctive features of sporocyst: spheroid SSB.

Prevalence: 1/112 (<1%) *S. monticolus*; 2/12 (8%) *S. pacificus*; 3/41 (7%) *S. palustris*; 3/105 (3%) *S. trowbridgii*; 1/48 (2%) *S. unguiculatus*.

Sporulation: Exogenous. Oocysts sporulated in 7–10 days in 2.5% aqueous (w/v) K₂Cr₂O₇ solution at ~23°C.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Materials deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 41122 (NK 1002, male), R.A. Hoyt #098, 6 July 1979. Photosyntypes in the USNPC No. 86357.

Remarks: Oocysts and sporocysts of this species are very similar to those of *I. brevicauda*, but differ in two ways: oocyst length, oocyst width, sporocyst length, sporocyst width and oocyst L/W ratio of *I. brevicauda* from *Blarina* sp. were highly significantly smaller ($P < 0.0001$, Student's t-distribution) than those of *I. palustris* from *Sorex* spp. even though the respective means and ranges are similar; and the width of the SSB is about the same as the SB in *I. palustris*, whereas it is two times wider than the SB in *I. brevicauda*; also, the shape of the SSB is different between the two species.

Reference: Hertel and Duszynski (1987a).

***Isoospora soricis* Golemansky and Yankova, 1973 (Fig. 33)**

Type host: *Sorex araneus* Linnaeus, 1758, Eurasian common shrew.

Other hosts: None to date.

Type locality: EUROPE: Bulgaria.

Geographic distribution: EUROPE: Bulgaria.

Description of oocyst: Oocyst shape: ellipsoid; number of walls: 1; wall thickness: ≤ 1.0 ; wall characteristics: thin, smooth, light yellow; L x W: 24 x 17 (23–25 x 16–18); L/W ratio: 1.5; M: absent; OR: absent; PG: sometimes 1. Distinctive features of oocyst: ellipsoid shape.

Description of sporocysts and sporozoites: Sporocyst shape: described as piriform (pear-shaped), but pictured as spheroid (line drawing); L x W: 10.5 x 10.5; L/W ratio: 1.0; SB: absent; SSB: absent; PSB: absent; SR: present; SR characteristics: tiny granules, dispersed; SP: with 1 small RB at rounded end (line drawing). Distinctive features of sporocyst: spheroid shape.

Prevalence: 1/17 (6%).

Sporulation: Unknown.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Materials deposited: None.

Remarks: This species has not been reported since its original description.

Reference: Golemansky and Yankova (1973).

Family Tenrecidae Gray, 1821 (10 genera, 24 spp.)

Host Genus *Hemicentetes* Mivart, 1871 (1 sp.)

Eimeria semispinosi Uilenberg, 1970 (Fig. 34)

Type host: *Hemicentetes semispinosus* (G. Cuvier, 1798), Streaked tenrec.

Other hosts: None to date.

Type locality: AFRICA: Madagascar: Amparafara.

Geographic distribution: AFRICA: Madagascar.

Description of oocyst: Oocyst shape: ellipsoid to ovoid; number of walls: 2 or more; wall thickness: 1.0–1.5; wall characteristics: outer is rough, granular, yellow-maroon and sometimes gives impression of being several layers; thinner at pointed end and thicker at more rounded end; L x W: 19.2 x 14.3 (16–21 x 12–17); L/W ratio: 1.3; M: absent; OR: absent; PG: rarely 1. Distinctive features of oocyst: thick, rough, colored outer wall.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 10.0 x 6.6 (9–11 x 6–7); L/W ratio: 1.5; SB: present; SSB: absent (?); PSB: absent; SR: present; SR characteristics: tiny granules, dispersed; SP: possibly with 1–2 RB as large, clear globules (line drawing). Distinctive features of sporocyst: pointed at end with SB and clear globules of SP.

Prevalence: 4/10 (40%).

Sporulation: Oocysts sporulated in 6–7 days in 2% $K_2Cr_2O_7$ at $\sim 25^\circ C$.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Materials deposited: None.

Remarks: Given the size and the manner in which the SB was drawn, it is possible that the pointed end of the sporocyst represents a SB with a wider, clear SSB beneath it. This species has not been reported since its original description.

Reference: Uilenberg (1970).

Host Genus *Setifer* Friepe, 1860 (1 sp.)

Eimeria madagascariensis Uilenberg, 1967 (Fig. 35)

Type host: *Setifer setosus* (Schreber, 1777), Large Madagascar "hedgehog."

Other hosts: Probably none, see *Remarks*.

Type locality: AFRICA: Madagascar: ~ 15 km, NE of Tananarive.

Geographic distribution: AFRICA: Madagascar.

Description of oocyst: Oocyst shape: subspheroid to spheroid; number of walls: 1; wall thickness: ~ 0.5 ; wall characteristics: thin, smooth, colorless; L x W: 16.3 x 15.4 (13–22 x 12–19); L/W ratio: 1.05; M: absent; OR: absent; PG: 1. Distinctive features of oocyst: very thin wall.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 11.1 x 7.1 (10–12.5 x 6–8); L/W ratio: 1.6; SB: present; SSB: absent (?); PSB: absent; SR: present; SR characteristics: irregular mass of granules; SP: short, stocky, without clear globules and lie sideways in sporocyst. Distinctive features of sporocyst: short, stocky shape of SP.

Prevalence: 2/5 (40%).

Sporulation: Oocysts sporulated in 4 days in 2% $K_2Cr_2O_7$ at $\sim 25^\circ C$.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Cross-Transmission: Uilenberg (1967) was not able to transmit oocysts of this species from *S. setosus* to *Tenrec ecaudatus*.

Materials deposited: None.

Remarks: Given the size and shape of the SB in his line drawing, we think the sporocysts of this species also may possess a SSB (see *Remarks* under *E. semispinosi*). Although Uilenberg (1967) could not transmit this species to *T. ecaudatus*, he said he also found it in 3/6 (50%) *T. ecaudatus* and, later (Uilenberg, 1970), in 2/10 *Hemicentetes semispinosus*. Pellérdy (1969) assigned the form Uilenberg saw in *T. ecaudatus* to a new species he called *E. uilenbergi* (see below under *species inquirendae*).

References: Pellérdy (1969, 1974); Uilenberg (1967, 1970).

***Eimeria setosi* Uilenberg, 1967 (Fig. 36)**

Type host: *Setifer setosus* (Schreber, 1777), Large Madagascar "hedgehog."

Other hosts: None reported to date.

Type locality: AFRICA: Madagascar: ~ 15 km, NE of Tananarive.

Geographic distribution: AFRICA: Madagascar.

Description of oocyst: Oocyst shape: subspheroid to ellipsoid; number of walls: 1; wall thickness: 2.0; wall characteristics: thick, rough, striated, yellow-chestnut colored; L x W: 24.6 x 21.8 (21–29 x 18–25); L/W ratio: 1.1; M: absent; OR: absent; PG: 1. Distinctive features of oocyst: thick, striated, colored outer wall.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid to football-shaped, slightly pointed at end opposite SB; L x W: 14.3 x 8.9 (13–19 x 8–11.5); L/W ratio: 1.6; SB: present; SSB: absent (?); PSB: absent; SR: present; SR characteristics: irregular mass of large and small granules in center of sporocyst; SP: short, stocky, without clear globules and often lie sideways in sporocyst. Distinctive features of sporocyst: football-shape with short, stocky SP without RB.

Prevalence: 2/5 (40%).

Sporulation: Oocysts sporulated in 8–9 days in 2% $K_2Cr_2O_7$ at $\sim 25^\circ C$.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Cross-transmission: Uilenberg's (1967) transmission experiment of this species from *S. setosus* to 1 *Tenrec ecaudatus* was negative.

Materials deposited: None.

Remarks: The size and shape of the SB in the original drawing suggest that a SSB may be present in the sporulated oocysts of this species (see *Remarks* under *E. semispinosi*). This species has not been reported since its original description.

Reference: Uilenberg (1967).

Family Talpidae G. Fischer, 1817 (3 subfamilies, 17 genera, 42 spp.)

Subfamily Talpinae G. Fischer, 1817 (14 genera, 36 spp.)

Host Genus *Condylura* Illiger, 1811 (1 sp.)

***Eimeria condylurae* Duszynski, 1989 (Fig. 37, 82)**

Type host: *Condylura cristata* (Linnaeus, 1758), Star-nosed mole.

Other hosts: None reported to date.

Type locality: NORTH AMERICA: U.S.A., Vermont, Lamoille County, 10.3 km N of Stowe off Highway 100.

Geographic distribution: NORTH AMERICA: U.S.A., Ohio, Vermont.

Description of oocyst: Oocyst shape: subspheroid; number of walls: 2; wall thickness: ~ 1.5 ; wall characteristics: outer, smooth, yellow, $\sim 2/3$ of total thickness; inner, smooth, pale yellow; L x W: 17.7 x 15.7 (17–23 x 14–21); L/W ratio: 1.1 (1.05–1.25); M: absent; OR: present; OR characteristics: irregularly shaped, highly refractile (transmitted light) body $\sim 2 \times 3$; PG: absent. Distinctive features of oocyst: thick outer wall and highly refractile OR.

Description of sporocysts and sporozoites: Sporocyst shape: elongate-ellipsoid, pointed at both ends; L x W: 11.7 x 5.6 (11–14 x 5–6); L/W ratio: 2.1 (1.9–2.6); SB: present; SSB: present, ~ 2 times wider than SB; PSB: absent; SR:

present; SR characteristics: large granules that may be a compact mass or diffuse and occupies $\sim 1/2$ of space in sporocyst; SP: with a large, posterior RB. Distinctive features of sporocyst: large posterior RB of SP and large, granular SR.

Prevalence: 3/24 (12.5%) including 2/12 (17%) from Vermont and 1/6 (17%) from Ohio, but 0/4 from Massachusetts and 0/2 from Maine.

Sporulation: Exogenous. Oocysts sporulated in 7–10 days in 2.5% aqueous (w/v) $K_2Cr_2O_7$ solution at $\sim 23^\circ C$.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Materials deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 43334 (NK 3024, male), R.M. Sullivan #479, 13 June 1980. Photosyntypes in the USNPC No. 80625.

Remarks: Sporulated oocysts of this species resemble in size and shape those of *E. madagascarensis* (see Uilenberg, 1967), but differ by being somewhat larger (18 x 16 vs. 16 x 15) and by having sporocysts that have a SSB and are pointed at the end opposite the SB.

Reference: Duszynski (1989).

***Isospora condyluræ* Duszynski, 1989 (Fig. 38, 100)**

Type host: *Condylura cristata* (Linnaeus, 1758), Star-nosed mole.

Other hosts: None reported to date.

Type locality: NORTH AMERICA: U.S.A., Vermont, Lamoille County, 9.7 km N of Stowe, ungrazed pasture by Highway 100.

Geographic distribution: NORTH AMERICA: U.S.A., Massachusetts, Ohio, Vermont.

Description of oocyst: Oocyst shape: ellipsoid, sometimes slightly asymmetrical; number of walls: 2; wall thickness: ~ 1.0 ; wall characteristics: outer layer smooth $\sim 1/2$ of total thickness; inner, smooth, but difficult to distinguish in intact oocyst; L x W: 19.4 x 9.3 (17–21 x 8–11); L/W ratio: 2.1 (1.7–2.3); M: absent; OR: absent; PG: 1, highly refractile. Distinctive features of oocyst: elongate–ellipsoidal shape and highly refractile PG.

Description of sporocysts and sporozoites: Sporocyst shape: elongate–ovoid; L x W: 11.7 x

5.8 (11–13 x 5–7); L/W ratio: 2.0 (1.8–2.4); SB: present; SSB: present, ~ 2 times wider than SB; PSB: absent; SR: present; SR characteristics: 10–12 homogeneous globules dispersed or in a compact mass; SP: with 1 RB in posterior half. Distinctive features of sporocyst: elongate shape with globular SR and SSB.

Prevalence: 12/24 (50%) including 7/12 (58%) from Vermont, 3/6 (50%) from Ohio, and 2/4 (50%) from Massachusetts, but 0/2 from Maine.

Sporulation: Exogenous. Oocysts sporulated in 7–10 days in 2.5% aqueous (w/v) $K_2Cr_2O_7$ solution at $\sim 23^\circ C$.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Materials deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 43346 (NK 3038, male), K. McBee #96, 14 June 1980. Photosyntypes in the USNPC No. 80626.

Remarks: Oocysts and sporocysts of this species have the largest L/W ratios of any *Isospora* spp. yet described from insectivores.

Reference: Duszynski (1989).

***Isospora cristatæ* Duszynski, 1989 (Fig. 39, 101)**

Type host: *Condylura cristata* (Linnaeus, 1758), Star-nosed mole.

Other hosts: None reported to date.

Type locality: NORTH AMERICA: U.S.A., Ohio, Ashtabula County, Ashtabula, 2302 Morningside Drive.

Geographic distribution: NORTH AMERICA: U.S.A., Maine, Massachusetts, Ohio, Vermont.

Description of oocyst: Oocyst shape: ellipsoid, sometimes slightly asymmetrical; number of walls: 2; wall thickness: ~ 1.0 ; wall characteristics: outer layer smooth $\sim 1/2$ of total thickness; inner, smooth; L x W: 15.7 x 10.1 (13–18 x 9–13); L/W ratio: 1.55 (1.35–1.8); M: absent; OR: absent; PG: present, 1. Distinctive features of oocyst: ellipsoid shape and small PG.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 11.0 x 5.7 (10–12 x 5–7); L/W ratio: 1.9 (1.6–2.1); SB: present; SSB: present, >2 times wider than SB; PSB:

absent; SR: present; SR characteristics: 2–8 dispersed globules; SP: with 1 visible RB in posterior half. Distinctive features of sporocyst: elongate shape with SSB >2 times wider than SB.

Prevalence: 19/24 (79%) including 9/12 (75%) from Vermont, 5/6 (83%) from Ohio, 3/4 (75%) from Massachusetts, and 2/2 (100%) from Maine.

Sporulation: Exogenous. Oocysts sporulated in 7–10 days in 2.5% aqueous (w/v) $K_2Cr_2O_7$ solution at ~23°C.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Materials deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 43403 (NK 3112, male), R.M. Sullivan #512, 28 June 1980. Photosyntypes in the USNPC No. 80627.

Remarks: Sporulated oocysts of this species are similar in size and shape to those of *I. dymecodi* and *I. sporopointaea* (Duszynski and Moore, 1986; Duszynski and Wattam, 1988b). They differ from the former by having a larger L/W ratio (1.55 vs. 1.25) and by having sporocysts with both SB and SSB that those of *I. dymecodi* lack. They differ from the latter by having a smooth outer wall (vs. mammillated), having a PG (vs. none), having sporocysts rounded at end opposite SB (vs. pointed), and by having a SSB that is twice as wide as the SB (vs. equal in width).

Reference: Duszynski (1989).

***Isospora lamoillensis* Duszynski, 1989 (Fig. 40, 102)**

Type host: *Condylura cristata* (Linnaeus, 1758), Star-nosed mole.

Other hosts: None reported to date.

Type locality: NORTH AMERICA: U.S.A., Vermont, Lamoille County, 6.4 km E, 3.2 km S Morrisville.

Geographic distribution: NORTH AMERICA: U.S.A., Ohio, Vermont.

Description of oocyst: Oocyst shape: ellipsoid, tapering toward both ends; number of walls: only 1 obvious layer; wall thickness: ~1.5; wall characteristics: outer layer smooth; L x W: 21.6 x 13.0 (19–23 x 11–14); L/W ratio: 1.7 (1.4–

1.8); M: absent; OR: absent; PG: 1. Distinctive features of oocyst: large size, ellipsoid shape that tapers toward both ends and small PG.

Description of sporocysts and sporozoites: Sporocyst shape: spindle-shaped, tapering toward a point at end opposite SB; L x W: 14.9 x 7.7 (14–16 x 7–8); L/W ratio: 1.95 (1.8–2.2); SB: prominent, wide; SSB: absent; PSB: absent; SR: present; SR characteristics: many dispersed granules of various sizes; SP: with 1 RB at mid-body. Distinctive features of sporocyst: spindle-shape with prominent SB, but no SSB.

Prevalence: 2/24 (8%) including 1/6 (17%) from Ohio and 1/12 (8%) from Vermont, but 0/2 from Maine, and 0/4 from Massachusetts.

Sporulation: Exogenous. Oocysts sporulated in 7–10 days in 2.5% aqueous (w/v) $K_2Cr_2O_7$ solution at ~23°C.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Materials deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 43323 (NK 3055, female), R.M. Sullivan #488, 17 June 1980. Photosyntypes in the USNPC No. 80628.

Remarks: Sporulated oocysts of this species most closely resemble those of *I. sporopointaea* and *I. talpae* (Agostinucci, 1955; Duszynski and Wattam, 1988b). They differ from the former by not having a mammillated outer wall, having a PG (vs. none), having larger oocysts with a larger L/W ratio (1.7 vs. 1.5), and lacking a SSB. They differ from the latter by having a PG, the shape of the SB (flat vs. nipple-like), and having sporocysts that are pointed at end opposite SB (vs. rounded).

Reference: Duszynski (1989).

**Host Genus *Mogera* Pomel, 1848
(7 spp.)**

***Eimeria tanabei* Levine and Ivens, 1979 (No figure available)**

Synonym: *Eimeria* sp. 2 of Tanabe (1938).

Type host: *Mogera robusta* Nehring, 1891 (= *M. wogura coreana*), Large Asian mole.

Other hosts: None reported to date.

Type locality: ASIA: Japan, Keijo, suburbs surrounding Keijo Imperial University.

Geographic distribution: ASIA: Japan.

Description of oocyst: Oocyst shape: presumably ellipsoid; number of walls: 1 (?); wall thickness: <1 (?); wall characteristics: thin, smooth; L x W: 10–13 x 6–8; L/W ratio: not given; M: absent; OR: absent (?); PG: absent (?). Distinctive features of oocyst: none.

Description of sporocysts and sporozoites: Sporocyst shape: not given; L x W: not given; L/W ratio: not given; SB: present (?); SSB: absent (?); PSB: absent (?); SR: present; SR characteristics: not given; SP and RB: not given. Distinctive features of sporocyst: none

Prevalence: 26/26 (100%) (?).

Sporulation: Exogenous (?).

Prepatent and patent periods: Unknown.

Site of infection: Distal to the host cell nucleus in the villar epithelium of the intestine.

Endogenous development: Usually a single organism was present in an epithelial cell, but sometimes 2–3 were present. A unique feature of this species is that a “crescent body is connected with every endogenous (sic) stage.” This body stained with H & E, with iron-haematoxylin, and was Feulgen positive. Tanabe (1938) believed it was not a deformed host-cell nucleus.

Young meronts were small, ~1.8, and eventually gave rise to 16 lancet-shaped merozoites, without residual body, that measured 5–8 x 0.7–1.0. Merozoites had an oval nucleus, located in their posterior part, with a tiny, eccentric nucleolus, but no granules.

Young micro- and macrogamonts could not be distinguished from young meronts. Tanabe (1938) provided drawings of these developmental stages, but gave no measurements. He noted that microgametes “are the smallest of any of the species described.” Macrogamonts had coarse granules that became larger and more numerous as they developed. The nucleus of young macrogamonts had a large, central nucleolus and, as development progressed, the nucleus enlarged to about half the size of the macrogamont. In general, the development of both micro- and macrogamonts proceeded in a manner “similar to those of *E. scapani* (Tanabe, 1938).”

Materials deposited: None.

