

In a penultimate chapter on "Territory and Population," the purpose of which is to draw to a common conclusion the two lines of thought just briefly outlined, it is emphasized that an average of twelve or thirteen locations were all that became available, annually, for about thirty-three young which attain the age of independence. It is quite possible that more space might mean more survivals. Possession of ground may not be necessary to the individual life—it is certainly essential to reproduction, and ". . . what selection takes place is not based so much on the individual's ability to live, but rather on its ability to leave offspring." "*The ultimate competition is for space.*" The space requirement, rarely compressed to the limit, is a kind of elastic cushion or governor, variously modifiable, but in final control of the potentially illimitable reproductive forces. Yet it is to be noticed that in the period studied, admittedly "depression years," it was not the territorial factor but other agencies of reduction of numbers which lowered the waters below mean sea level. The total young reaching their first spring was not enough to fill the spaces. The territorial control is ever-present, but is the final arbiter of numbers only when other controls are insufficient.

It is a great pity that so high a wall of statistical matter lies between the average reader and these later chapters, as well as that final summation called "A Wren-tit's Life," and we unblushingly advise readers, not concerned with professional technicalities, to skip. "God gives us our relatives,"—no one can control his own birth, and this embryo, which was fit to be a book, was fated to be born a dissertation.

AVIAN HOSTS OF EIMERIAN COCCIDIA

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INTRODUCTION

THE senior author has elsewhere (Boughton, 1937) pointed out to ornithologists that coccidiosis is a disease widely distributed among birds. The two genera of Coccidia responsible for this disease in birds—*Isospora* and *Eimeria*—were distinguished as to type of oocyst development outside the host body and in regard to the orders of birds parasitized. A survey of the literature revealed that various species of *Isospora* are found in birds of the "higher" orders (Cuculiformes, Passeriformes, etc.), while species of *Eimeria* occur in birds of the "lower" orders (Pelecaniformes, Galliformes, Columbiformes, etc.). The nature of Isosporan coccidiosis as it is found in small birds was described. More recently (Boughton, 1938) a host list of some 175 species and sub-

species of birds which may be parasitized by *Coccidia* of the genus *Isospora* has been published.

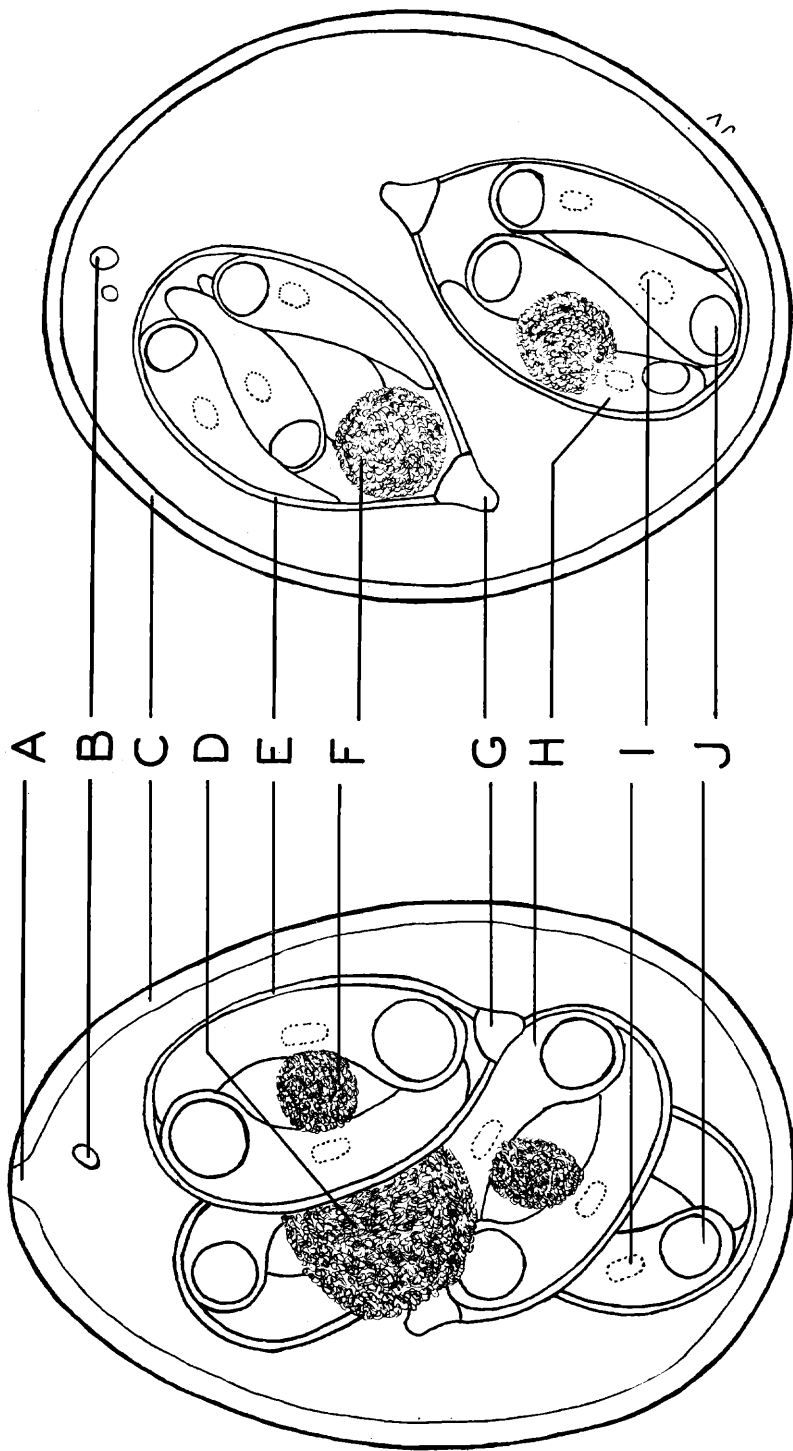
The purpose of this paper is to present a classified list of birds parasitized by *Eimeria* together with a brief review of the species of parasites involved. It is hoped that this will serve to summarize and, at the same time, to indicate the gaps in our present information on Eimerian coccidiosis. Ornithologists are in a favorable position to fill in some of these gaps, especially those involving the distribution of *Coccidia* in avian hosts.