Remarks: Tanabe (1938) described some of the endogenous stages (presumably) of this species. He was convinced that, although it was simi-

lar to *E. scapani*, that it was, nonetheless, a different species, but he did not name it; also, he did not describe the sporulated oocyst or provide a line drawing or a photomicrograph of one. Pellérdy (1974) did not mention this form in his classic monograph on coccidia, so Levine and Ivens (1979) named this “new species” seen by Tanabe (1938) as *E. tanabei*, “in order to bring it to the attention of other workers and to ensure that further research is done on it.” Although we would place this name into the *species inquirendae* because of the absence of a photo or line drawing of a sporulated oocyst, Tanabe (1938) provided minimal measurements of the oocyst along with drawings and photomicrographs of both asexual and sexual endogenous stages. The real issue is whether or not the endogenous stages drawn by Tanabe (1938) can actually be attributed to this “species.” Tanabe’s work (1938) was based on tissue sections of 26 mole intestines, which he admits all were infected by at least two other coccidia, *Cyclospora caryolytica* and *E. scapani*. The endogenous stages of *C. caryolytica* all are reported to occur intranuclearly. It is not clear to us how he was able to distinguish between endogenous stages of two (presumed) *Eimeria* spp. that both had cytoplasmic endogenous development, in wild caught host animals, when the endogenous stages of both were not known when he conducted his study (i.e., how did he conclude which meront went with which species?). Finally, Levine and Ivens (1959) stated that Tanabe’s moles came from South Korea. However, Tanabe’s paper is written in English and in several places (e.g., pp. 1, 48) he clearly states, “26 moles . . . which were captured alive in the suburbs of Keijo,” which is in Japan.

References: Levine and Ivens (1979); Pellérdy (1974); Tanabe (1938).

Host Genus *Neurotrichus* Günther, 1880 (1 sp.)

Eimeria heterocapita Duszynski, 1985 (Fig. 41, 83)

Type host: *Neurotrichus gibbsii* (Baird, 1858), American shrew mole.

Other hosts: None reported to date.

Type locality: NORTH AMERICA: U.S.A., Washington, Pierce County, R3E, T20N, Sec. 24, 5.8 km S, 3.8 km E of Tacoma Center.

Geographic distribution: NORTH AMERICA: U.S.A., Washington.

Description of oocyst: Oocyst shape: subspheroid to ellipsoid; number of walls: 2; wall thickness: ~1.5, outer ~2/3 of total; wall characteristics: outer, smooth, colorless to pale yellow, with a membranous cap-like structure (amicropylar cap, see Duszynski, 1985) at one end that appears to be foamy in consistency and measures 1–5 high x 6–12 wide; inner, light blue to light green; L x W: 25.5 x 21.4 (23–27 x 18–23); L/W ratio: 1.2 (1.1–1.3); M: absent; OR: absent; PG: absent. Distinctive features of oocyst: only oocyst described to date from insectivores with an amicropylar cap.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 13.6 x 10.0 (12–15 x 9–11); L/W ratio: 1.3 (1.2–1.6); SB: absent; SSB: absent; PSB: absent; SR: present; SR characteristics: a compact, faceted mass, ~6–8 x 5–6 that appears to be membrane-bound; SP: with 2 RBs, an elongate posterior one and a spheroid central one. Distinctive features of sporocyst: absence of SB and SSB and SP with 2 RBs.

Prevalence: 2/17 (12%).

Sporulation: Exogenous. Oocysts sporulated in 7–10 days in 2.5% aqueous (w/v) $K_2Cr_2O_7$ solution at ~23°C.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Materials deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 43477 (NK 3162, female), R.M. Sullivan #519, 8 July 1980. Photosyntypes in the USNPC No. 85986.

Remarks: This species has not been reported since its original description.

Reference: Duszynski (1985).

***Eimeria neurotrichi* Duszynski, 1985 (Fig. 42, 84)**

Type host: *Neurotrichus gibbsii* (Baird, 1858), American shrew mole.

Other hosts: None reported to date.

Type locality: NORTH AMERICA: U.S.A., Oregon, Benton County, 11.3 km E of Alsea.

Geographic distribution: NORTH AMERICA: U.S.A., Oregon, Washington.

Description of oocyst: Oocyst shape: ovoid; number of walls: only 1 obvious layer; wall thickness: ~1; wall characteristics: it thins slightly at one end and has a striated appearance under Nomarski optics; L x W: 17.6 x 13.6 (16–20 x 11–16); L/W ratio: 1.3 (1.15–1.5); M: absent; OR: absent; PG: present, usually 1; PG characteristics: irregular in shape, ~3.0 x 1.5. Distinctive features of oocyst: rather small size, irregularly shaped PG, and nondescript outer wall.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 10.7 x 5.5 (9–12 x 5–6); L x W ratio: 2.0 (1.75–2.1); SB: present, small, pointed, nipple-like; SSB: absent; PSB: absent; SR: present; SR characteristics: consists of many granules or globules of various sizes as an irregular, central mass in sporocyst; SP: each with a large, posterior RB. Distinctive features of sporocyst: nipple-like SB.

Prevalence: 2/18 (11%).

Sporulation: Exogenous. Oocysts sporulated in 7–10 days in 2.5% aqueous (w/v) $K_2Cr_2O_7$ solution at 23°C.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Material deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 40785 (NK 754, male), D.J. Hafner #1553, 23 June 1979. Photosyntypes in the USNPC No. 85999.

Remarks: Oocysts of this species most closely resemble those of *E. bentongi* Colley and Mullin, 1971 described from the lesser gymmure in Malaysia. They differ from *E. bentongi* in general shape (ovoid vs. subspheroid), by having a thinner oocyst wall (~1 vs. 1.5) that appears striated in optical cross section, and by having sporozoites with a large, clear posterior globule. This species has not been reported since its original description.

Reference: Duszynski (1985).

***Eimeria parastiedica* Duszynski, 1985 (Fig. 43, 85)**

Type host: *Neurotrichus gibbsii* (Baird, 1858), American shrew mole.

Other hosts: None reported to date.

Type locality: NORTH AMERICA: U.S.A., Washington, Kittitas County, 3.2 km S, 0.8 km W of Roslyn.

Geographic distribution: NORTH AMERICA: U.S.A., Washington.

Description of oocyst: Oocyst shape: subspheroid, rarely spheroid; number of walls: 2; wall thickness: ~1.5; wall characteristics: outer with irregular bumps, yellow-brown, ~3/4 of total thickness; inner is membranous, colorless; L x W: 27.4 x 25.5 (25–30 x 22–28); L/W ratio: 1.1 (1.0–1.2); M: absent; OR: absent; PG: absent. Distinctive features of oocyst: large size, subspheroid shape, with irregular bumps on outer wall.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid to football-shaped, pointed at both ends; L x W: 18.3 x 10.4 (16–20 x 9–11); L/W ratio: 1.8 (1.6–1.9); SB: prominent, ~2–3 wide; SSB: prominent, ~3.8 x 4.0; PSB: present at pointed end opposite SB/SSB; SR: present; SR characteristics: 1 large (~7.5) lipid-like globule with 2–3 smaller, satellite bodies; SP: lie lengthwise in sporocyst without RB. Distinctive features of sporocyst: pointed at both ends with distinct SB, SSB and PSB all present.

Prevalence: 2/17 (12%).

Sporulation: Exogenous. Oocysts sporulated in 7–10 days in 2.5% aqueous (w/v) $K_2Cr_2O_7$ solution at 23°C.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Material deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 43426 (NK 3131, sex undetermined), J.A. Cook #379, 6 July 1980. Photosyntypes in the USNPC No. 86000.

Remarks: This is one of only two *Eimeria* spp. from insectivores that have sporocysts with a SSB. This species has not been reported since its original description.

Reference: Duszynski (1985).

***Isospora neurotrichi* Duszynski, 1985 (Fig. 44, 103)**

Type host: *Neurotrichus gibbsii* (Baird, 1858), American shrew mole.

Other hosts: None reported to date.

Type locality: NORTH AMERICA: U.S.A., Washington, Clallam County, 7.9 km S, 1.0 km E of Port Angeles.

Geographic distribution: NORTH AMERICA: U.S.A., Washington.

Description of oocyst: Oocyst shape: subspheroid; number of walls: 3; wall thickness: 1.0; wall characteristics: outer layer is smooth, colorless, transparent, ~1/5 of total thickness; middle layer is light yellow, ~3/5 of total thickness; inner is green; L x W: 13.9 x 12.0 (11–16 x 10–15); L/W ratio: 1.1 (1.05–1.4); M: absent; OR: absent; PG: present, 1–3 round, lipid-like bodies. Distinctive features of oocyst: small size and 3-layered oocyst wall.

Description of sporocysts and sporozoites: Sporocyst shape: ellipsoid; L x W: 9.2 x 6.1 (8–11 x 5–8); L/W ratio: 1.5 (1.3–1.8); SB: present, small; SSB: absent; PSB: absent; SR: present; SR characteristics: composed of many large globules, often obscuring SP; SP: with central RB. Distinctive features of sporocyst: tiny, inconspicuous SB.

Prevalence: 17/17 (100%) from 3 counties in Washington, but 0/1 from 1 county in Oregon.

Sporulation: Exogenous. Oocysts sporulated in 7–10 days in 2.5% aqueous (w/v) $K_2Cr_2O_7$ solution at 23°C.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Material deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 43543 (NK 3230, female), K. McBee #151, 14 July, 1980. Photosyntypes in the USNPC No. 85993.

Remarks: The sporulated oocysts of this species are most similar in size to those of *Isospora neomyi* Golemansky, 1978, and to *Isospora softiae* Levine and Ivens, 1979. They differ from the former in shape (always subspheroid vs. always spheroid), by having multiple PGs, the presence a SB, a non-granular SR, and SP with a clear globule that is centrally located rather than at one end. They differ from the latter by having a thicker oocyst wall, by the presence of PGs, the shape of the sporocyst (ellipsoid vs. ovoid with a pointed end), the presence of a SB, having a globular (vs. granular) SR, and the location of the RB in the SP (central vs. terminal).

Reference: Duszynski (1985).

**Host Genus *Parascalops* True, 1894
(1 sp.)**

***Cyclospora ashtabulensis* Ford and Duszynski,
1989 (Fig. 45, 112)**

Type host: *Parascalops breweri* (Bachman, 1842), Hairy-tailed mole.

Other hosts: None reported to date.

Type locality: NORTH AMERICA: U.S.A., Ohio, Ashtabula County.

Geographic distribution: NORTH AMERICA: U.S.A., Ohio.

Description of oocyst: Oocyst shape: subspheroid to ellipsoid; number of walls: 2; wall thickness: >1.0; wall characteristics: outer layer rough ~2/3 of total thickness; inner, smooth; L x W: 18.0 x 14.3 (14–23 x 11–19); L/W ratio: 1.3 (1.1–1.7); M: absent; OR: absent; PG: absent. Distinctive features of oocyst: a membranous material, perhaps a thin inner oocyst wall layer, appears to hold the sporocysts together.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 11.6 x 7.2 (8–14 x 5–9); L/W ratio: 1.6 (1.2–2.0); SB: present as crescent-shaped cap covering rounded end of sporocyst; SSB: absent; PSB: absent; SR: present; SR characteristics: several large globules, often obscuring SP or as a compact mass; SP: without RB. Distinctive features of sporocyst: crescent-shaped SB.

Prevalence: 7/16 (44%).

Sporulation: Exogenous. Oocysts sporulated in 7–10 days in 2.5% aqueous (w/v) K₂Cr₂O₇ solution at 23°C.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Material deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 43419 (NK 3121, male), K. McBee #120, 29 June, 1980. Photosyntypes in the USNPC No. 80590.

Remarks: The sporulated oocysts of this species resemble those of *C. megacephali* because both have an unusual crescent-like SB. They differ, however, by lacking a PB, having a rough outer wall (vs. smooth), being somewhat smaller (18 x 14 vs. 19 x 16), and by having

sporocysts with a smaller L/W ratio (1.6 vs. 2.1) and without a pointed end opposite the SB.

Reference: Ford and Duszynski (1989).

***Cyclospora parascalopi* Ford and Duszynski,
1989 (Fig. 46, 113)**

Type host: *Parascalops breweri* (Bachman, 1842), Hairy-tailed mole.

Other hosts: None reported to date.

Type locality: NORTH AMERICA: U.S.A., Ohio, Ashtabula County.

Geographic distribution: NORTH AMERICA: U.S.A., Massachusetts, Ohio.

Description of oocyst: Oocyst shape: subspheroid; number of walls: 2; wall thickness: >1.0; wall characteristics: outer layer slightly sculptured, appears striated in optical cross section, ~3/4 of total thickness; inner, smooth; L x W: 16.5 x 13.6 (13–20 x 11–20); L/W ratio: 1.2 (1.0–1.5); M: absent; OR: absent; PG: absent. Distinctive features of oocyst: striated appearance of oocyst wall and absence of M, OR, PG.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 11.1 x 6.9 (8–14 x 5–8); L/W ratio: 1.6 (1.2–2.0); SB: present as thick cap-like covering of sporocyst; SSB: absent; PSB: absent; SR: present; SR characteristics: a single, large, lipid-like sphere. Distinctive features of sporocyst: thick, cap-like SB.

Prevalence: 8/16 (50%) *P. breweri*, including 2/9 (22%) from Franklin County, Massachusetts, and 6/7 (86%) from Ashtabula County, Ohio.

Sporulation: Exogenous. Oocysts sporulated in 7–10 days in 2.5% aqueous (w/v) K₂Cr₂O₇ solution at 23°C.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Material deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 43418 (NK 3109, female), R.M. Sullivan #509, 28 June, 1980. Photosyntypes in the USNPC No. 80591.

Remarks: The sporulated oocysts of this species are similar in size to those of *C. megacephali* from *S. aquaticus* and to *C. ashtabulensis*; however, numerous qualitative features of both oocyst and sporocyst structures distinguish these species from each other.

Reference: Ford and Duszynski (1989).

***Eimeria aethiospora* Ford and Duszynski, 1989 (Fig. 47, 86)**

Type host: *Parascalops breweri* (Bachman, 1842), Hairy-tailed mole.

Other hosts: None reported to date.

Type locality: NORTH AMERICA: U.S.A., Ohio, Ashtabula County.

Geographic distribution: NORTH AMERICA: U.S.A., Massachusetts, Ohio.

Description of oocyst: Oocyst shape: subspheroid (rare) to ellipsoid; number of walls: 2; wall thickness: ~1.0; wall characteristics: outer and inner layers both smooth and of equal thickness; L x W: 19.3 x 13.0 (15–24 x 10–16); L/W ratio: 1.5 (1.1–1.8); M: absent; OR: absent; PG: 1. Distinctive features of oocyst: arrangement of sporocysts such that SB of all 4 converge at a point on one side of oocyst wall.

Description of sporocysts and sporozoites: Sporocyst shape: spindle-shaped, pointed at both ends; L x W: 10.6 x 5.7 (8–13 x 4–7); L/W ratio: 1.9 (1.4–2.3); SB: small, pointed; SSB: present, ~same width as SB; PSB: absent; SR: present; SR characteristics: several small globules that may be dispersed or concentrated in a single mass. Distinctive features of sporocyst: spindle-like shape and pointed SB.

Prevalence: 4/16 (25%) *P. breweri*, including 1/9 (11%) from Franklin County, Massachusetts, and 3/7 (43%) from Ashtabula County, Ohio.

Sporulation: Exogenous. Oocysts sporulated in 7–10 days in 2.5% aqueous (w/v) $K_2Cr_2O_7$ solution at 23°C.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Material deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 43417 (NK 3115, female), R.M. Sullivan #513, 28 June, 1980. Photosyntypes in the USNPC No. 80589.

Remarks: The unique shape and arrangement of the sporocysts distinguish the oocysts of this species from all other insectivore coccidia.

Reference: Ford and Duszynski (1989).

***Eimeria titthus* Ford and Duszynski, 1989 (Fig. 48, 87)**

Type host: *Parascalops breweri* (Bachman, 1842), Hairy-tailed mole.

Other hosts: None reported to date.

Type locality: NORTH AMERICA: U.S.A., Ohio, Ashtabula County.

Geographic distribution: NORTH AMERICA: U.S.A., Massachusetts, Ohio.

Description of oocyst: Oocyst shape: subspheroid; number of walls: 2; wall thickness: ~1.0; wall characteristics: outer layer smooth, light yellow, ~2/3 of total thickness; inner layer smooth; L x W: 15.8 x 13.5 (13–19 x 11–17); L/W ratio: 1.2 (1.1–1.6); M: absent; OR: present; OR characteristics: scattered granules; PG: absent. Distinctive features of oocyst: none.

Description of sporocysts and sporozoites: Sporocyst shape: ellipsoid, pointed at end with SB; L x W: 11.2 x 5.8 (9–13 x 4–7); L/W ratio: 1.9 (1.7–2.3); SB: protruding, nipple-like structure; SSB: present, slightly wider than SB; PSB: absent; SR: present; SR characteristics: a few small, dispersed granules. Distinctive features of sporocyst: protruding, nipple-like SB with SSB.

Prevalence: 4/16 (25%) *P. breweri*, including 1/9 (11%) from Franklin County, Massachusetts, and 3/7 (43%) from Ashtabula County, Ohio.

Sporulation: Exogenous. Oocysts sporulated in 7–10 days in 2.5% aqueous (w/v) $K_2Cr_2O_7$ solution at 23°C.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Material deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 43418 (NK 3109, female), R.M. Sullivan #509, 28 June, 1980. Photosyntypes in the USNPC No. 80588.

Remarks: Oocysts of this species resemble those of *E. bentongi* and *E. neurotrichi* (Colley and Mullin, 1971; Duszynski, 1985). In addition to host and geographic differences between these species, oocysts of *E. titthus* differ from those of *E. bentongi* by having a thinner oocyst wall (1.0 vs. 1.5) with two layers (vs. one), by having sporocysts with a larger L/W ratio (1.9 vs. 1.7), and by the protruding, nipple-like SB with a SSB, both of which *E. bentongi* lack. Oocysts of *E.*

neurotrichi have only one thin wall (vs. two) and contain sporocysts without SSB or protruding SB.

Reference: Ford and Duszynski (1989).

***Isospora ashtabulensis* Ford and Duszynski, 1989 (Fig. 49, 104)**

Type host: *Parascalops breweri* (Bachman, 1842), Hairy-tailed mole.

Other hosts: None reported to date.

Type locality: NORTH AMERICA: U.S.A., Ohio, Ashtabula County.

Geographic distribution: NORTH AMERICA: U.S.A., Massachusetts, Ohio.

Description of oocyst: Oocyst shape: spheroid to ellipsoid; number of walls: 2; wall thickness: >1.0; wall characteristics: outer layer smooth, ~ $\frac{2}{3}$ of total thickness; inner layer smooth; L x W: 19.7 x 14.4 (16–24 x 10–18); L/W ratio: 1.4 (1.1–1.8); M: absent; OR: absent; PG: absent. Distinctive features of oocyst: a membranous material, perhaps a thin inner oocyst wall layer, appears to hold the sporocysts together.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 10.2 x 7.2 (7–14 x 5–9); L/W ratio: 1.4 (1.1–2.0); SB: a thickened, but not pointed structure; SSB: absent; PSB: absent; SR: present; SR characteristics: small, dispersed granules obscuring SP. Distinctive features of sporocyst: thick, flattened SB without SSB.

Prevalence: 5/16 (25%) *P. breweri*, including 2/9 (22%) from Franklin County, Massachusetts, and 3/7 (43%) from Ashtabula County, Ohio.

Sporulation: Exogenous. Oocysts sporulated in 7–10 days in 2.5% aqueous (w/v) $K_2Cr_2O_7$ solution at 23°C.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Material deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 43418 (NK 3109, female), R.M. Sullivan #509, 28 June, 1980. Photosyntypes in the USNPC No. 80587.

Remarks: Oocysts of this species resemble only those of *I. araneae*, but differ by having a SB and lacking a PG. The original description

of *I. araneae* (Golemansky, 1978) did not include a photomicrograph of a sporulated oocyst, but the line drawing showed one end of each sporocyst to be pointed, which is not the case with *I. ashtabulensis*.

Reference: Ford and Duszynski (1989).

***Isospora parascalopi* Ford and Duszynski, 1989 (Fig. 50, 105)**

Type host: *Parascalops breweri* (Bachman, 1842), Hairy-tailed mole.