Eimerian coccidiosis is a severe disease of domestic pigeons and chickens. It causes enormous losses to the poultry industry. The parasites multiply in, and destroy the epithelium or sub-epithelial layers of the intestine and caeca, causing, in some types of the disease, severe internal hemorrhage. The birds in this case literally bleed to death. Sometimes the upper intestine is invaded with a resulting destruction of tissue and emaciation of the bird. In chickens the most critical age is between 4 and 8 weeks. Chickens which recover are often stunted and may never become profitable.

To what extent *Coccidia* cause death or affect birds adversely in nature is difficult to say. Certainly there can be no doubt in the case of quail, which are known to suffer severely from coccidiosis (Stoddard, 1932). Isosporan coccidiosis in small birds has been noted (Boughton, 1937) as the cause of death in nature as well as in captivity. Frankly, there is not sufficient evidence either to condemn the *Coccidia* as universally pathogenic parasites or to consider them of no importance in many bird species. Some writers maintain that severe coccidiosis is the result of man-made mass production or of unusual conditions in nature. On the other hand, it has been pointed out that deaths of wild birds in nature due to coccidiosis (Boughton, 1937) or to malaria (Herman, 1938) would ordinarily escape notice. It seems fair to say, in the light of known pathogenicity in many cases and wide distribution among birds, that infections with *Eimeria* must be considered as a potential cause of death in wild birds.

Coccidial infections are transferred from one host to another by means of microscopic oocysts. These end-products of the multiplication within the host are passed from the body in the faecal discharges. Eimerian oocysts require a developmental period of 24 hours to several days in a moist place outside the host in order to produce the minute infective forms (sporozoites) which are capable of beginning again the parasitic life within another host. When developed oocysts are ingested by a susceptible bird the asexual multiplication, and consequent destruction of host tissue, is resumed.

In the laboratory, the droppings containing freshly passed oocysts may be cultured in 2 per cent potassium-bichromate solution. The latter inhibits bacterial growth and thus allows the oocysts to sporulate. Oocysts of *Eimeria* develop 4 sporocysts, each with



EIMERIA

ISOSPORA

Diagrammatic representation of sporulated coccidian oocysts of the genera *Eimeria* and *Isospora*. A, Micropyle. B, Polar globule. C, Oocyst wall. D, Residual body of oocyst. E, Sporocyst wall. F, Residual body of sporocyst. G, "Plug" of sporocyst. H, Sporozoite. I, Nucleus of sporozoite. J, Refractile body of sporozoite.

2 sporozoites. Oocysts of *Isospora* develop 2 sporocysts, each with 4 sporozoites. These details are shown diagrammatically in Figure 1.

HOST LIST

In compiling the list of avian hosts presented here, we have been aided by the published host lists of Levine and Becker (1933) and of Becker (1934). In so far as was possible we have examined the original references and relevant subsequent papers for details regarding the species of *Eimeria* involved, incidence of infection, pathogenicity, etc. Accounts of avian *Eimeria* reported in the literature since the publication of the above mentioned host lists as well as a few of our own observations are also included.