Other hosts: None reported to date.

Type locality: NORTH AMERICA: U.S.A., Ohio, Ashtabula County.

Geographic distribution: NORTH AMERICA: U.S.A., Massachusetts, Ohio.

Description of oocyst: Oocyst shape: subspheroid; number of walls: 2; wall thickness: > 1.0; wall characteristics: outer layer sculptured, rough, ~ $\frac{2}{3}$ of total thickness; inner layer smooth; L x W: 14.8 x 12.9 (12–17 x 11–15); L/W ratio: 1.1 (1.1–1.3); M: absent; OR: absent; PG: absent. Distinctive features of oocyst: none.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 9.2 x 6.3 (7–13 x 5–8); L/W ratio: 1.45 (1.1–1.9); SB: a thick, rounded dome; SSB: absent; PSB: absent; SR: present; SR characteristics: 5–10 clumped globules that overlie the SP. Distinctive features of sporocyst: thick, rounded, dome-like SB without SSB.

Prevalence: 12/16 (75%) *P. breweri*, including 8/9 (89%) from Franklin County, Massachusetts, and 4/7 (57%) from Ashtabula County, Ohio.

Sporulation: Exogenous. Oocysts sporulated in 7–10 days in 2.5% aqueous (w/v) $K_2Cr_2O_7$ solution at 23°C.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Material deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 43419 (NK 3121, male), K. McBee #120, 29 June, 1980. Photosyntypes in the USNPC No. 80586.

Remarks: Oocysts of this species resemble in size only those of *I. neurotrichi* and *I. dymecodi*, both from shrew moles, from the U.S.A. and Japan, respectively (Duszynski,

1985; Duszynski and Moore, 1986). Oocysts of *I. parascalopi* differ from those of *I. neurotrichi* by lacking a PG, in the number of oocyst wall layers (three vs. two), in the difference of the outermost wall layer texture (rough vs. smooth), and by the size of the SB. They differ from those of *I. dymecodi* by having a multilayered oocyst wall, lacking a PG, and having sporocysts with SB.

Reference: Ford and Duszynski (1989).

Host Genus *Scalopus* Desmarest, 1804
(1 sp.)

***Cyclospora megacephali* Ford and Duszynski, 1988 (Fig. 51, 114)**

Type host: *Scalopus aquaticus* (Linnaeus, 1758), Eastern American mole.

Other hosts: None reported to date.

Type locality: NORTH AMERICA: U.S.A., Texas, Motley County.

Geographic distribution: NORTH AMERICA: U.S.A., Texas.

Description of oocyst: Oocyst shape: subspheroid; number of walls: 2; wall thickness: ~1.0; wall characteristics: outer layer smooth, ~½ of total thickness; L x W: 18.9 x 15.7 (14–21 x 12–18); L/W ratio: 1.2 (1.1–1.4); M: absent; OR: absent; PG: present, 3–5 small granules or 1 large globule, but usually obscured by sporocysts. Distinctive features of oocyst: none.

Description of sporocysts and sporozoites: Sporocyst shape: ellipsoid with large rounded SB at one end and pointed at other end; L x W: 15.0 x 7.2 (11–17 x 6–9); L/W ratio: 2.1 (1.7–2.4); SB: present as a large, rounded cap-like structure completely covering end of sporocyst; end of sporocyst opposite SB slightly pointed; SSB: absent; PSB: absent; SR: present; SR characteristics: a compact mass of large clumped globules; SP: with 1–2 RB. Distinctive features of sporocyst: unique shape of sporocyst with large, rounded SB.

Prevalence: 4/13 (31%).

Sporulation: Exogenous. Oocysts sporulated in 7–10 days in 2.5% aqueous (w/v) K₂Cr₂O₇ solution at 23°C.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Material deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 42353 (NK 2034, female), J.A. Cook #239, 19 May, 1980. Photosyntypes in the USNPC No. 85987.

Remarks: Of all the other *Cyclospora* spp. described from insectivores, none has the unique shape of its sporocysts with their large, cap-like SB.

Reference: Ford and Duszynski (1988).

***Eimeria aquatici* Ford and Duszynski, 1988 (Fig. 52, 88)**

Type host: *Scalopus aquaticus* (Linnaeus, 1758), Eastern American mole.

Other hosts: None reported to date.

Type locality: NORTH AMERICA: U.S.A., Texas, Motley County.

Geographic distribution: NORTH AMERICA: U.S.A., Texas.

Description of oocyst: Oocyst shape: asymmetrically ellipsoid; number of walls: 2; wall thickness: < 1.0; wall characteristics: outer layer smooth, ~½ of total thickness; L x W: 17.0 x 10.6 (14–20 x 9–14); L/W ratio: 1.6 (1.1–2.0); M: absent; OR: absent; PG: present, 1, highly refractile. Distinctive features of oocyst: asymmetrical-ellipsoid shape with thin wall that can be distorted by the sporocysts.

Description of sporocysts and sporozoites: Sporocyst shape: elongate-ovoid; L x W: 9.0 x 5.2 (8–11 x 4–6); L/W ratio: 1.75 (1.5–2.0); SB: present; SSB: present, ~2 times wider than SB; PSB: absent; SR: present; SR characteristics: 3–4 membrane-enclosed globules; SP: with a prominent RB at rounded end of SP. Distinctive features of sporocyst: presence of SSB and membrane-bound SR.

Prevalence: 2/13 (15%).

Sporulation: Exogenous. Oocysts sporulated in 7–10 days in 2.5% aqueous (w/v) K₂Cr₂O₇ solution at 23°C.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Material deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 42353 (NK 2034, female), J.A. Cook #239,

19 May, 1980. Photosyntypes in the USNPC No. 85980.

Remarks: Oocysts of this species resemble in size those of *E. avonensis*, from the European mole and *E. honshuensis*, from the Japanese shrew mole. They differ from those of the former by having oocysts with a distinct PG and sporocysts with a SSB, both of which are absent in *E. avonensis*. They differ from those of *E. hoshuensis* by having oocysts that are narrower (L/W ratio 1.6 vs. 1.4) with sporocysts that have a SSB and a membrane-bounded SR, which are lacking in *E. hoshuensis*.

Reference: Ford and Duszynski (1988).

***Eimeria motleiensis* Ford and Duszynski, 1988 (Fig. 53, 89)**

Type host: *Scalopus aquaticus* (Linnaeus, 1758), Eastern American mole.

Other hosts: None reported to date.

Type locality: NORTH AMERICA: U.S.A., Texas, Motley County.

Geographic distribution: NORTH AMERICA: U.S.A., Texas.

Description of oocyst: Oocyst shape: subspheroid; number of walls: 2; wall thickness: >1.0; wall characteristics: outer layer mammillated, ~2/3 of total thickness; inner, smooth; L x W: 17.0 x 15.3 (15–20 x 13–18); L/W ratio: 1.1 (1.0–1.2); M: absent; OR: present, amorphous mass of a few large granules; PG: absent. Distinctive features of oocyst: knobby, mammillated outer wall, absence of PG.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 10.7 x 6.8 (10–13 x 6–8); L/W ratio: 1.6 (1.4–1.75); SB: present; SSB: present, same width as SB; PSB: absent; SR: present; SR characteristics: small granules as compact sphere or band-shaped body between SP; SP: with 2 prominent RB. Distinctive features of sporocyst: combination of SB–SSB complex and 2 RB in SP.

Prevalence: 7/13 (54%).

Sporulation: Exogenous. Oocysts sporulated in 7–10 days in 2.5% aqueous (w/v) K₂Cr₂O₇ solution at 23°C.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Material deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in

the Mammal Division of the MSB, UNM: MSB No. 42354 (NK 2048), D.W. Moore #719, 20 May, 1980. Photosyntypes in the USNPC No. 85998.

Remarks: Oocysts of this species resemble those of *E. bentongi*, *E. blarinae* and *E. madagascarensis*. They differ from those of *E. bentongi* by having an oocyst with a sculptured (vs. smooth) outer wall and an OR; they also lack a PG that is present in *E. bentongi* and have sporocysts with SB, which the latter lacks. They differ from those of *E. blarinae* by being somewhat smaller (17 x 15 vs. 21 x 18), by lacking a PG, and by having a SB. They differ from those of *E. madagascarensis* by having a thicker oocyst wall (> 1.0 vs. 0.5) that is sculptured rather than smooth, by having an OR and sporocysts with a SSB, and by not having a PG.

Reference: Ford and Duszynski (1988).

***Eimeria scalopi* Ford and Duszynski, 1988 (Fig. 54, 90)**

Type host: *Scalopus aquaticus* (Linnaeus, 1758), Eastern American mole.

Other hosts: None reported to date.

Type locality: NORTH AMERICA: U.S.A., Texas, Motley County.

Geographic distribution: NORTH AMERICA: U.S.A., Texas.

Description of oocyst: Oocyst shape: spheroid to subspheroid; number of walls: 2; wall thickness: ~1.0; wall characteristics: both layers smooth and of equal thickness; L x W: 13.6 x 12.6 (11–17 x 11–15); L/W ratio: 1.1 (1.0–1.2); M: absent; OR: present; OR characteristics: an irregular mass of small granules; PG: absent. Distinctive features of oocyst: smooth, outer wall with distinct OR and sporocysts tightly packed into oocyst.

Description of sporocysts and sporozoites: Sporocyst shape: lemon-shaped; L x W: 8.7 x 5.5 (7–10 x 4–7); L/W ratio: 1.6 (1.2–2.0); SB: present; SSB: absent; PSB: absent; SR: present; SR characteristics: small granules either concentrated or dispersed; SP: with a posterior RB. Distinctive features of sporocyst: small size and lack of SSB.

Prevalence: 6/13 (46%).

Sporulation: Exogenous. Oocysts sporulated in 7–10 days in 2.5% aqueous (w/v) K₂Cr₂O₇ solution at 23°C.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Material deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 42352 (NK 2001, female), J. Haydock #149, 19 May, 1980. Photosyntypes in the USNPC No. 86001.

Remarks: Oocysts of this species resemble those of *E. bentongi*, *E. madagascarensis* and *E. milleri*. They differ from those of *E. bentongi* with two layers in the oocyst wall that, combined, are thinner than the one-layered wall of *E. bentongi* (1.0 vs. 1.5); they also have a granular OR, absent in *E. bentongi*, and they lack a small PG, present in *E. bentongi*. They differ from those of *E. madagascarensis* by having a bi-layered wall ~1.0 vs. a one-layered wall <0.5, by having a granular OR and SP with RBs that *E. madagascarensis* lacks, and by lacking a small PG present in *E. madagascarensis*. They differ from those of *E. milleri* by the shape of the oocyst (spheroid-sub-spheroid vs. distinctly ovoid) and by having an OR that *E. milleri* lacks.

Reference: Ford and Duszynski (1988).

***Isospora aquatici* Ford and Duszynski, 1988 (Fig. 55, 106)**

Type host: *Scalopus aquaticus* (Linnaeus, 1758), Eastern American mole.

Other hosts: None reported to date.

Type locality: NORTH AMERICA: U.S.A., Texas, Motley County.

Geographic distribution: NORTH AMERICA: U.S.A., Texas.

Description of oocyst: Oocyst shape: subspheroid; number of walls: 2; wall thickness: ~2.5; wall characteristics: outer layer rough, yellow-brown, ~ $\frac{3}{4}$ of total thickness; L x W: 20.9 x 18.4 (15–24 x 13–21); L/W ratio: 1.1 (1.0–1.35); M: absent; OR: absent; PG: absent. Distinctive features of oocyst: thick, rough outer wall and lack of M, OR and PG.

Description of sporocysts and sporozoites: Sporocyst shape: ellipsoid; L x W: 11.8 x 9.0 (9–14 x 7–11); L/W ratio: 1.4 (1.1–1.5); SB: absent; SSB: absent; PSB: absent; SR: present; SR characteristics: many small, dispersed globules that obscure SP. Distinctive features of sporocyst: lack of SB, SSB and PSB.

Prevalence: 2/13 (15%).

Sporulation: Exogenous. Oocysts sporulated in 7–10 days in 2.5% aqueous (w/v) $K_2Cr_2O_7$ solution at 23°C.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Material deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 46334 (NK 4858, female), R.M. Sullivan #625, 14 March, 1981. Photosyntypes in the USNPC No. 85989.

Remarks: Oocysts of this species are similar in size to those of *I. rastegaevae*, but differ from it by the thickness (2.5 vs. 1.0) and structure (rough vs. smooth) of the oocyst wall.

Reference: Ford and Duszynski (1988).

***Isospora motleiensis* Ford and Duszynski, 1988 (Fig. 56, 107)**

Type host: *Scalopus aquaticus* (Linnaeus, 1758), Eastern American mole.

Other hosts: None reported to date.

Type locality: NORTH AMERICA: U.S.A., Texas, Motley County.

Geographic distribution: NORTH AMERICA: U.S.A., Texas.

Description of oocyst: Oocyst shape: spheroid to subspheroid; number of walls: 2; wall thickness: < 1.0; wall characteristics: both layers smooth, of equal thickness; L x W: 13.6 x 12.0 (10–17 x 8–15); L/W ratio: 1.1 (1.0–1.6); M: absent; OR: absent; PG: 1. Distinctive features of oocyst: smooth, thin wall with 1 prominent PG.

Description of sporocysts and sporozoites: Sporocyst shape: broadly ovoid; L x W: 9.5 x 6.7 (7–11 x 4–8); L/W ratio: 1.4 (1.0–1.8); SB: present, small; SSB: absent; PSB: absent; SR: present; SR characteristics: composed of 7 or more globules clumped in middle of sporocyst; SP with 1 posterior and 1 mid RB, although this was not mentioned in the original description. Distinctive features of sporocyst: SR of clumped globules and SP with 2 RB.

Prevalence: 9/13 (69%).

Sporulation: Exogenous. Oocysts sporulated in 7–10 days in 2.5% aqueous (w/v) $K_2Cr_2O_7$ solution at 23°C.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Material deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 46331 (NK 4860, female), R.M. Sullivan #622, 14 March, 1981. Photosyntypes in the USNPC No. 85992.

Remarks: Oocysts of this species resemble those of *I. neurotrichi*, and *I. urotrichi* (Duszynski, 1985; Duszynski and Moore, 1986). They differ from those of the former by having only two layers to the oocyst wall (<1.0), whereas *I. neurotrichi* has three layers (1.0) when seen with transmitted light. They differ from those of the latter only by having a smooth outer oocyst wall, whereas that of *I. urotrichi* is lightly mammillated. The only other structural difference between these *Isoospora* spp. is that both *I. neurotrichi* and *I. urotrichi* have multiple PGs, whereas those of *I. motleiensis* always have only one PG. Although structurally similar, their hosts are not closely related and the ranges of their hosts do not overlap. Both *I. neurotrichi* and *I. urotrichi* are found in shrew moles; the former in *N. gibbsii*, which occurs only in the northwestern U.S.A., and the latter in *U. talpoides*, found on the islands of Japan.

Reference: Ford and Duszynski (1988).

Host Genus *Scapanus* Pomel, 1848 (3 spp.)

Eimeria scapani Henry, 1932 (Fig. 57)

Type host: *Scapanus latimanus* (Bachman, 1842), Broad-footed mole.

Other hosts: Probably none, see Remarks.

Type locality: NORTH AMERICA: U.S.A., California, near Berkeley.

Geographic distribution: NORTH AMERICA: U.S.A., California.

Description of oocyst: Oocyst shape: subspheroid; number of walls: 1; wall thickness: ~1.0; wall characteristics: thin, smooth; L x W: 19.2 x 16.0 (16–22 x 14–16); L/W ratio: 1.2; M: absent; OR: absent; PG: "several small granules." Distinctive features of oocyst: none.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid, pointed at one end; L x W: not given; L/W ratio: not given; SB: present; SSB: absent; PSB: absent; SR: present; SR char-

acteristics: numerous large granules; SP: not visible in her photomicrograph. Distinctive features of sporocyst: pointed end with large granules.

Prevalence: 1/2 *S. latimanus*.

Sporulation: Exogenous. Oocysts sporulated in 5 days, presumably at room temperature.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from feces and intestinal contents.

Materials deposited: None.

Remarks: The oocysts of this species were not adequately described by Henry (1932), who did not, for example, give measurements or a detailed description of the sporocysts. However, she did present a photomicrograph of a sporulated oocyst showing the pointed nature of one end of the sporocysts. Tanabe (1938) said he found this species in the intestinal epithelium of *Mogera robusta* (= *M. wogura*) from Japan, in which he said oocysts were 16–21 x 13–15. However, the 2/26 moles from which most of his conclusions were made had "considerable numbers of asexual as well as sexual stages of [at least two?] *Eimeria* species together with those of *C. caryolytica*." We find it difficult to understand how one can look at tissue sections of endogenous stages of coccidia, in which the correct sequence and structure of the stages is not previously known for any of the presumed three species present, and conclude which merogonous stage leads to which gamogonous stage without knowing the sequence of events in single species infections first. Also, because coccidia only rarely cross generic boundaries and because *Scapanus* and *Mogera* do not share a recent common ancestor (Moore, 1986), it is likely that the form reported by Tanabe (1938), and the endogenous stages he attributed to it, was not of the same species first seen by Henry (1932).

References: Henry (1932); Tanabe (1938).

Host Genus *Talpa* Linnaeus, 1758 (9 spp.)

Cyclospora caryolytica Schaudinn, 1902 (Fig. 58)

Type host: *Talpa europaea* Linnaeus, 1758, European mole.

Other hosts: Probably none (see Remarks).

Type locality: EUROPE: Italy: near Rovigno.

Geographic distribution: EUROPE: Bulgaria; Germany, Italy.

Description of oocyst: Oocyst shape: ellipsoid; number of walls: 1; wall thickness: ≤ 1.0 ; wall characteristics: smooth; L x W: 12 x 11 (Agostinucci, 1955); L/W ratio: 1.1; M: absent; OR: absent; PG: 1 (?). Distinctive features of oocyst: None.

Description of sporocysts and sporozoites: Sporocyst shape: Spindle-shaped (Schaudinn, 1902, line drawing); L x W: 10 x 4 (Agostinucci, 1955); L/W ratio: 2.5; SB: present at both ends of sporocyst (Schaudinn, 1902, line drawing); SSB: absent; PSB: possibly the 2nd SB illustrated by Schaudinn (1902) at end of sporocyst opposite SB; SR: present; SR characteristics: compact mass of granules; SP: elongate, lying head to tail in sporocyst with 1 posterior RB. Distinctive features of sporocyst: according to Schaudinn's line drawing, each sporocyst has a longitudinal suture line all the way around sporocyst, which the SP eventually break to escape.

Prevalence: 28/28 (100%) in type host, but not the type locality (Agostinucci, 1955).

Sporulation: Exogenous; 3–4 days (Schaudinn, 1902); 4–5 days (Tanabe, 1938).

Prepatent and patent periods: Unknown.

Site of infection: Intranuclear in villar epithelial cells of the small (and large?) intestine.

Endogenous development: The accounts of Schaudinn (1902) and Tanabe (1938) of the endogenous life history of this species differ considerably and it is likely that both were confusing the endogenous stages of at least two species in the naturally infected hosts each examined. Therefore, we do not give the measurements/description here of merogony and gamogony from these authors because it is not clear which stage(s) actually are attributed to *C. caryolytica*. The interested reader can consult the original references for details; this is certainly an area of inquiry that needs to be studied experimentally and resolved.

Material deposited: None.

Remarks: The literature on this species is equivocal, at best. In his detailed description of the endogenous stages of *C. caryolytica*, Schaudinn (1902) said that the merozoites that form male and female gamonts are different from

each other morphologically, essentially being sexually dimorphic. Reichenow (1931) suggested that the two developmental lines seen by Schaudinn (1902) represented a mixed infection. Tanabe (1938), who also detailed the endogenous development of this (?) species by studying the intestines of 26 moles, described a life cycle that differed significantly from Schaudinn's (1902) description, suggesting they were dealing with different species. Pellérdy (1974, p. 390) mentioned that *C. caryolytica* was found in *P. breweri*, but gave no locality data or other supporting evidence, either in his work or from others. Henry (1932) supposedly saw *C. caryolytica* in *S. latimanus*, but she based her decision on unsporulated oocysts with only two sporoblasts (which could have been an *Isospora* sp.). Golemansky (1979) reported this species in 4/10 *T. europaea* from the Sreburna Reserve in Bulgaria. The sporulated oocysts he described were 19 x 11.7 (15–23 x 10.5–13) and sporocysts were 12–15 x 5–8, but no picture was presented. Levine and Ivens (1979) said that Agostinucci (1955) recorded this species from England, but Agostinucci (1955) actually collected animals in the vicinity of Rome. Entzeroth and Scholtyseck (1984) reported the fine structure of *C. caryolytica* in the intestine of a mole caught near Bonn, Germany. Both macro- and microgamonts were seen within nuclei of epithelial cells of the small intestine. All developing stages were located in a parasitophorous vacuole. Identification of *C. caryolytica* was confirmed by finding oocysts in the feces (their Fig. 1); the oocysts they saw were 16–19 x 13–16, but did not resemble those first reported by Schaudinn (1902).

References: Schaudinn (1902); Reichenow (1931); Henry (1932); Tanabe (1938); Agostinucci (1955, 1956); Loser and Gonnert (1965); Canning et al. (1973); Pellérdy (1974); Golemansky (1979); Levine and Ivens (1979); Entzeroth and Scholtyseck (1984).

***Cyclospora talpae* Pellérdy and Tanyi, 1968 (Figs. 59, 115)**

Type host: *Talpa europaea* Linnaeus, 1758, European mole.

Other hosts: None reported to date.

Type locality: EUROPE: Hungary.

Geographic distribution: EUROPE: Austria, Bulgaria, England, Hungary.

Description of oocyst: Oocyst shape: subspheroid to ellipsoid; number of walls: 2; wall thickness: ≤ 1.0 ; wall characteristics: outer layer is smooth, $\sim 1/3$ of total thickness; L x W: 14.3 x 9.6 (12–19 x 6–13); L/W ratio: 1.5 (1.2–1.9); M: absent; OR: absent; PG: present or absent. Distinctive features of oocyst: small size and thin wall.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 9.4 x 5.7 (6–13 x 4–8); L/W ratio: 1.7 (1.3–2.1); SB: present; SSB: present, about equal in width to SB; PSB: absent; SR: present; SR characteristics: composed of many scattered, spheroid globules; SP: with central RB. Distinctive features of sporocyst: conspicuous, rounded SB.

Prevalence: 5/5 (100%) moles from Hungary (Pellérdy and Tanyi, 1968); 1/3 (33%) from Austria (Mahnert, 1972); 4/10 (40%) from the Sreburna Reserve, Bulgaria (Golemansky, 1979); 21/33 (64%) moles from five localities in England (Duszynski and Wattam, 1988a).

Sporulation: Exogenous. Pellérdy and Tanyi (1968) found that oocysts derived from the liver took ~ 2 weeks to sporulate in aqueous $K_2Cr_2O_7$ solution.

Prepatent and patent periods: Unknown.

Site of infection: Micro- and macrogametocytes both were found "in intracellular position, occupying the inter-spaces between the epithelial cells constituting the walls of the biliary capillaries" of moles in Hungary (Pellérdy and Tanyi, 1968); merogonous stages have yet to be described.

Material deposited: Photosyntypes in the USNPC No. 85988.

Remarks: The oocyst description given here combines the information from both Pellérdy and Tanyi (1968) and Duszynski and Wattam (1988a). The latter authors studied oocysts from English moles that differed somewhat from those from Hungarian moles in the original description. First, oocysts from English moles were generally ellipsoid and not asymmetrical bodies that tapered towards both ends and, second, the sporocysts had a SSB, not reported in the original description. However, the photomicrograph published by Pellérdy and Tanyi (1968; their Fig. 1b) convinced Duszynski and Wattam (1988a)

that they were probably observing the same species. Pellérdy (1969), in a brief review, reported the oocysts of *C. talpae* were 15–18 x 20–21, but the latter seems to be an obvious typographical error.

References: Pellérdy and Tanyi (1968); Pellérdy (1969); Mahnert (1972); Golemansky (1979); Duszynski and Wattam (1988a).

***Eimeria avonensis* Duszynski and Wattam, 1988a (Fig. 60, 91)**

Type host: *Talpa europaea* Linnaeus, 1758, European mole.

Other hosts: None reported to date.

Type locality: EUROPE: England: Avon, 1.0 km E of the town of Frenchay.

Geographic distribution: EUROPE: England.

Description of oocyst: Oocyst shape: elongate-ellipsoid; number of walls: 2; wall thickness: ≤ 1.0 ; wall characteristics: outer layer smooth, $\sim 1/2$ of total thickness; inner layer transparent; L x W: 15.0 x 9.6 (13–20 x 7–12); L/W ratio: 1.7 (1.3–2.3); M: absent; OR: absent; PG: absent. Distinctive features of oocyst: elongate-ellipsoid shape with thin wall.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid, distinctly pointed at one end; L x W: 6.6 x 3.6 (5–9 x 3–7); L/W ratio: 1.7 (1.2–2.2); SB: present; SSB: absent; PSB: absent; SR: present; SR characteristics: several large, dispersed globules; SP: with 1 large, central RB, although this was not included in the original description. Distinctive features of sporocyst: very small size.

Prevalence: 15/33 (45%).

Sporulation: Oocysts were sporulated when returned to the laboratory from the field.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from intestinal contents and feces.

Material deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 48363 (male), T.L. Yates #1102, 22 August, 1982. Photosyntypes in the USNPC No. 85981.

Remarks: Only seven of the *Eimeria* spp. described from insectivores have oocysts that approach being ellipsoid, but six of these are short ellipsoids with L/W ratios ranging from 1.2–1.4. Only *E. tanabei* from the Large Asian

mole, *Mogera robusta* (= *M. wogura coreana*), from Japan (Tanabe, 1938) approaches the shape of *E. avonensis*; however, the latter is larger (13–20 x 7–12 vs. 10–13 x 6–8), and has sporocysts with a distinct SB, which is lacking in *E. tanabei*.

Reference: Duszynski and Wattam (1988a).

***Eimeria berea* Duszynski and Wattam, 1988a (Fig. 61, 92)**

Type host: *Talpa europaea* Linnaeus, 1758, European mole.

Other hosts: None reported to date.

Type locality: EUROPE: England: Avon, 1.0 km E of the town of Frenchay.

Geographic distribution: EUROPE: England.

Description of oocyst: Oocyst shape: spheroid to asymmetrically subspheroid; number of walls: only 1 is apparent in optical cross section; wall thickness: ≤ 1.0 ; wall characteristics: smooth; L x W: 12.1 x 10.5 (10–15 x 8–14); L/W ratio: 1.15 (1.0–1.7); M: absent; OR: absent; PG: absent. Distinctive features of oocyst: small size with spheroid to asymmetrically spheroid shape.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid, distinctly pointed at one end; L x W: 6.3 x 3.9 (5–10 x 2–5); L/W ratio: 1.65 (1.2–2.2); SB: present; SSB: absent; PSB: absent; SR: present; SR characteristics: several small globules that may be dispersed or may be concentrated in a single mass; neither SP nor RB were mentioned in the original description. Distinctive features of sporocyst: very small size.

Prevalence: 8/33 (24%).

Sporulation: Oocysts were sporulated when returned to the laboratory from the field.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from intestinal contents and feces.

Material deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 9168 (male), T.L. Yates #1116, 24 August, 1982. Photosyntypes in the USNPC No. 85982.

Remarks: Only two coccidia described from insectivores have oocysts as small as those of *E. berea*. One is *Cyclospora caryolytica* from *T. europaea* from Italy and the other is *E. chagasi* (= *E. komareki*, see Hertel and Duszynski, 1987) from shrews in Czechoslovakia and Russia.

Eimeria berea differs from *E. chagasi* by being smaller (12 x 10.5 vs. 14 x 12), by lacking a PG, and by having sporocysts with a SB, not found in *E. chagasi*.

Reference: Duszynski and Wattam (1988a).

***Eimeria flexilis* Golemansky, 1978 (Fig. 62)**

Type host: *Talpa europaea* Linnaeus, 1758, European mole.

Other hosts: None reported to date.

Type locality: EUROPE: Bulgaria: in SE Bulgaria near Montagne de Strandja.

Geographic distribution: EUROPE: Bulgaria.

Description of oocyst: Oocyst shape: spheroid; number of walls: 1; wall thickness: ≤ 1.0 ; wall characteristics: "thin and flexible"; L x W: 20–24 x 20–24; L/W ratio: 1.0; M: absent; OR: absent; PG: absent. Distinctive features of oocyst: thin, flexible, 1-layered wall.

Description of sporocysts and sporozoites: Sporocyst shape: elongate-ovoid to elongate-ellipsoid; L x W: 14–16 x 10–12.5; SB: absent; SSB: absent; PSB: absent; SR: present; SR characteristics: many small diffuse granules throughout sporocyst; SP are round at one end, pointed at the other, 12 x 4.5; 1 round RB pictured at rounded end. Distinctive features of sporocyst: thin wall, without SB.

Prevalence: 1/10 (10%).

Sporulation: Oocysts were sporulated in 3% $K_2Cr_2O_7$ at $23^\circ C \pm 2^\circ C$, but the length of time was not stated.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from intestinal contents and feces.

Material deposited: None.

Remarks: Oocysts of this species are similar to those of *E. goussevi*, but differ in the spheroid shape of the oocyst and the thin, flexible outer wall.

References: Golemansky (1978, 1979).

***Eimeria globula* Duszynski and Wattam, 1988a (Fig. 63, 93)**

Type host: *Talpa europaea* Linnaeus, 1758, European mole.

Other hosts: None reported to date.

Type locality: EUROPE: England: Norfolk, Thetford, Euston, TL 795 896, sheet 144.

Geographic distribution: EUROPE: England.

Description of oocyst: Oocyst shape: spheroid to slightly subspheroid; number of walls: 2; wall thickness: ~1.0; wall characteristics: outer, lightly mammillated, ~2/3 of total thickness and gives a striated appearance in optical cross section; inner, transparent; L x W: 20.9 x 19.9 (19–24 x 17–21); L/W ratio: 1.05 (1.0–1.2); M: absent; OR: absent; PG: absent. Distinctive features of oocyst: rough outer wall and striated appearance in optical cross section.

Description of sporocysts and sporozoites: Sporocyst shape: elongate-ovoid, distinctly pointed at both ends; L x W: 11.5 x 6.9 (9–16 x 6–9); L/W ratio: 1.7 (1.5–2.7); SB: present; SSB: present, 2–3 times as wide as SB; PSB: absent; SR: present; SR characteristics: many small globules often concentrate on one side of sporocyst; neither SP nor RB were mentioned in the original description. Distinctive features of sporocyst: pointed at both ends and large size of SSB.

Prevalence: 3/33 (9%).

Sporulation: Oocysts were sporulated when returned to the laboratory from the field.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from intestinal contents and feces.

Material deposited: Skin of the symbiotype host is preserved in the Ministry of Agriculture, Fisheries and Food, Tolworth Laboratory, Surrey, England, R. Redfern #274, 23 November, 1982. Photosyntypes in the USNPC No. 85984.

Remarks: Oocysts of this species are nearly identical in size and shape to those of *E. brevicauda* from *B. brevicauda*, a shrew, from the U.S.A. In addition to host and geographic differences, the oocysts of this species lack a PG, which those of *E. brevicauda* possess, and the SSB of *E. globula* is always two or three times wider than the SB, whereas in *E. brevicauda*, the SB and SSB are of equal width. Qualitatively, the shape of the SBs are very different between them.

Reference: Duszynski and Wattam (1988a).

***Eimeria goussevi* Yakimoff, 1935 (Fig. 64)**

Type host: *Talpa europaea* Linnaeus, 1758, European mole.

Other hosts: None reported to date.

Type locality: EUROPE: former USSR: Russia, Polotzk District.

Geographic distribution: EUROPE: Bulgaria, Germany, Russia.

Description of oocyst: Oocyst shape: ovoid; number of walls: 1 (line drawing); wall thickness: ~1.0; wall characteristics: smooth; L x W: 21.9 x 15.7 (18–23 x 14–16); L/W ratio: 1.4; M: absent; OR: absent; PG: absent. Distinctive features of oocyst: neither OR nor PG.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid (text) to elongate-ellipsoid (line drawing); L x W: not given; L/W ratio: unknown; SB: absent; SSB: absent; PSB: absent; SR: absent; SP with 1 ovoid RB at rounded end (line drawing). Distinctive features of sporocyst: without SB and SR.

Prevalence: 2/10 (20%).

Sporulation: Unknown.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from intestinal contents and feces.

Material deposited: None.

Remarks: Although Yakimoff (1935) suggested that this species might be the same as the undescribed *Eimeria* oocysts first noted by Henry (1932), this seems unlikely given the host and geographic differences. Oocysts of this species seen by Golemansky (1979) in 1/10 *T. europaea* from Sreburna Reserve, Bulgaria, measured 20 x 17.8. Although they did not confirm the identity of this species by finding sporulated oocysts, Entzeroth and Scholtzseck (1984) said they were describing the ultrastructure of its macro- and microgametocytes when they examined the intestine of an infected mole caught near Bonn, Germany. Gamonts of both sexes were situated in the cytoplasm of crypt epithelial cells within a membrane-lined parasitophorous vacuole. Often, male and female gamonts were in the same host cell. Unfortunately, there is no solid evidence that these intracellular stages actually produce the sporulated oocysts reported by Yakimoff (1935).

References: Henry (1932); Yakimoff (1935); Golemansky (1979); Entzeroth and Scholtzseck (1984).

***Isospora riccii* Agostinucci, 1955 (Fig. 65)**

Type host: *Talpa europaea* Linnaeus, 1758, European mole.

Other hosts: None reported to date.

Type locality: EUROPE: Italy, near Rome.

Geographic distribution: EUROPE: Italy.

Description of oocyst: Oocyst shape: ellipsoid; number of walls: 1 (line drawing) or 2 (described as double contoured); wall thickness: ~1.0; wall characteristics: smooth, yellow; L x W: 22.9 x 14.5; L/W ratio: 1.6; M: absent; OR: absent; PG: 2 small granules at one end of oocyst. Distinctive features of oocyst: ellipsoid shape with 2 PG at one end.

Description of sporocysts and sporozoites: Sporocyst shape: ellipsoid; L x W: 14.8 x 8.1; L/W ratio: 1.8; SB: absent; SSB: absent; PSB: absent; SR: present; SR characteristics: irregular mass of large granules (line drawing); SP elongate, sausage-shaped without RB (line drawing). Distinctive features of sporocyst: elongate, sausage-shaped SP.

Prevalence: 1/28 (4%).

Sporulation: 2 days.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from intestinal contents and feces.

Material deposited: None.

Remarks: The 1956 paper by Agostinucci, in which he describes this species again, is identical to the 1955 paper.

References: Agostinucci (1955, 1956).

***Isospora sofiae* Levine and Ivens, 1979 (Fig. 66, 108)**

Synonyms: *Isospora talpae* Golemansky, 1978, *nomen preocc*; non *I. talpae* Agostinucci, 1955.

Type host: *Talpa europaea* Linnaeus, 1758, European mole.

Other hosts: None reported to date.

Type locality: EUROPE: Bulgaria: in the vicinity of Sofia and the Réserve of Srebarna, in NE Bulgaria.

Geographic distribution: EUROPE: Bulgaria, England.

Description of oocyst: Oocyst shape: spheroid to subspheroid; number of walls: only 1 layer; wall thickness: ≤ 1.0 ; wall characteristics: smooth; L x W: 12.2 x 11.0 (9–16 x 8–15); L/W ratio: 1.1 (1.0–1.4); M: absent; OR: absent; PG: absent. Distinctive features of oocyst: small size, thin oocyst wall.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 9.1 x 5.2 (6–13 x 3–8); L/W ratio: 1.75 (1.3–2.1); SB: present; SSB: present, about same width as SB, and best seen with NIC optics; PSB: absent; SR: present; SR characteristics: a compact mass of 3–6 globules; SP with 1 RB. Distinctive features of sporocyst: distinct ovoid shape with both SB and SSB.

Prevalence: 3/10 (30%) in Bulgaria; 25/33 (76%) in England.

Sporulation: Oocysts sporulated in ~48 hr at 22–25°C.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from intestinal contents and feces.

Material deposited: Photosyntypes in the USNPC No. 85994.

Remarks: Golemansky (1978) first described this species from *T. europaea* that he collected in Bulgaria, but named it *I. talpae*, apparently unaware of the paper by Agostinucci (1955) who first used the name *I. talpae* to describe another species in *T. europaea* from Italy. Levine and Ivens (1979) named the form seen by Golemansky (1978) *I. sofiae*; the oocysts seen by Duszynski and Wattam (1988a) from moles in England also were thought to be *I. sofiae*, even though Golemansky's (1978) description was considered to be incomplete by current standards. Golemansky (1978) saw both spheroid (12.5) and subspheroid (12.5–14 x 10–13) oocysts, as did Duszynski and Wattam (1988a), but subspheroid forms were rare in the former and more common than spheroid ones in the latter report. Golemansky (1978) also said that sporocysts were without a SB, but with some hyaline material at their pointed end. Duszynski and Wattam (1988a), however, thought that his drawing was similar to the SB/SSB complex they saw best only with NIC optics, which Golemansky did not have. Golemansky (1979) reported this species from 3/10 *T. europaea* from the Srebarna Reserve in Bulgaria (but see Remarks of *E. neomyi*).

References: Agostinucci (1955); Duszynski and Wattam (1988a); Golemansky (1978, 1979); Levine and Ivens (1979).

***Isospora sporopointaea* Duszynski and Wattam, 1988a (Fig. 67, 109)**

Type host: *Talpa europaea* Linnaeus, 1758, European mole.

Other hosts: None reported to date.

Type locality: EUROPE: England: Avon, 1.0 km E of the town of Frenchay.

Geographic distribution: EUROPE: England.

Description of oocyst: Oocyst shape: ellipsoid to subellipsoid; number of walls: 2; wall thickness: ~1.0; wall characteristics: outer, mammillated, ~2/3 of total thickness and gives a striated appearance in optical cross section; inner, transparent; L x W: 17.1 x 11.4 (13–21 x 8–14); L/W ratio: 1.5 (1.25–2.1); M: absent; OR: absent; PG: absent. Distinctive features of oocyst: rough outer wall and striated appearance in optical cross section.

Description of sporocysts and sporozoites: Sporocyst shape: elongate-ellipsoid, tapering toward both ends; L x W: 11.9 x 5.9 (9–16 x 4–8); L/W ratio: 1.95 (1.3–2.6); SB: present; SSB: present, about same width as SB, and best seen with bright field optics; PSB: absent; SR: present; SR characteristics: many small globules forming a spheroid body or of several large globules; neither SP nor RB were mentioned in the original description. Distinctive features of sporocyst: pointed at both ends and large size of SR.

Prevalence: 27/33 (82%).

Sporulation: Oocysts were sporulated when returned to the laboratory from the field.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from intestinal contents and feces.

Material deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 48363 (female), T.L. Yates #1102, 22 August, 1982. Photosyntypes in the USNPC No. 85995.

Remarks: Oocysts of this species are similar in size to those of *I. talpae*, also from the European mole from Italy (Agostinucci, 1955). They differ, however, by having a mammillated outer oocyst wall, by possessing a SSB, and by having sporocysts that taper to a point opposite the SB.

References: Agostinucci (1955); Duszynski and Wattam (1988a).

***Isospora talpae* Agostinucci, 1955 (Fig. 68)**

Type host: *Talpa europaea* Linnaeus, 1758, European mole.

Other hosts: None reported to date.

Type locality: EUROPE: Italy, near Rome.