The orders and families of birds are given according to Wetmore's (1934) classification. For each bird species one, or in some cases several, Eimerian species is indicated. Details regarding the latter in relation to their respective hosts can be found in the alphabetized list of avian Eimerian species which follows the host list.

Pelecaniformes

Phalacrocoracidae. Cormorants.

Phalacrocorax carbo lugubris. Cormorant. *E. urnula* Hoare, 1933

Phalacrocorax aristotelis. Shag. *E. roscoviensis* (Labbé, 1893)

Anseriformes

Anatidae. Ducks, Geese, Swans.

Anser a. anser. Domestic goose

E. anseris Kotlán, 1932

E. nocens Kotlán, 1933

E. parvula Kotlán, 1933

E. truncata (Raill. & Lucet, 1891)

Galliformes

Tetraonidae. Grouse.

Bonasa umbellus. Alaskan Spruce Grouse *E. angusta* Allen, 1934

Canachites canadensis. Willow Grouse *E. bonasae* Allen, 1934

Lagopus lagopus. Grouse *E. angusta* Allen, 1934

Lagopus mutus. Ptarmigan *E. bonasae* Allen, 1934

Lyrurus tetriz. Black Grouse *E. lagopodi* Galli-Valerio, 1929

Perdix perdix. Grey partridge *E. lyruri* Galli-Valerio, 1927

Caccabis chucar. Stone partridge *E. nadsoni* Yak. & Gouss., 1936

Tetrao urogallus. Grouse *E. kofoidi* Yak. & Matik., 1936

Tetrao urogallus. Grouse *E. kofoidi* Yak. & Matik., 1936

Tetrao urogallus. Grouse *E. brumpti* Yak. & Gouss., 1936

Phasianidae. Quails, Pheasants, Peacocks.

Gallus d. domesticus. Domestic Chicken

E. acervulina Tyzzer, 1929

E. beachi Yak. & Rast., 1931

E. johnsoni Yak. & Rast., 1931

E. maxima Tyzzer, 1929

E. mitis Tyzzer, 1929

E. necatrix Johnson, 1930

E. praecox Johnson, 1930

E. tenella (Raill. & Lucet, 1891)

E. tyzzeri Yak. & Rast., 1931

E. dispersa Tyzzer, 1929

E. phasiani Tyzzer, 1929

E. dispersa Tyzzer, 1929

E. langeroni Yak. & Matsch.,

1937

Colinus v. virginianus. Bobwhite.

Phasianus colchicus torquatus. Ring-necked pheasant

Phasianus chrysomelas. Pheasant

- Alectoris graeca*. "Berghuhn" =
Mountain-partridge *E. caucasica* Yak. & Buew., 1932
- Meleagrididæ. Turkeys.
Meleagris mexicana. Domestic Turkey *E. meleagris* Tyzzer, 1927
E. meleagrimitis Tyzzer, 1929
- Gruiformes.
Gruidæ. Cranes.
Anthropoides (= *Grus*) *virgo*. Demoiselle crane *E. gruis* Yak. & Matsch., 1935
E. reichenovi Yak. & Matsch., 1935
- Rallidæ. Rails, Coots, Gallinules.
Fulica atra. Coot *E. paludosa* (Léger & Hesse, 1922)
Gallinula chloropus. Moor-hen *E. paludosa* (Léger & Hesse, 1922)
- Charadriiformes.
Charadriidæ. Plovers, Turnstones, Surf-birds.
Charadrius alexandrinus. Kentish Plover. *E. roscoviensis* (Labbé, 1893)
Charadrius dubius. Little Ringed Plover. do.
Pluvialis apricarius. Golden Plover. do.
- Scolopaciidæ. Snipes, Sandpipers, Woodcock.
Numenius phaeopus. Whimbrel. *E. roscoviensis* (Labbé, 1893)
Totanus totanus. Redshank. do.
Totanus hypoleucos. Common Sandpiper. do.
Calidris arenaria. Sanderling. do.
Tringa alpina. Dunlin. do.
Pelidna torquata. do.
- Laridæ. Gulls, Terns.
Sterna forsteri. Forster's tern. *E. meservei* Coaney, 1935
- Columbiformes.
Columbidæ. Pigeons, Doves.
Columba l. livia. Domestic Pigeon. *E. columbarum* Nieschulz, 1935
E. labbeana Pinto, 1928
Columba leucocephala. White-crowned pigeon. *E. sp.*
Zenaidura macroura carolinensis. Eastern mourning dove. *E. sp.*
Melopelia a. asiatica. Eastern white-dove. *E. sp.*
Oreopeleia chrysia. Key West Quail-dove. *E. sp.*
- Piciformes.
Picidæ. Woodpeckers.
Dryobates major. Woodpecker. *E. brumpti* Yak. & Gouss., 1936
E. lyruri Galli-Valerio, 1927
- Passeriformes.
Motacillidæ. Wagtails, Pipits.
Motacilla alba. European White Wagtail. *E. roscoviensis* (Labbé, 1893)