Geographic distribution: EUROPE: Bulgaria, Italy.

Description of oocyst: Oocyst shape: ellipsoid; number of walls: 1 (line drawing) or 2 (described as double contoured); wall thickness: ≤1.0; wall characteristics: smooth, thin, and becomes very thin at one end, resembling a M; L x W: 17.8 x 11.9; L/W ratio: 1.5; M: absent (?); OR: absent; PG: absent. Distinctive features of oocyst: ellipsoid shape, without OR or PG and wall becomes very thin at one end.

Description of sporocysts and sporozoites: Sporocyst shape: piriform to ovoid; L x W: 12.0 x 7.4; L/W ratio: 1.6; SB: present; SSB: absent; PSB: absent; SR: present; SR characteristics: compact mass of large granules (line drawing); SP sausage-shaped without RB (line drawing). Distinctive features of sporocyst: large, protruding nipple-like SB.

Prevalence: 3/28 (11%).

Sporulation: 3 days.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from intestinal contents and feces.

Material deposited: None.

Remarks: The 1956 paper by Agostinucci, in which he also describes this species again, is identical to his 1955 paper. This species also was reported in 3/10 (30%) *T. europaea* by Golemansky (1979) from the Sreburna Reserve, Bulgaria. These oocysts were 12.5–13.8 x 10–13; sporocysts were 10–13 x 5.4–7.6.

References: Agostinucci (1955, 1956); Golemansky (1979).

Host Genus *Urotrichus* Temminck, 1841 (2 spp.)***Eimeria amorphospora* Duszynski and Moore, 1986 (Fig. 69, 94)**

Type host: *Urotrichus talpoides* Temminck, 1841, Greater Japanese shrew mole.

Other hosts: None reported to date.

Type locality: ASIA: Japan, Honshu, Nagano Prefecture, 2.0 km E Haramura.

Geographic distribution: ASIA: Japan, Honshu.

Description of oocyst: Oocyst shape: subspheroid/ellipsoid; number of walls: 2; wall thickness: ~1.0+; wall characteristics: outer layer smooth, ~2/3 of total thickness; inner layer transparent; L x W: 21.1 x 17.9 (18–25 x 16–21); L/W ratio: 1.2 (1.1–1.3); M: absent; OR: absent; PG: absent. Distinctive features of oocyst: none.

Description of sporocysts and sporozoites: Sporocyst shape: amorphous, gelatinoid envelopes that fill the length of the oocyst; L x W: 20.3 x 7.5 (17–24 x 7–9); L/W ratio: 2.7; SB: absent; SSB: absent; PSB: absent; SR: absent; SP: appear to be enclosed in a membrane within the sporocyst that gives them an irregular/ellipsoid shape and measures 13.2 x 6.8 (12–14 x 6–8); 1 spheroid RB at opposite ends of each SP. Distinctive features of sporocyst: no other sporocyst of an *Eimeria* sp. described to date has the unique structural features described in this form.

Prevalence: 9/45 (20%) in type host; 0/6 in *U. pilirostris*.

Sporulation: Oocysts were sporulated when returned to the laboratory from the field.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from intestinal contents and feces.

Material deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 45307 (NK 6047, male), D.W. Reduker #400, 28 May, 1981. Photosyntypes in the USNPC No. 85979.

Remarks: Based on the structure of the sporocysts, this is one of the most unusual species of *Eimeria* ever described. This species has not been reported since its original description.

Reference: Duszynski and Moore (1986).

***Eimeria gonocilia* Duszynski and Moore, 1986 (Fig. 70, 95)**

Type host: *Urotrichus talpoides* Temminck, 1841, Greater Japanese shrew mole.

Other hosts: None reported to date.

Type locality: ASIA: Japan, Honshu, Aichi Prefecture, Innyama City, Near Jyakkoin Temple.

Geographic distribution: ASIA: Japan, Honshu.

Description of oocyst: Oocyst shape: subspheroid to ellipsoid; number of walls: 2; wall thickness: ~2.0+; wall characteristics: outer, pale yellow, highly ornate, with thick, cilia-like processes extending through it and beyond its outer surface, ~3/4 of total wall thickness; inner, smooth, transparent and capable of maintaining its integrity when outer layer breaks away (Fig. 6 in Duszynski and Moore, 1986); L x W: 28.8 x 24.4 (25–30 x 21–28); L/W ratio: 1.2 (1.05–1.5); M: absent; OR: absent; PG: present, 1, ~1 x 2 in 36% of all oocysts seen. Distinctive features of oocyst: the thick, cilia-like processes extending from the outer wall surface.

Description of sporocysts and sporozoites: Sporocyst shape: football-shaped, pointed at both ends, with distinct knob at end opposite SB; L x W: 17.0 x 9.0 (15–19 x 7–11); L/W ratio: 1.9 (1.7–2.2); SB: present; SSB: present; PSB: absent; SR: absent; SP: elongate, seem highly intertwined within sporocyst, with a spheroid RB at one end. Distinctive features of sporocyst: pointed end with a protruding knob, opposite SB.

Prevalence: 4/45 (9%) in type host; 0/6 in *U. pilirostris*.

Sporulation: Oocysts were sporulated when returned to the laboratory from the field.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from intestinal contents and feces.

Material deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 45240 (NK 6013, male), D.W. Reduker #381, 24 May, 1981. Photosyntypes in the USNPC No. 85985.

Remarks: The outer surface of the oocyst wall of this species distinguishes it from all other *Eimeria* species described from insectivores. This species has not been reported since its original description.

Reference: Duszynski and Moore (1986).

***Eimeria honshuensis* Duszynski and Moore, 1986 (Fig. 71, 96)**

Type host: *Urotrichus talpoides* Temminck, 1841, Greater Japanese shrew mole.

Other hosts: *Urotrichus pilirostris* (True, 1886), Lesser Japanese shrew mole.

Type locality: ASIA: Japan, Honshu, Nagano Prefecture, 2.0 km E Haramura.

Geographic distribution: ASIA: Japan, Honshu.

Description of oocyst: Oocyst shape: ellipsoid, slightly ovoid; number of walls: only 1 obvious layer; wall thickness: ≤ 1.0 ; wall characteristics: smooth of uniform thickness; L x W: 15.5 x 11.4 (13–18 x 10–13); L/W ratio: 1.4 (1.1–1.6); M: absent; OR: absent; PG: 1, a highly refractile body $\sim 2.3 \times 2.5$. Distinctive features of oocyst: among the smallest of all *Eimeria* sp. described from this host group.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 9.1 x 5.2 (8–10 x 4–6); L/W ratio: 1.75 (1.5–2.1); SB: small, inconspicuous; SSB: absent; PSB: absent; SR: present; SR characteristics: 1 spheroid, lipid-like body, ~ 2.5 ; SP: with a large, posterior RB. Distinctive features of sporocyst: they are tightly packed within oocyst.

Prevalence: 10/45 (22%) in type host; 5/6 (83%) in *U. pilirostris*.

Sporulation: Oocysts were sporulated when returned to the laboratory from the field.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from intestinal contents and feces.

Material deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: *U. talpoides*: MSB No. 45308 (NK 6060, female), D.W. Reduker #404, 29 May, 1981; also *U. pilirostris*: MSB No. 45665 (NK 6433, male), T.L. Yates #1000, 8 July, 1981. Photosyntypes in the USNPC No. 85997.

Remarks: Oocysts of this species are among the smallest eimerian oocysts yet described from this host group; the species has not been reported since its original description.

Reference: Duszynski and Moore (1986).

***Eimeria talpoides* Duszynski and Moore, 1986 (Fig. 72, 97)**

Type host: *Urotrichus talpoides* Temminck, 1841, Greater Japanese shrew mole.

Other hosts: None reported to date.

Type locality: ASIA: Japan, Honshu, Yamagata Prefecture, 3.2 km E Zao-onsen.

Geographic distribution: ASIA: Japan, Honshu.

Description of oocyst: Oocyst shape: ovoid, slightly asymmetrical; number of walls: 2; wall

thickness: ≤ 1.0 ; wall characteristics: outer, smooth, transparent to pale yellow, of uniform thickness, $\sim 3/4$ of total thickness; inner, smooth, transparent; L x W: 20.6 x 13.3 (18–23 x 12–15); L/W ratio: 1.6 (1.4–1.75); M: absent; OR: absent; PG: 1, of irregular shape, usually located at pointed end of oocyst. Distinctive features of oocyst: the asymmetrical shape with PG almost always at its pointed end.

Description of sporocysts and sporozoites: Sporocyst shape: lacrimiform; L x W: 12.0 x 5.8 (10–14 x 5–7); L/W ratio: 2.1 (1.9–2.4); SB: prominent, nipple-like; SSB: absent; PSB: absent; SR: absent; SP: show a frothy appearance and have a large, posterior RB. Distinctive features of sporocyst: the sporocyst shape and its nipple-like SB.

Prevalence: 7/45 (16%) in type host; 0/6 in *U. pilirostris*.

Sporulation: Oocysts were sporulated when returned to the laboratory from the field.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from intestinal contents and feces.

Material deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 45678 (NK 6392, female), S.B. George #820, 6 July, 1981. Photosyntypes in the USNPC No. 86003.

Remarks: This species has not been reported since its original description.

Reference: Duszynski and Moore (1986).

***Isospora dymecodi* Duszynski and Moore, 1986 (Fig. 73, 110)**

Type host: *Urotrichus* (= *Dymecodon*) *pilirostris* (True, 1886), Lesser Japanese shrew mole.

Other hosts: None reported to date.

Type Locality: ASIA: Japan, Honshu, Yamagata Prefecture, 3.2 km E Zao-onsen.

Geographic Distribution: ASIA: Japan, Honshu.

Description of oocyst: Oocyst shape: subspheroid to ellipsoid; number of walls: only 1 obvious layer; wall thickness: ≤ 1.0 ; wall characteristics: smooth, of uniform thickness; L x W: 15.8 x 12.6 (13–17 x 11–13); L/W ratio: 1.25 (1.1–1.35); M: absent; OR: absent; PG: 1 always

present. Distinctive features of oocyst: small size and thin, one-layered wall.

Description of sporocysts and sporozoites: Sporocyst shape: ellipsoid; L x W: 10.9 x 6.9 (10–13 x 6–8); L/W ratio: 1.6 (1.4–1.9); SB: absent; SSB: absent; PSB: absent; SR: present; SR characteristics: a granular mass or a homogeneous, lipid-like body up to 5, or both; SP: appear tightly coiled within sporocyst. Distinctive features of the sporocyst: absence of SB, SSB and PSB.

Prevalence: 6/6 (100%) *U. pilirostris*; 0/45 *U. talpoides*.

Sporulation: Oocysts were sporulated when returned to the laboratory from the field.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from intestinal contents and feces.

Material deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 45664 (NK 6449, male), D.W. Moore #900, 8 July, 1981. Photosyntypes in the USNPC No. 85990.

Remarks: Oocysts of this species resemble somewhat those of *I. araneae* Golemansky, 1978 from *Sorex araneus* and *I. hylomysis* Colley and Mullin, 1971 from *Hylomys suillus*. They differ by being smaller and more elongate than those of *I. araneae*, have only one obvious oocyst wall, and have smaller sporocysts with a larger mean L:W ratio (1.6 vs. 1.3). They are larger than those of *I. hylomysis*, have a thinner oocyst wall that is not striated, and have larger sporocysts (11 x 7 vs. 7 x 5).

Reference: Duszynski and Moore (1986).

***Isospora urotrichi* Duszynski and Moore, 1986 (Fig. 74, 111)**

Type host: *Urotrichus talpoides* Temminck, 1841, Greater Japanese shrew mole.

Other hosts: None reported to date.

Type Locality: ASIA: Japan, Honshu, Aichi Prefecture, Innyama City near Jyakkoin Temple.

Geographic Distribution: ASIA: Japan, Honshu.

Description of oocyst: Oocyst shape: spheroid to subspheroid; number of walls: 2; wall thickness: ≤ 1.0 ; wall characteristics: outer, pale yellow, lightly mammillated, $\sim 1/2$ of total thickness; inner, transparent; L x W: 13.4 x 12.4 (11–

16 x 9–14); L/W ratio: 1.1 (1.0–1.3); M: absent; OR: absent; PG: 1–2 always present. Distinctive features of oocyst: small size with mammillated outer wall.

Description of sporocysts and sporozoites: Sporocyst shape: ovoid; L x W: 9.2 x 6.3 (8–11 x 5–7); L/W ratio: 1.5 (1.3–1.7); SB: present; SSB: absent; PSB: absent; SR: present; SR characteristics: granules dispersed among SP or as a large, lipid-like body; SP: with one large posterior RB. Distinctive features of the sporocyst: small SB.

Prevalence: 27/45 (60%) *U. talpoides*; 0/6 *U. pilirostris*.

Sporulation: Oocysts were sporulated when returned to the laboratory from the field.

Prepatent and patent periods: Unknown.

Site of infection: Unknown. Oocysts recovered from intestinal contents and feces.

Material deposited: Skin, skull, skeleton and tissues of the symbiotype host are preserved in the Mammal Division of the MSB, UNM: MSB No. 45279 (NK 6044, female), S.B. George #729, 27 May, 1981. Photosyntypes in the USNPC No. 85996.

Remarks: Oocysts of this species do not resemble those from any species previously described from insectivores. This species has not been reported since its original description.

Reference: Duszynski and Moore (1986).

Species Inquirendae

***Coccidium* sp. of Cable and Conaway, 1953**

Original host: *Sorex palustris navigator* Richardson, 1828, Northern water shrew.

Remarks: Cable and Conaway (1953) described this species from the mammary glands of 3/9 (33%) lactating female water shrews from Montana, U.S.A. They saw merogony, gamogony and unsporulated oocysts in the tissue, but did not name or describe the parasite. This information was published as an abstract of a paper presented at the 28th Annual Meeting (1953) of the American Society of Parasitologists; however, the data were never published.

***Coccidia* spp. of Duszynski and Wattam, 1988b**

Original host: *Euroscaptor mizura* (Günther, 1880), Japanese mountain mole.

Remarks: Duszynski and Wattam (1988b) described five morphologically distinct oocyst forms from this host; unfortunately, all oocysts seen were unsporulated so it is not possible to even place them into the correct genus.

Coccidia spp. of Duszynski and Wattam, 1988b

Original host: *Mogera kobeae* Thomas, 1905, Large Japanese Mole.

Remarks: Duszynski and Wattam (1988b) described five morphologically distinct oocyst forms from this host; unfortunately, all oocysts seen were unsporulated so it is not possible to even place them into the correct genus.

Coccidia spp. of Duszynski and Wattam, 1988b

Original host: *Mogera tokudae* Kuroda, 1940, Large Sado Island mole.

Remarks: Duszynski and Wattam (1988b) described five morphologically distinct oocyst forms from this host; unfortunately, all oocysts seen were unsporulated so it is not possible to even place them into the correct genus.

Coccidia spp. of Duszynski and Wattam, 1988b

Original host: *Mogera wogura* (Temminck, 1842), Large Japanese mole.

Remarks: Duszynski and Wattam (1988b) described five morphologically distinct oocyst forms from this host; unfortunately, all oocysts seen were unsporulated so it is not possible to even place them into the correct genus.

***Cyclospora caryolytica* Schaudinn, 1902 of Henry (1932)**

Original host: *Scapanus latimanus* (Bachman, 1842), Broad-footed mole.

Remarks: Henry (1932) reported oocysts from *S. latimanus* in Berkeley, California; the oocysts measured 16–19 x 13–16 and she said they were *C. caryolytica*. The oocysts, however, were much too large to be *C. caryolytica* and the photomicrograph she presented (her Fig. 11) does not even closely resemble the line drawing of Schaudinn (1902). In addition, she based her identification on oocysts with which “by the fifth day they contained two sporoblasts, but none were found then or later in which the sporozoi-

tes could be detected.” Thus, she didn’t know if she had an *Isospora* or a *Cyclospora* species.

***Cyclospora caryolytica* Schaudinn, 1902 of Pellérdy (1974)**

Original host: *Parascalops breweri* (Bachman, 1842), Hairy-tailed mole.

Remarks: Pellérdy (1974) mentioned that *C. caryolytica* is “also found in *P. breweri*,” but provided no measurements or other documentation.

***Cyclospora caryolytica* Schaudinn, 1902 of Tanabe (1938)**

Original host: *Mogera robustus* Nehring 1891 (= *M. wogura*), Large Asian mole.

Remarks: Tanabe (1938) described what he said were the endogenous stages of *C. caryolytica*, but noted that they differed significantly from the endogenous stages first described by Schaudinn (1902). Nonetheless, Tanabe (1938) stated, “the oocysts of my species corresponded in size to those of *C. caryolytica*. Consequently, I believe that my species may be identified with *C. caryolytica*.” However, the photomicrographs he presented (his Figs. 4, 5) do not even closely resemble the line drawing presented by Schaudinn (1902).

***Cyclospora* sp. Duszynski and Wattam, 1988a**

Original host: *Talpa europaea* Linnaeus, 1758, European mole.

Remarks: Duszynski and Wattam (1988a) described the sporulated oocysts and provided both photomicrographs and a line drawing, but declined to name it as a new species because of the close resemblance to *C. talpae*. The oocysts of this form differed from those of *C. talpae* in only subtle ways: by being slightly smaller, having a SB that was more pointed than blunt, and by having a SR with fewer globules. Although both oocyst and sporocyst length and width measurements differed significantly between the two forms, and there is a shape difference between their SBs, Duszynski and Wattam (1988a) reasoned these may be part of the normal variation in the oocysts/sporocysts of a single species.

***Cyclospora* sp. Ford and Duszynski, 1989**

Original host: *Parascalops breweri* (Bachman, 1842), Hairy-tailed mole.

Remarks: Ford and Duszynski (1989) mentioned the presence of this species in *P. breweri* and presented a photomicrograph of it, but they did not give mensural data, descriptive parameters or name it because there were too few oocysts in their samples to do an adequate description.

***Eimeria crociduræ* Galli-Valerio, 1933**

Original host: *Crocidura russula* (Hermann, 1780) (= *C. aranea* [?]), Greater white-toothed shrew.

Remarks: This description was published in a short paragraph with no figure. Oocysts were subspheroid, 16 x 12.7 with a very small micropyle, and sporocysts were ovoid, 7.5 x 6. No other structural or qualitative information was given for the sporulated oocyst. There also was great confusion about the correct identity of the host as discussed by Levine and Ivens (1979). For these reasons, this species must be regarded as a *species inquirendæ*.

***Eimeria domashnevae* Dzerskinskii, 1982**

Original host: *Sorex asper* Thomas, 1914, Tien Shan shrew.

Remarks: This description was published as a one-paragraph note in a book about Kashkstan Lawra and the problems of its protection. Oocysts were ovoid with a smooth wall consisting of 1 layer, ~0.5; L x W: 14.0 x 13.0 (13–16.5 x 12–15); L/W ratio: 1.04–1.1; OR: absent; sporocysts were ovoid, 7.0 x 6.7; SR: absent; SP: comma-shaped. Sporulation “continues for 2–3 days.” His description lacked both a line drawing and/or a photomicrograph of a sporulated oocyst. This form, therefore, must be regarded as a *species inquirendæ*.

***Eimeria fedoseevi* Dzerskinskii, 1982**

Original host: *Sorex asper* Thomas, 1914, Tien Shan shrew.

Remarks: This description was published as a one-paragraph note in a book about Kashkstan Lawra and the problems of its protection. Oocysts were ovoid with a smooth wall consisting of two layers, ~2.0, with inner layer thicker than outer; L x W: 28.0 x 19.0 (24–30 x 17–21); L:W ratio: 1.4; M: present, ~5.7 wide; OR: present; sporocysts were ovoid; L x W: 15.5 x 10.0; SP: bean-shaped, 10 x 3. Sporulation “continues for

2–3 days.” His description lacked both a line drawing and/or a photomicrograph of a sporulated oocyst. This form, therefore, must be regarded as a *species inquirendæ*.

***Eimeria leporis* Nieschulz, 1923 of Yakimoff (1935)**

Type host: *Lepus europæus* Pallas, 1778, European hare.

Remarks: Yakimoff (1935) reported this species from the feces of *Talpa europæa* in the Polotzk District of Russia. He believed the form he saw was not a true parasite of the mole, but rather that the mole probably had ingested some hare feces and the oocysts were passing through the gut. The oocysts he measured were elongate-cylindroids, 35.1 x 16.2 (32–37 x 14–18) and spindle-shaped sporocysts were 16.2 x 9.0; both OR and SR were both present, but PG was absent. These mensural and qualitative characters conform to those of *E. leporis* and, thus, probably represent a pseudoparasite.

***Eimeria soricinae* Galli-Valerio, 1927**

Original host: *Sorex araneus* Linnaeus, 1758 (= *S. vulgaris*), Eurasian common shrew.

Remarks: This description was published as a note under observations on some animal parasites from Czechoslovakia. Oocysts were ovoid, 50 x 30, with a slightly flattened, very small M; sporocysts were spheroid, ~20; SP were 10 x 9. His description lacked qualitative detail and there was neither line drawing nor a photomicrograph of a sporulated oocyst. Therefore, this form must be regarded as a *species inquirendæ*. The only other time this “species” was mentioned was when Frank (1978) said she found it in *S. araneus* in Austria.

***Eimeria uilenbergi* Pellérdy, 1969**

Synonym: *Eimeria madagascarensis* of Uilenberg (1967), pro parte (in *Setifer setosus*).

Original host: *Tenrec ecaudatus* (Schreber, 1777), Streaked tenrec.

Remarks: Uilenberg (1967) described *E. madagascarensis* from *S. setosus*; he then said that oocysts from *T. ecaudatus*, which differed slightly in size, were also *E. madagascarensis*. Pellérdy (1974) suggested (with which we agree for reasons stated earlier) they should be regarded as independent species, since their hosts

belong to different genera, and named the form from *T. ecaudatus* as *E. uilenbergi*. The oocysts were subspheroid, with a thin, colorless, smooth wall; L x W: 17.0 x 16.3 (13–22 x 13–21); M: absent; OR: absent; PG: present. No mensural or qualitative data were given for the sporocysts. The parasite was reported to localize in the cells of the small intestine, 5 cm from the pylorus. Sporulation was completed in 6 days. Unfortunately, neither Uilenberg (1967, 1970), who first described it, nor Pellérdy (1969, 1974), who later named it, ever produced a photomicrograph or a line drawing of *E. uilenbergi*; therefore, it must be relegated, for the time being, to a *species inquirendae*.

***Eimeria* sp. Arnastauskienė and Maldžiūnaitė, 1978**

Original host: *Sorex minutus* Linnaeus, 1766, Pygmy shrew.

Remarks: Oocysts were 38–39 x 25–26, but no other mensural or qualitative information was given and neither a line drawing nor a photomicrograph were presented. Therefore, this form must be regarded as a *species inquirendae*.

***Eimeria* sp. Ford and Duszynski, 1989**

Original host: *Parascalops breweri* (Bachman, 1842), Hairy-tailed mole.

Remarks: Ford and Duszynski (1989) mentioned the presence of this species in *P. breweri* and presented a photomicrograph of it, but they did not give mensural data, descriptive parameters or name it because there were too few oocysts in their samples for an adequate description.

***Eimeria* sp. Golemansky and Yankova, 1973**

Original host: *Crocidura suaveolens* (Pallas, 1811), Lesser white-toothed shrew.

Remarks: Golemansky and Yankova (1973) measured some oocysts from *C. suaveolens* in Bulgaria. The oocysts were 24 x 16.5 (23–25 x 16–17), but never sporulated. Thus, it is unclear how they could have assigned this form to the correct genus.

***Eimeria* sp. Henry, 1932**

Original host: *Scapanus latimanus* (Bachman, 1842), Broad-footed mole.

Remarks: Henry (1932) found a few oocysts of a large *Eimeria* sp. that measured 28–30 x

22–26, but “the numbers were insufficient to ascertain whether or not this represented a different species.” She did not draw nor present a photomicrograph of this species. Yakimoff (1935) later described *E. goussevi* from 2/10 *Talpa europea* from Russia, which he said was this form first recorded by Henry (1932); this, however, is unlikely given the host and geographic differences.

***Eimeria* sp. Mullin, Colley and Welch, 1975**

Original host: *Echinosorex gymnura* (Raffles, 1822), Moon rat.

Remarks: Mullin et al. (1975) found 6/9 *E. gymnura* infected with an *Eimeria* sp. while doing an ecological study of Malaysian forest mammals. They neither described nor named it.

***Eimeria* sp. 1 of Tanabe, 1938**

Original host: *Mogera robusta* Nehring, 1891 (= *M. wogura*), Large Asian mole.

Remarks: Tanabe (1938) studied intestinal tissue sections from 26 moles from Japan that all were infected with three presumably different coccidia species. Based only on asexual and sexual endogenous stages (which had not been described previously), he concluded that this species was *E. scapani* described by Henry (1932) from *S. latimanus* from Berkeley, California. Given host and geographic differences, it seems highly unlikely that the tissue stages he described could be those of *E. scapani*. This form, therefore, must remain a *species inquirendae*.

***Eimeria* sp. Uilenberg, 1970**

Original host: *Hemicentetes semispinosus* (G. Cuvier, 1798), Streaked tenrec.

Remarks: Uilenberg (1970) found this form in 2/10 hosts and assigned it to *E. madagascariensis*, which he had described earlier (Uilenberg, 1967), from *Setifer setosus*. The oocysts were 16.2 x 14.8. He did not present a drawing or a photomicrograph, and only stated that the oocysts from *H. semispinosus* were identical to those from *S. setosus* and *T. ecaudatus*, all three genera belonging to the Tenrecidae. However, as we have noted above, there is not enough information yet on the *Eimeria*, *Isospora* and *Cyclospora* spp. of insectivores to know if they cross host generic boundaries or not. Thus,

to err on the conservative side, we propose it unlikely that this is *E. madagascariensis* and without evidence of a specimen, it must be relegated to a *species inquirendae*.

***Eimeria* sp. Glebezdin, 1985**

Original host: *Hemiechinus auritus* (Gmelin, 1770), Long-eared desert hedgehog.

Remarks: Glebezdin (1985) found some oocysts in hedgehogs from Turkmenistan that he identified as *E. ostertagi*. Given the generic differences of the hosts, we are inclined to believe these may be different species. Without a drawing of photomicrograph, this form must be considered a *species inquirendae*.

***Eimeria* sp. Glebezdin and Kolodenko, 1969**

Original host: *Hemiechinus auritus* (Gmelin, 1770), Long-eared desert hedgehog.

Remarks: Glebezdin and Kolodenko (1969) reported finding oocysts they identified as *E. ostertagi* in hedgehogs in Turkmenia; these oocysts were 26.9 x 23.9 (23–32 x 21.5–26.5) and sporocysts were 13.7 x 8.7 (8.5–14.5 x 6.5–11.5). Thus, the oocysts they saw were smaller and the sporocysts larger than those of *E. ostertagi* and the host genera were different. This form also must be considered a *species inquirendae* until additional information is available.

***Eimeria* sp. Yakimoff and Gousseff, 1935b**

Original host: *Sorex araneus* Linnaeus, 1758, Eurasian common shrew.

Remarks: Yakimoff and Gousseff (1935b) said that an *Eimeria* sp. they found in *S. araneus* in Russia, "resembles *E. soricis* Henry, 1932, with which it is probably identical." This seems unlikely given the host and geographic differences. The oocysts they saw were 20.8 x 14.6 (16–22 x 12–18). Thus, the form they saw must be considered a *species inquirendae*.

***Eimeria* sp. Yakimoff and Gousseff, 1940**

Original host: *Hemiechinus albulus* Stolid (?), Hedgehog.

Remarks: Yakimoff and Gousseff (1940) said that an *Eimeria* sp. they found in *H. albulus* in Kara-Kalpakia were "close to *E. ostertagi* [Yakimoff and Gousseff, 1936] in size and form-index." This seems unlikely given the host and geographic differences. The oocysts they saw

were round, 37.9 (37–40) or subspheroid, 38.5 x 29.7 (36–40 x 27–36). Thus, the form they saw must be considered a *species inquirendae*.

***Gousseffia erinacei* (Gousseff, 1937) Levine and Ivens, 1979**

Synonym: *Yakimovella erinacei* Gousseff, 1937.

Original host: *Erinaceus europaeus* Linnaeus, 1758, Eurasian hedgehog.

Remarks: Gousseff (1937) coined the generic designation *Yakimovella* for some oocysts he found in *E. europaeus* that had thin walls (membranes) containing 8 sporocysts, each with many SP. However, he had mentioned this name previously (Gousseff, 1936) for *Mantonella potamobii* Gousseff, 1936. Since the earlier usage invalidated the generic designation of *Yakimovella*, Levine and Ivens (1979) created a new genus name, *Gousseffia* to accommodate the oocysts seen by Gousseff (1937), even though both they and Pellérdy (1974) were doubtful about the validity of this form as a real parasite of the hedgehog. The oocysts were reported as spheroid, with a bi-layered wall and no M, but no measurements, drawings or photomicrographs were presented. We also consider this organism as doubtful; it is probably an *Adelina* pseudo-parasite and, since there is no recorded specimen, it must be considered a *species inquirendae*.

***Isospora* sp. Ford and Duszynski, 1989**

Original host: *Parascalops breweri* (Bachman, 1842), Hairy-tailed mole.

Remarks: Ford and Duszynski (1989) mentioned the presence of this species in *P. breweri* and presented a photomicrograph of it, but they did not give mensural data, descriptive parameters or name it because there were too few oocysts in their samples to do an adequate description. This species must be considered a *species inquirendae*.

DISCUSSION

Here we summarize the world's literature (through 1999) on the coccidian parasites (family Eimeriidae) known to infect insectivorous mammals. The order Insectivora is comprised of seven families, 66 genera and 428 species (Wil-

son and Reeder, 1993). Only 37 species (8.6%) in 19 genera (28.8%) from four families (57%) have been examined for, and are reported to harbor, coccidia; these reports are widespread temporally and geographically, and most represent only one collection event from one locality. Within these 37 host species are found 75 coccidia species, including five cyclosporas, 48 eimerians and 22 isosporans (Table 1). Nine host species are reported to have only a single coccidia species (all *Eimeria*) that appears to be unique to that host; however, seven of these nine had 16 or fewer host individuals examined, so it is likely that at least some harbor additional coccidia species, as yet unknown. The remaining 28 insectivore species that have been examined for coccidia have from two to 11 coccidia (mean = 3.4) that appear to be unique to each. Thus, if we assume that each insectivore species may have at least three unique coccidia species, there should be at least 1,200 species of coccidia yet to be discovered from the 428 known insectivore species. Or to put it another way, to date only about 5.8% of the total species of coccidia from insectivores have been reported. From the limited sample of insectivore species summarized in this monograph, it appears that their coccidia species can be shared between members of the same genus, but not between genera within the same family.

What else is yet to be learned about the coccidia from insectivores? Many of the described species of insectivore coccidia are known from descriptions that either are incomplete or contain ambiguities. Of the descriptions of sporulated oocysts reported herein, we consider at least 20 of the 75 (27%) to lack sufficient details to make the descriptions adequate by today's standards. These include: *E. blarinae*, *E. chagasi*, *E. dissimilis*, *E. goussevi*, *E. madagascariensis*, *E. ostertagi*, *E. perardii*, *E. ropotomae*, *E. scapani*, *E. semispinosi*, *E. setosi*, *E. soricis*, *E. suncus*, *E. tanabei*, *I. erinacei*, *I. rastegaievae*, *I. ricci*, *I. schmaltzi*, *I. soricis* and *I. talpae*. Nothing is known about sporulation time and/or location (endogenous/exogenous) for 17 of the 75 (23%) species, and none of the species have been passed in hosts under laboratory conditions, so we know nothing about the prepatent and patent periods. The location of endogenous development is not known for 67 of the 75 (89%) species and endogenous devel-

opmental stages are completely unknown for 68 of the 75 (91%) coccidia species. Some portion of endogenous development is known for *E. chagasi*, *E. darjeelingensis*, *E. firestoni*, *E. murinus*, *E. suncus* and *E. tanabei* and the complete life cycle has been described twice for *C. caryolytica*. Unfortunately, however, the description of the endogenous life cycle stages of *C. caryolytica* by Schaudinn (1902) differs significantly from that of the description by Tanabe (1938) and, given the conditions under which both descriptions were made (tissues from different naturally infected host genera [*Talpa* and *Mogera*] in widely separated locations [Europe and Japan, respectively]), both may be incorrect in some or every detail. About the only observation that seems to be in agreement on this life cycle is that the endogenous stages occur in nuclei of epithelial cells of the small intestine. There is only one paper (Entzeroth and Schotyseck, 1984) that examines ultrastructure, in this case of some of the intranuclear endogenous stage of *C. caryolytica*; nothing is known of the ultrastructure of any of the oocysts from insectivores. There is only one cross-transmission study in which Uilenberg (1967) was unable to transmit *E. setosi* from *Setifer setosus* to *Tenrec ecaudatus*. There are no "type" materials of any kind on deposit in accredited museums for 30 of the 75 (40%) coccidia species and there are no molecular data available on insectivore coccidia; the DNA of not one of the 75 species has been sequenced. Overall, our knowledge of the coccidia of insectivores is dismal.

In the absence of type material such as photosyntypes, certain portions of many descriptions must be viewed cautiously. For instance, some insectivore coccidia have been reported to vary greatly in size and shape, even ranging from spheroid to ovoid to ellipsoid. Thus, it is likely that some of the original descriptions (e.g., *I. erinacei*, *I. rastegaievae*) represent multiple species that were confused as one. Some of the morphologic characteristics of the oocyst wall should be considered dubious, or at least with caution. Oocysts are frequently reported to be yellow or orange in color, but how much of this represents true color, light refraction by different types of lenses (achromatic vs. apochromatic), or potassium dichromate impregnating the wall is unknown. Thus,

wall color should be viewed skeptically for several species, including *E. auritus*, *E. bijlikuli*, *E. leucodontis*, *E. setosi*, *E. suncus* and *I. ricci*. Likewise, the number of wall layers that are reported frequently are erroneous because observations may be influenced by lens quality and overall inexperience in interpretation. Thus, many of the reports of single-layered walls in non-aquatic hosts may be in error.

Lengths of SPs *in situ* also must be viewed cautiously in several reports. Sporozoites rapidly shorten and eventually degenerate once they become non-viable, and the large posterior RB in some species commonly is confused with the SP itself. Thus, SP sizes for various insectivore coccidia (e.g., *E. darjeelingensis*, *E. firestonei*, *E. murinus*, *E. suncus* and others) are questionable. Another common mistake is for the PG, which sometimes becomes attached to the inner oocyst wall, to be confused with and called a M. This most likely is the case for *E. suncus*. In other descriptions, the SSB may have been overlooked or considered a portion of the SB itself, such as may be the case for *E. neomyi*, *E. ropotomae* and *I. sofiae*.

As noted earlier, the coccidia are obligate, intracellular parasites that undergo both asexual (merogony) and sexual (gamogony) reproduction, culminating in the production of resistant propagules, the oocysts, which are discharged from the host in its feces. Thus, oocysts can be collected easily in the field and represent the stage most used, to date, in the identification of coccidia. Vertebrate biologists working on insectivores, other mammals, or even other vertebrate groups can play a pivotal role in our understanding of the coccidia from their particular host group simply by properly collecting fecal samples. Before oocysts can be studied critically, however, they must be maintained properly to keep them viable so that their structural integrity remains intact. The methods for collecting and preserving coccidian oocysts in the field have been outlined in detail (Duszynski and Wilber, 1997); it must be emphasized that the *only* preservation fluid known to keep oocysts alive for extended periods of time is 2–3% aqueous (w/v) potassium dichromate ($K_2Cr_2O_7$) solution. Previous studies on insectivore coccidia have clearly shown that other types of solutions sometimes used for coccidia (e.g., dilute sulfuric acid

solution) fail to maintain parasite viability and oocyst integrity (Duszynski and Wattam, 1988b). Attempts to fix and preserve internal details of the oocysts also have failed and traditional fixatives such as 5–10% neutral buffered formalin or polyvinyl alcohol (PVA), which routinely are used to fix helminth fecal stages, should be avoided (Duszynski and Gardner, 1991).

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Table 1. Summary of the known Eimeriidae (*Cyclospora*, *Eimeria* and *Isoospora* species) described, through 1999, from all Insectivora worldwide.

Insectivore	
Family/Subfamily	
<i>Genus/species</i>	<i>Cyclospora, Eimeria, Isoospora</i> spp. described
Chrysochloridae	have not been examined; no species described
Erinaceidae	
<i>Erinaceus europaeus</i>	<i>E. ostertagi</i> , <i>E. perardi</i> , <i>I. erinacei</i> , <i>I. rastegaievae</i> , <i>I. schmaltzi</i>
<i>Hemiechinus auritus</i>	<i>E. auriti</i> , <i>E. bijlikuli</i>
<i>Hylomys suillus</i>	<i>E. bentongi</i> , <i>E. hylomysis</i>
Nesophontidae	all fossil species
Solenodontidae	have not been examined; no species described
Soricidae	
Crociturinae	
<i>Crocitura poensis</i>	<i>E. firestonei</i> , <i>E. milleri</i>
<i>C. leucodon</i>	<i>E. leucodontis</i> , <i>E. ropotamae</i>
<i>C. suaveolens</i>	<i>E. leucodontis</i>
<i>Suncus murinus</i>	<i>E. darjeelingensis</i> , <i>E. murinus</i> , <i>E. suncus</i>
Soricinae	
<i>Blarina brevicauda</i>	<i>E. blarinae</i> , <i>E. brevicauda</i> , <i>I. brevicauda</i>
<i>Cryptotis parva</i>	<i>E. cryptotis</i> , <i>E. whitakeri</i>
<i>Neomys anomalus</i>	<i>E. neomyi</i> , <i>I. neomyi</i>
<i>N. fodiens</i>	<i>E. neomyi</i> , <i>I. neomyi</i>
<i>Sorex araneus</i>	<i>E. chagasi</i> , <i>E. dissimilis</i> , <i>E. soricis</i> , <i>I. araneae</i> , <i>I. soricis</i>
<i>S. arcticus</i>	<i>E. chagasi</i>
<i>S. cinereus</i>	<i>E. longirostris</i>
<i>S. fontinalis</i>	<i>E. longirostris</i>
<i>S. fumeus</i>	<i>E. fumeus</i> , <i>E. longirostris</i> , <i>E. vagrantis</i>
<i>S. haydeni</i>	<i>E. longirostris</i>
<i>S. longirostris</i>	<i>E. longirostris</i>
<i>S. minimus</i>	<i>E. chagasi</i> , <i>E. dissimilis</i> , <i>E. soricis</i>
<i>S. monticolus</i>	<i>E. fumeus</i> , <i>E. longirostris</i> , <i>E. vagrantis</i> , <i>I. palustris</i>
<i>S. ornatus</i>	<i>E. longirostris</i> , <i>E. soricis</i>
<i>S. pacificus</i>	<i>E. fumeus</i> , <i>E. longirostris</i> , <i>I. pacificus</i>
<i>S. palustris</i>	<i>E. longirostris</i> , <i>I. palustris</i>
<i>S. tenellus</i>	<i>E. inyoni</i> , <i>E. longirostris</i>
<i>S. trowbridgii</i>	<i>E. longirostris</i> , <i>E. vagrantis</i> , <i>I. palustris</i>
<i>S. unguiculatus</i>	<i>E. fumeus</i> , <i>I. palustris</i>
Tenrecidae	
<i>Hemicentetes semispinosus</i>	<i>E. semispinosi</i>
<i>Setifer setosus</i>	<i>E. madagascariensis</i> , <i>E. setosi</i>
Talpidae	
Talpinae	
<i>Condylura cristata</i>	<i>E. condylurae</i> , <i>I. condylurae</i> , <i>I. cristatae</i> , <i>I. lamoil-lensis</i>
<i>Mogera robusta</i>	<i>E. tanabei</i>

Table 1. continued.

<i>Neurotrichus gibbsi</i>	<i>E. heterocapita</i> , <i>E. neurotrichi</i> , <i>E. parastiedica</i> , <i>I. neurotrichi</i>
<i>Parascalops breweri</i>	<i>C. ashtabulensis</i> , <i>C. parascalopi</i> , <i>E. aethiospora</i> , <i>E. tithus</i> , <i>E. ashtabulensis</i> , <i>I. parascalopi</i>
<i>Scalopus aquaticus</i>	<i>C. megacephali</i> , <i>E. aquatici</i> , <i>E. motleiensis</i> , <i>E. scalopi</i> , <i>I. aquatici</i> , <i>I. motleiensis</i>
<i>Scapanus latimanus</i>	<i>E. scapani</i>
<i>Talpa europaea</i>	<i>C. caryolytica</i> , <i>C. talpae</i> , <i>E. avonensis</i> , <i>E. berea</i> , <i>E. flexilis</i> , <i>E. globula</i> , <i>E. goussevi</i> , <i>I. ricci</i> , <i>I. sofiae</i> , <i>I. sporopointea</i> , <i>I. talpae</i>
<i>Urotrichus talpoides</i>	<i>E. amorphospora</i> , <i>E. gonocilia</i> , <i>E. honshuensis</i> , <i>E. talpoides</i> , <i>I. urotrichi</i>
<i>U. pilostris</i>	<i>E. honshuensis</i> , <i>I. dyomecodi</i>
<hr/>	
Totals:	
4 families, 19 genera, 37 species	5 Cyclospora, 48 Eimeria, 22 Isospora species
<hr/>	

LEGEND TO FIGURES

Figures 1–74. Line drawings of 74 of the 75 coccidia species known from insectivores. Bar = 10 μ m.

Figures 75–115. Photomicrographs of sporulated oocysts that are on deposit as photosyntypes in the U.S. National Parasite Collection, Beltsville, MD. Bar = 10 μ m.

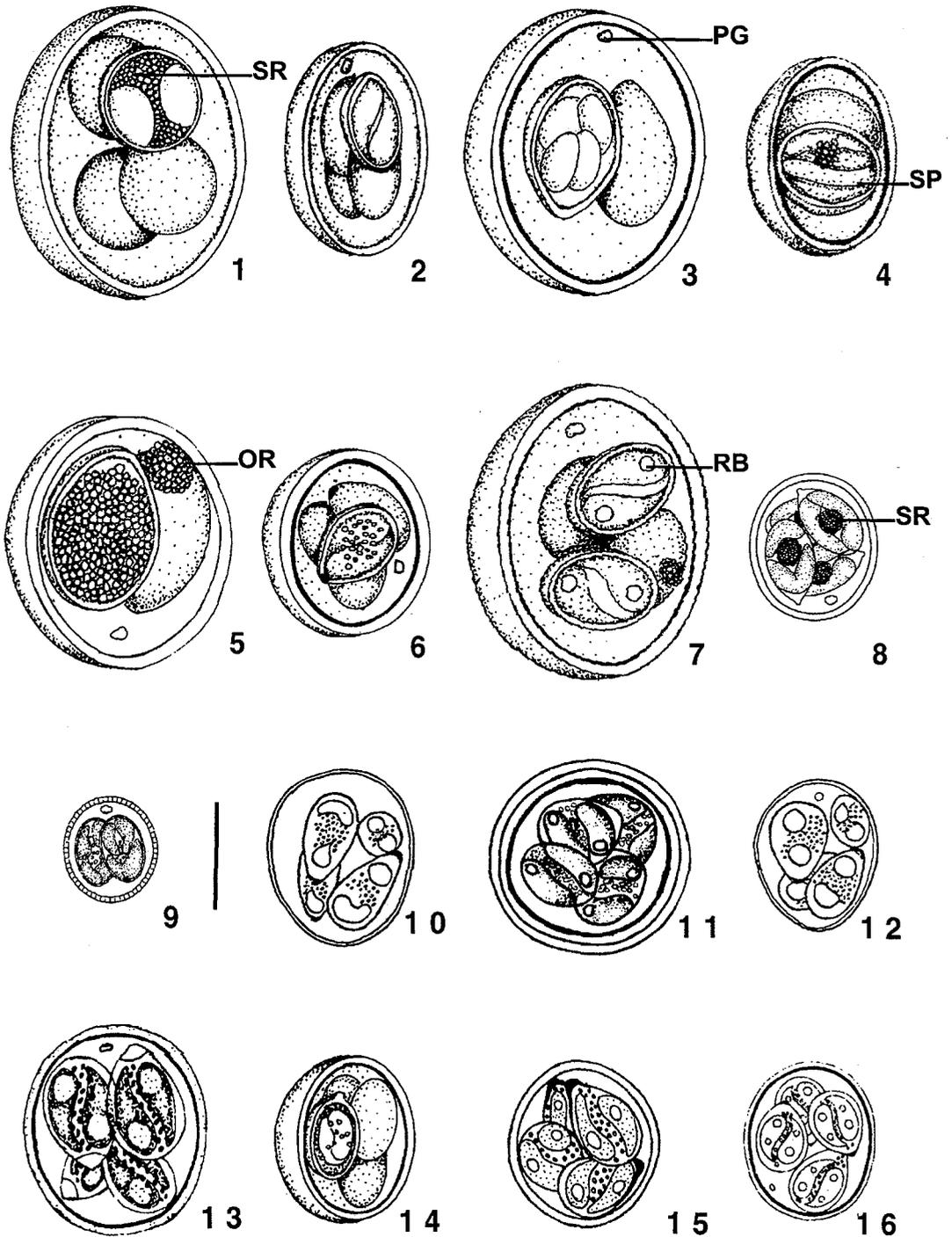


Plate I. Figures 1-16.

1. *Eimeria ostertagi*. 2. *Eimeria perardi*. 3. *Isospora erinacei*. 4. *Isospora rastegaievae*. 5. *Isospora schmalzi*. 6. *Eimeria auriti*. 7. *Eimeria bijlikuli*. 8. *Eimeria bentongi*. 9. *Isospora hylomysis*. 10. *Eimeria firestonei*. 11. *Eimeria leucodontis*. 12. *Eimeria milleri*. 13. *Eimeria ropotamae*. 14. *Eimeria darjeelingensis*. 15. *Eimeria murinus*. 16. *Eimeria suncus*.

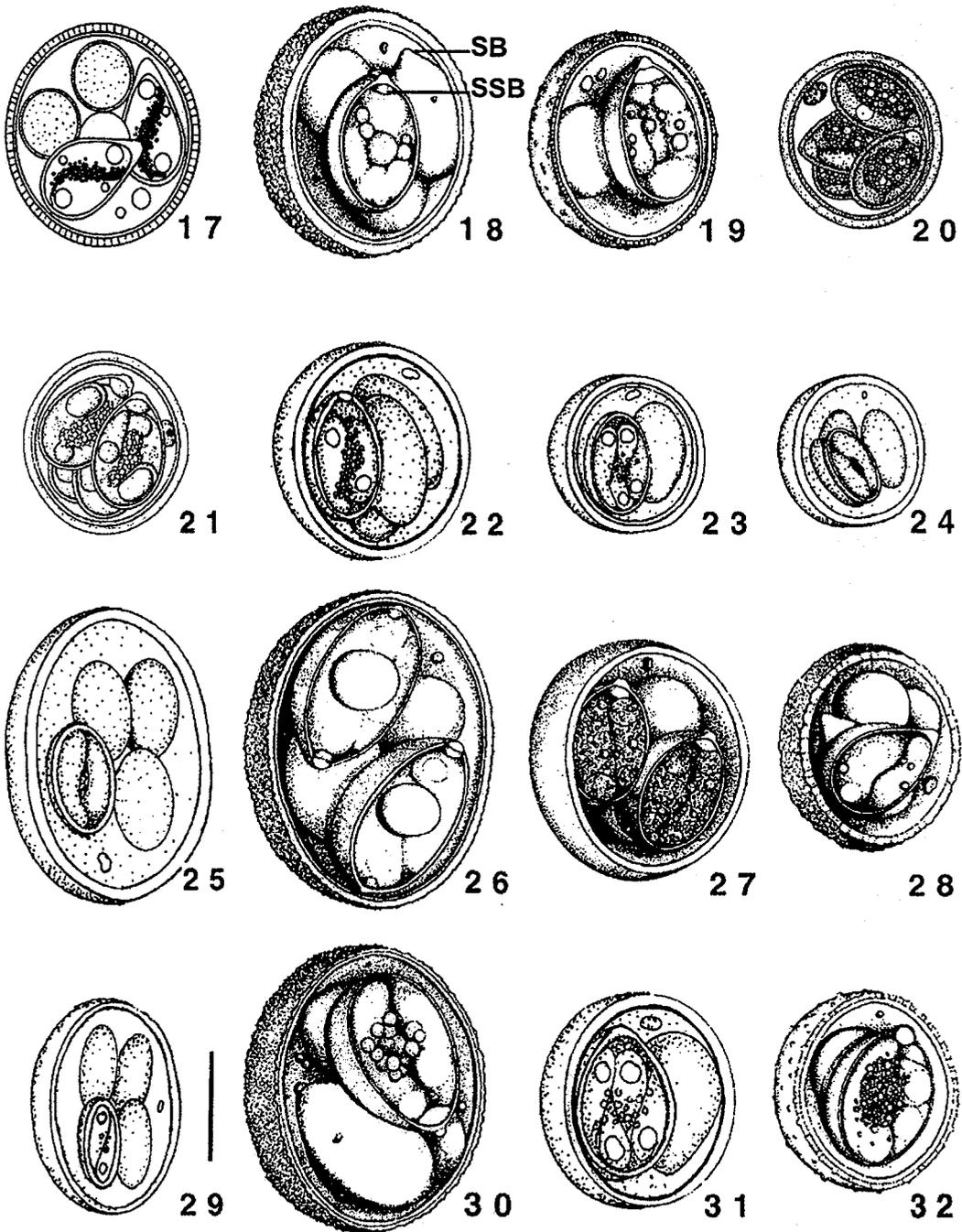


Plate II. Figures 17-32.

17. *Eimeria blarinae*. 18. *Eimeria brevicauda*. 19. *Isospora brevicauda*. 20. *Eimeria cryptotis*. 21. *Eimeria whitakeri*. 22. *Eimeria neomyi*. 23. *Isospora neomyi*. 24. *Eimeria chagasi*. 25. *Eimeria dissimilis*. 26. *Eimeria funeus*. 27. *Eimeria inyoni*. 28. *Eimeria longirostris*. 29. *Eimeria soricis*. 30. *Eimeria vagrantis*. 31. *Isospora araneae*. 32. *Isospora palustris*.

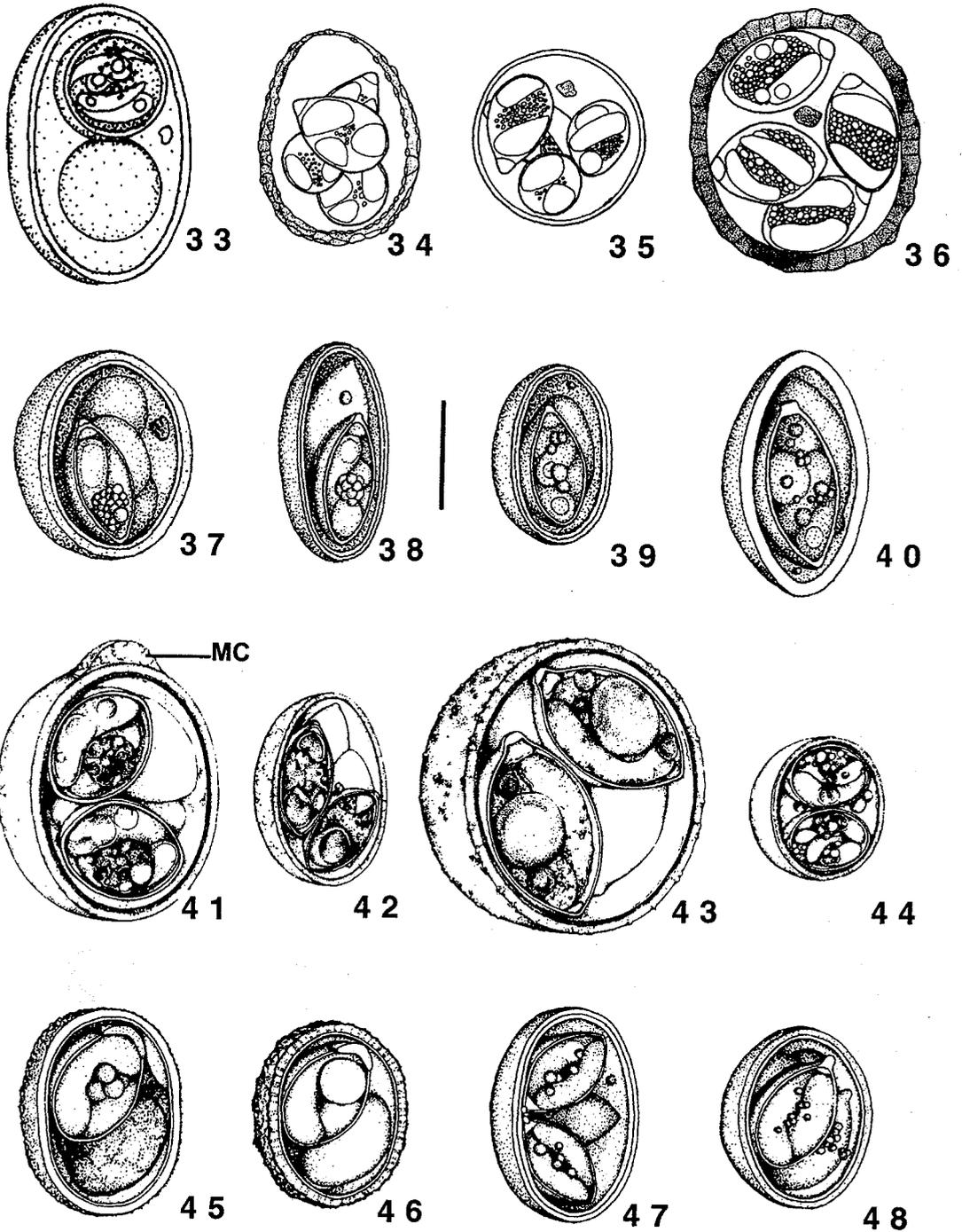


Plate III. Figures 33-48.

33. *Isospora soricis*. 34. *Eimeria semispinosi*. 35. *Eimeria madagascariensis*. 36. *Eimeria setosi*. 37. *Eimeria condyluræ*. 38. *Isospora condyluræ*. 39. *Isospora cristatae*. 40. *Isospora lamoillensis*. 41. *Eimeria heterocapita*. 42. *Eimeria neurotrichi*. 43. *Eimeria parastiedica*. 44. *Isospora neurotrichi*. 45. *Cyclospora ashtabulensis*. 46. *Cyclospora parascalopi*. 47. *Eimeria aethiospora*. 48. *Eimeria titthus*.

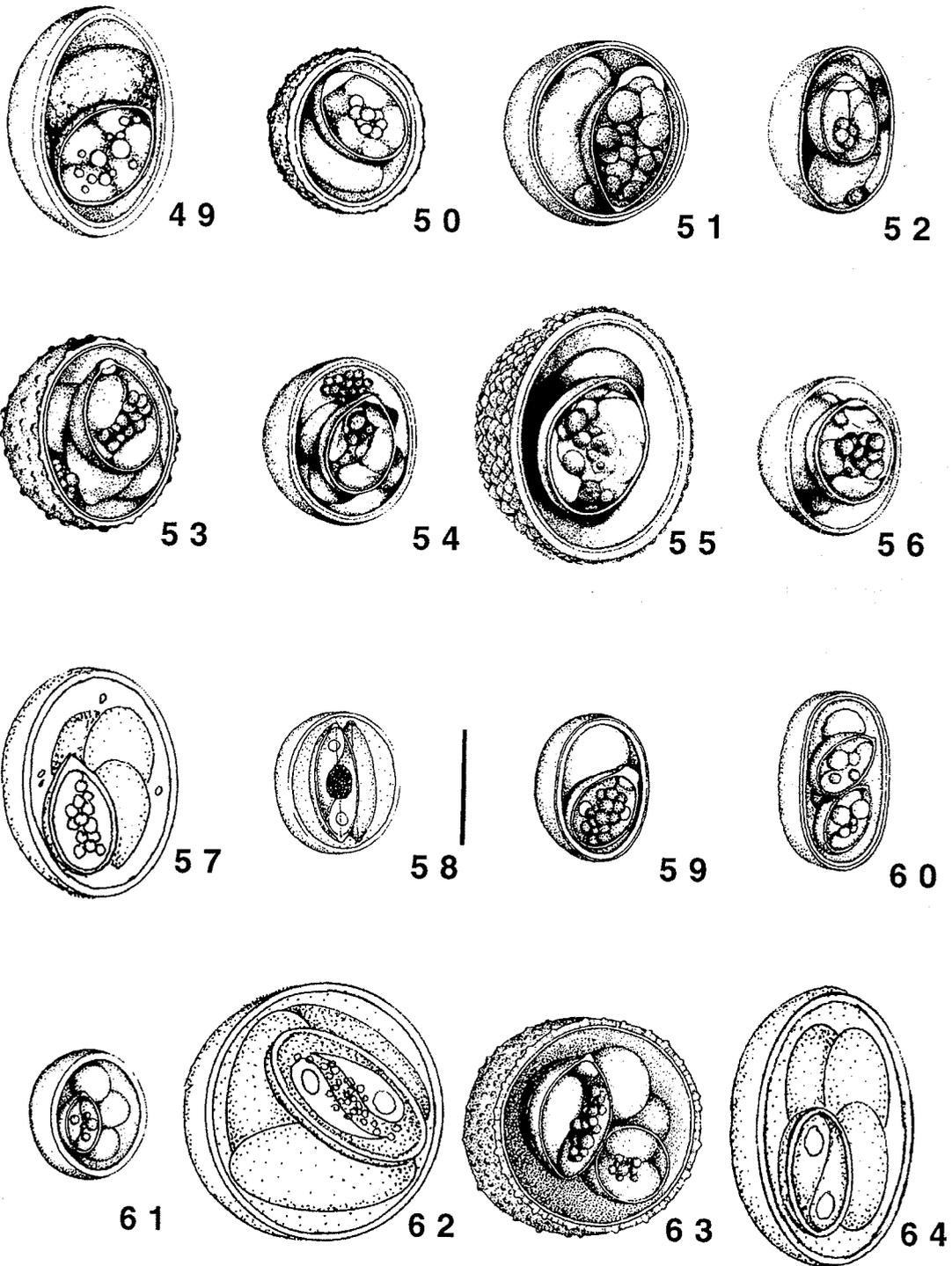


Plate IV. Figures 49-64.

49. *Isospora ashtabulensis*. 50. *Isospora parascalopi*. 51. *Cyclospora megacephali*. 52. *Eimeria aquatici*. 53. *Eimeria motleiensis*. 54. *Eimeria scalopi*. 55. *Isospora aquatici*. 56. *Isospora motleiensis*. 57. *Eimeria scapani*. 58. *Cyclospora caryolytica*. 59. *Cyclospora talpae*. 60. *Eimeria avonensis*. 61. *Eimeria berea*. 62. *Eimeria flexilis*. 63. *Eimeria globula*. 64. *Eimeria goussevi*.

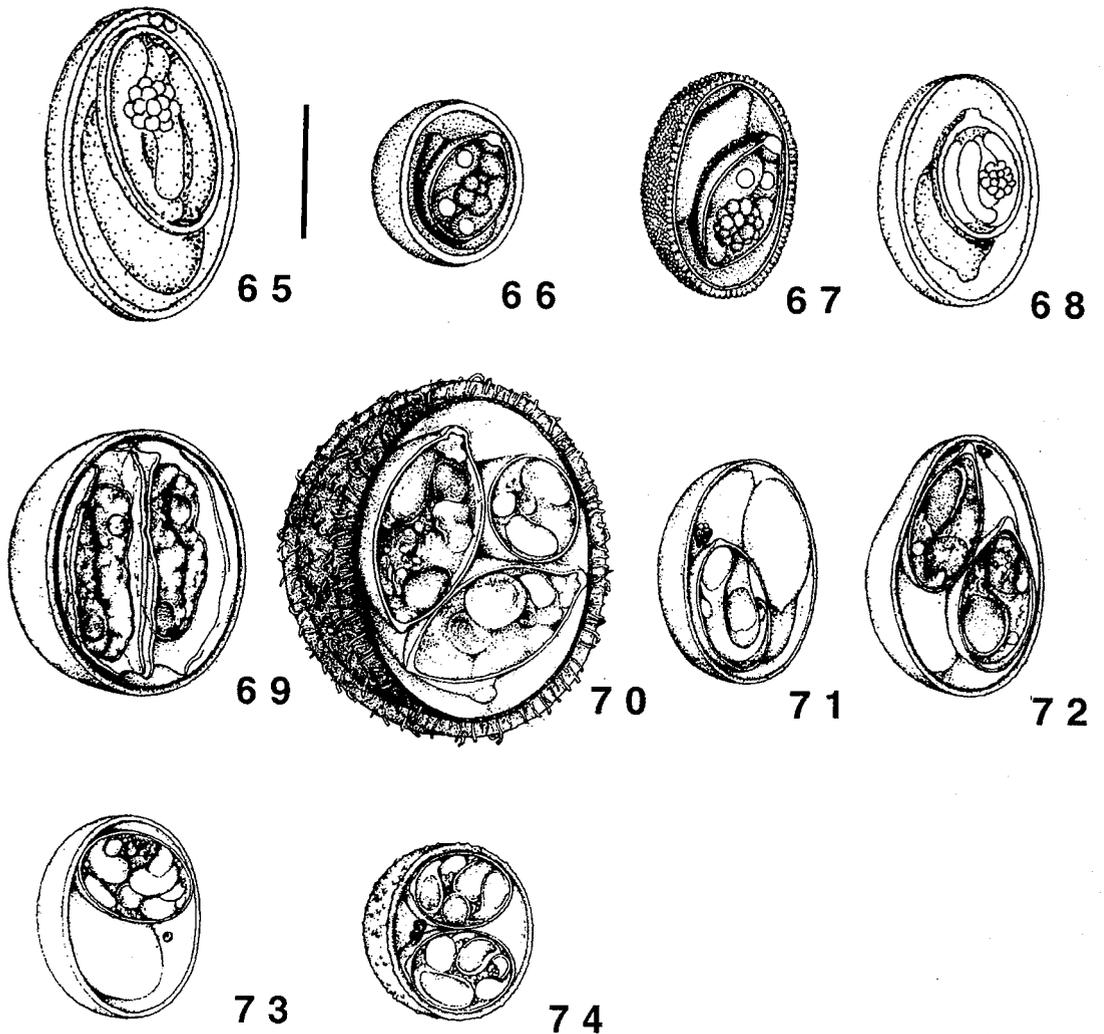


Plate V. Figures 65-74.

65. *Isospora ricci*. 66. *Isospora softiae*. 67. *Isospora sporopointaea*. 68. *Isospora talpae*. 69. *Eimeria amorphospora*. 70. *Eimeria gonocilia*. 71. *Eimeria honshuensis*. 72. *Eimeria talpoidei*. 73. *Isospora dymecodi*. 74. *Isospora urotrichi*.

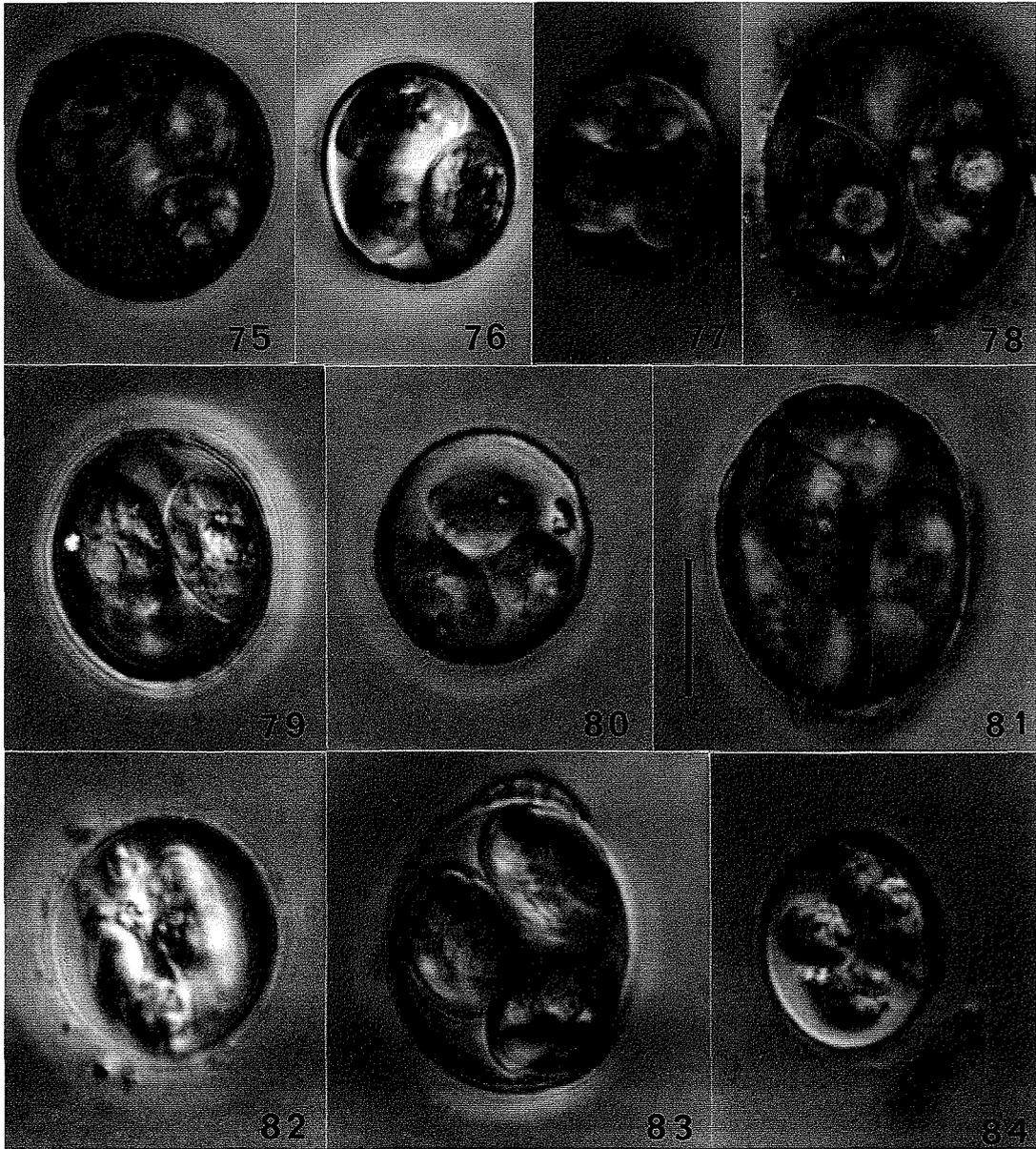


Plate VI. Figures 75–84, *Eimeria* species.

75. *Eimeria brevicauda*. 76. *Eimeria cryptotis*. 77. *Eimeria whitakeri*. 78. *Eimeria fumeus*. 79. *Eimeria inyoni*. 80. *Eimeria longirostris*. 81. *Eimeria vagrantis*. 82. *Eimeria condylurae*. 83. *Eimeria heterocapita*. 84. *Eimeria neurotrichi*.

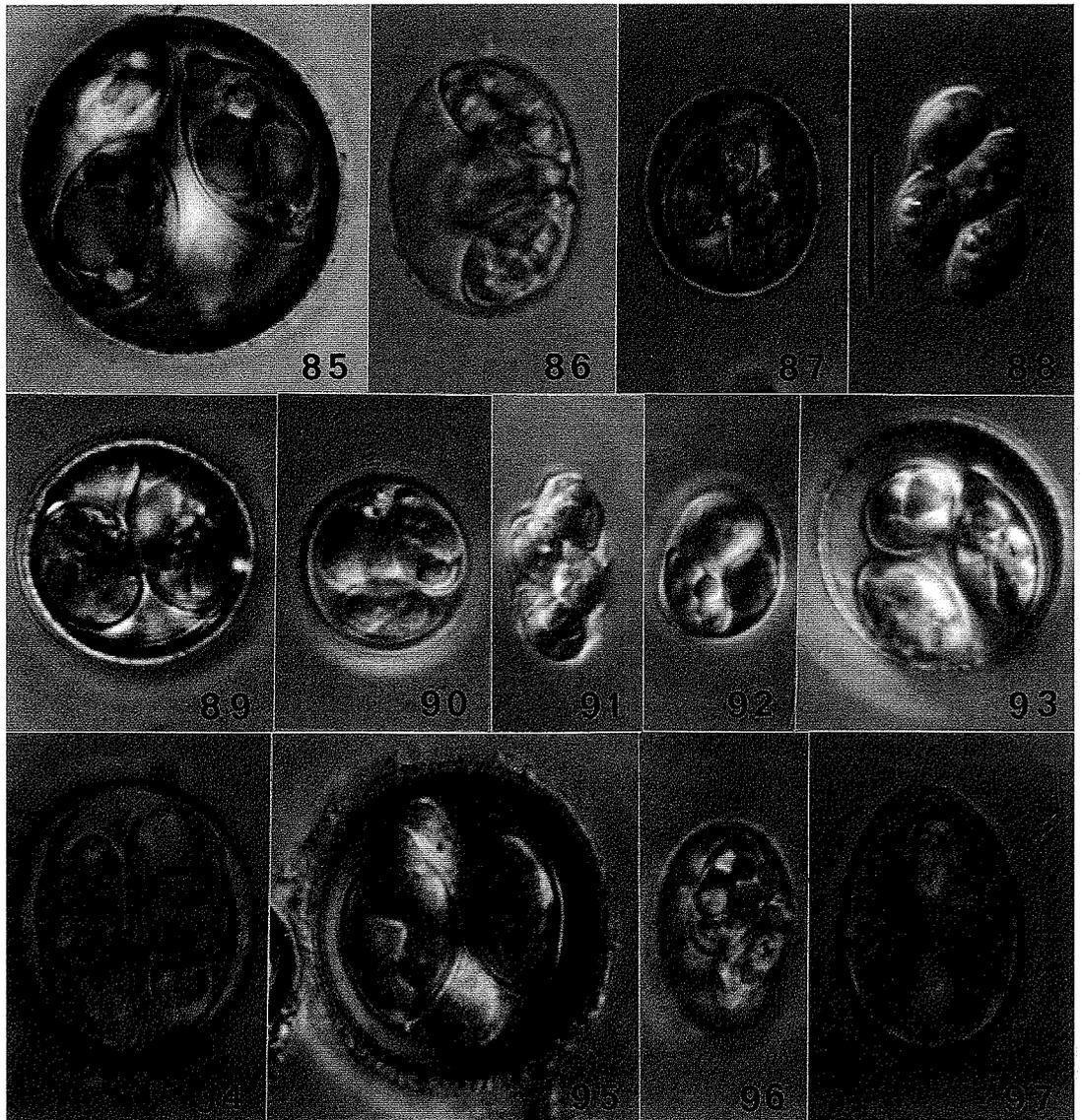


Plate VII. Figures 85–97. *Eimeria* species (continued).

85. *Eimeria parastiedica*. 86. *Eimeria aethiospora*. 87. *Eimeria titthus*. 88. *Eimeria aquatici*. 89. *Eimeria motleiensis*. 90. *Eimeria scalopi*. 91. *Eimeria avonensis*. 92. *Eimeria berea*. 93. *Eimeria globula*. 94. *Eimeria amorphospora*. 95. *Eimeria gonocilia*. 96. *Eimeria honshuensis*. 97. *Eimeria talpoidei*.

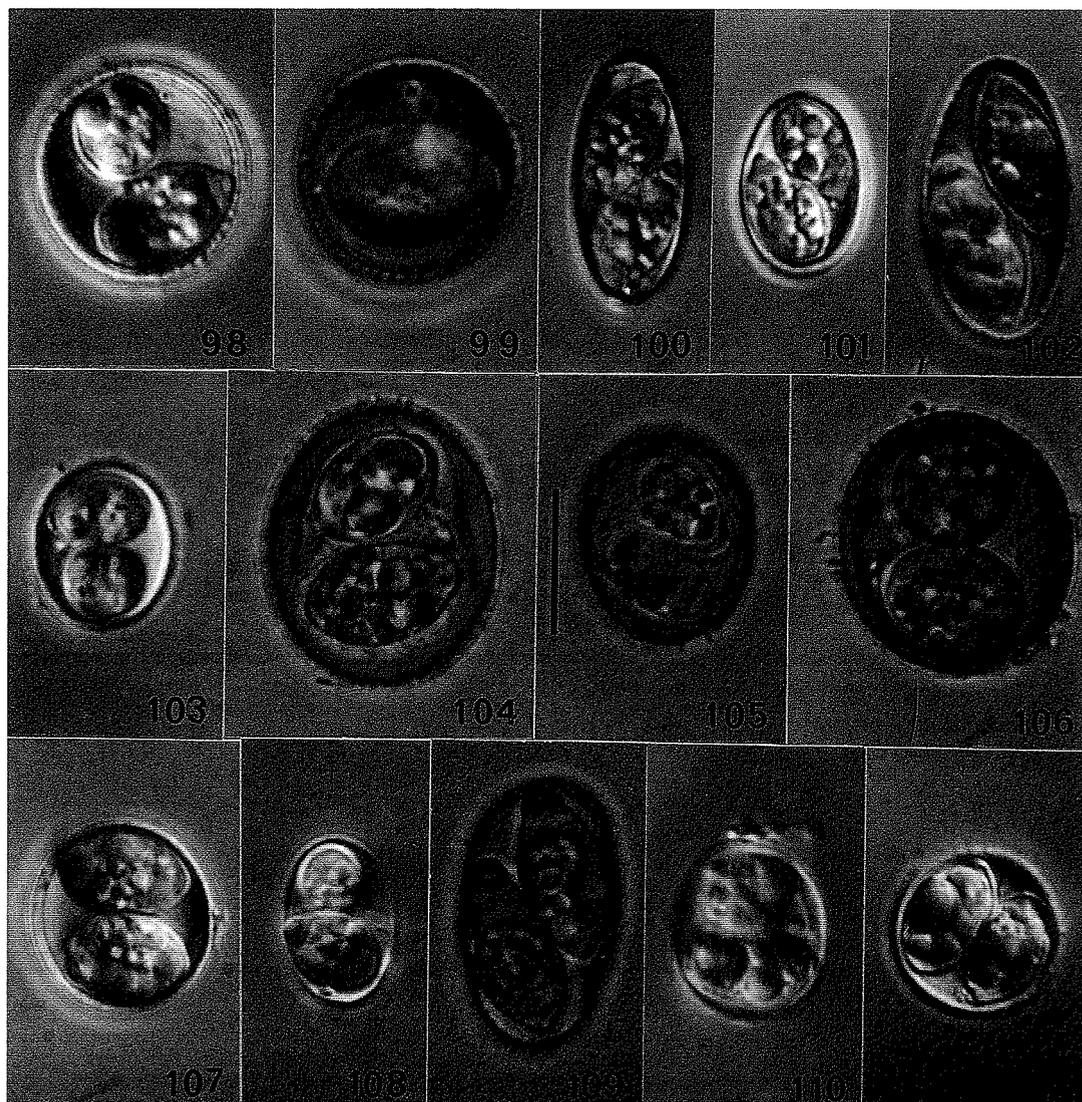


Plate VIII. Figures 98–111, *Isospora* species.

98. *Isospora brevicauda*. 99. *Isospora palustris*. 100. *Isospora condyluræ*. 101. *Isospora cristatæ*. 102. *Isospora lamoillensis*.
 103. *Isospora neurotrichi*. 104. *Isospora ashtabulensis*. 105. *Isospora parascalopi*. 106. *Isospora aquatici*. 107. *Isospora motleiensis*. 108. *Isospora sofiaæ*. 109. *Isospora sporopointea*. 110. *Isospora dymecodi*. 111. *Isospora urotrichi*.

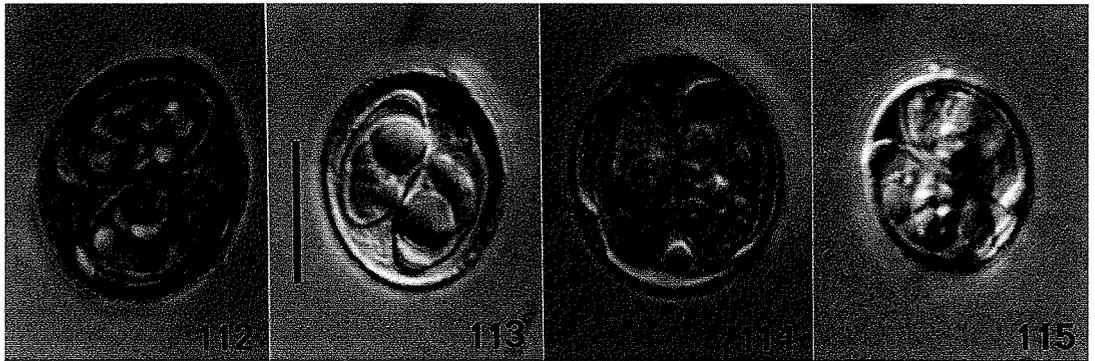


Plate IX. Figures 112–115. *Cyclospora* species.

112. *Cyclospora ashtabulensis*. 113. *Cyclospora parascalopi*. 114. *Cyclospora megacephali*. 115. *Cyclospora talpae*.

ADDENDUM

After this manuscript went to press, a paper was presented (Abstract No. 115, June 26, 2000) at the 75th Anniversary Meeting of the American Society of Parasitologists, San Juan, Puerto Rico, by W.C. Marquardt and D.W. Duszynski, that is relevant to this monograph. Their paper, "A second report of a coccidium (Phylum Apicomplexa) in the mammary glands of shrews," documented both micro- and macrogamonts (sexual stages), in various stages of development, and unsporulated oocysts of an unidentified coccidium in both lactating and non-lactating glands of three of six *Sorex unguiculatus* that were collected on the island of Hokkaido, Japan. Gamonts developed in the alveoli of the mammary glands and oocysts could be seen in the lactiferous ducts and in pools of milk. Oocysts measured 19.5 x 13.8 μm and had a smooth outer wall that was $<1 \mu\text{m}$ thick. Little histopathology was associated with the infections. Infected cells were enlarged and rather cloudy, and in some areas there was leucocytic infiltration with macrophages, small and large lymphocytes, polymorphonuclear neutrophils and eosinophils. No basophils were seen. More questions were raised than answers given. Why were no merogonous stages seen? Is this a two-host coccidium? If mothers' milk transmits the infection to young shrews, why are only unsporulated oocysts present? What is the genus of this parasite? Since obvious coccidia tissue stages now have been found in two species of *Sorex* that are widely separated geographically, is mammary (or other) tissue development of coccidia common in this host genus? If we routinely looked in mammary, urogenital, hepatic or other epithelial cell surfaces that eventually can lead to the external environment of the host animal, would many more unique and specialized coccidia be found? This certainly is an area that deserves additional study.

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