DESCRIPTION OF SPECIES

In describing coccidian species many authors have placed considerable emphasis upon oocyst characteristics, *i.e.*, shape, size, and sporulation time. Unfortunately details regarding other phases of the life cycle, the number of hosts examined, and the effects upon the host are often lacking. In the following brief descriptions we have attempted to give the salient points in a standardized form. The describer of the species is often the sole

authority for our information; in some cases other writers, indicated under *Relevant papers*, have added to our information on the species in question. The frequency with which the entry "not recorded" appears emphasizes the need for further work on Eimerian coccidiosis of birds.

The residual bodies of oocyst and sporocyst are features often involved in species description. The residual body of the oocyst, as the term is employed in the following descriptions, is the more or less compact ball of protoplasm not included within the sporocysts when the latter are formed from the original unsegmented mass of protoplasm. The residual body is not to be confused with small, isolated "polar globules." The latter may be present in some cases even before segmentation. The residual body of the sporocyst is a more or less compact mass of protoplasm about which the sporozoites are arranged. The residual bodies are shown diagrammatically in Figure 1.

E. acervulina Tyzzer, 1929

Hosts: *Gallus d. domesticus*. Epithelium of upper half of small intestine.

Oocyst description: Ovoid, 18–20 x 14–16 μ , mean 20 to 14 μ . No clear-cut micropyle.

Residual body: in oocyst, none, although one or more minute polar globules may be present; in sporocyst, probably none. Sporulation time: 24 hours.

Tissue Stages: Well described. Schizonts develop 16–32 merozoites. Occur in swarms of similarly developed forms.

Prevalence and Geographical Distribution: Common in chickens.

Pathogenicity: Questionable.

Host specificity: Probably restricted to chicken, although certain authors claim cross-infection with other gallinaceous birds.

Relevant papers: Tyzzer, Theiler, and Jones (1932), Henry (1931), Venard (1933), Stoddard (1932), Brinkman (1926), Verwey (1926).

E. angusta Allen, 1934

Hosts: *Bonasa umbellus*, *Canachites canadensis*. Caeca.

Oocyst description: Elliptical, 27–33 x 16–18 μ . Micropyle, "not always readily seen." Residual body: in oocyst, none, although a "very small" and globule like body is present; in sporocysts, none shown in drawing. Sporocysts: pyriform, with "plug" at one end. Sporulation time not recorded.

Tissue Stages: Not recorded.

Prevalence and Geographical Distribution: "Quite a number" of birds examined from Labrador and Alaska "had heavy infections."

Pathogenicity and Host specificity: Not recorded.

E. anseris Kotlán, 1932

Hosts: *Anser a. anser*. Epithelium and sub-epithelial tissue of lower small intestine.

Oocyst description: Pyriform, 16–23 x 13–18 μ . Micropyle present. Residual body: in oocyst, present; in sporocyst, not recorded. Sporulation time: 24–48 hours.

Tissue Stages: Briefly noted. Merozoites in groups of 15–25.

Prevalence and Geographical Distribution: Often found in geese of Europe.

Pathogenicity: Infections short-lived. Probably responsible for certain severe outbreaks of coccidiosis in geese in Germany reported by Reichenow (1921).

Host specificity: Not transmissible to chicken nor to turkey.

Relevant papers: Reichenow (1921), Kotlán (1933), Yakimoff (1933).

E. beachi, Yakimoff & Rastegaieff, 1931

Hosts: *Gallus d. domesticus*. Presumably intestine.

Oocyst description: Round, 22–13 μ , mean 17 μ . No micropyle. Residual body: in oocyst, none, although polar globules may be present; in sporocysts, no information. Sporocysts: ovoid. Sporulation time: not recorded.

Tissue Stages: Not recorded.

Prevalence and Geographical Distribution: Found in unrecorded number of chickens in Russia.

Pathogenicity and Host specificity: Not recorded.

E. bonasae Allen, 1934

Hosts: *Bonasa umbellus*, *Lagopus lagopus*. Caeca, rarely small intestine.

Oocyst description: Spherical, about 21 μ . No micropyle. Residual body: in oocyst, none shown in drawing; in sporocyst, not reported. Mature sporocysts not seen. Sporulation time: not recorded.

Tissue Stages: Not recorded.

Prevalence and Geographical Distribution: "Comparatively few" of birds examined from Massachusetts, Labrador, Quebec, and Alaska were positive.

Pathogenicity and Host specificity: Not recorded.

E. brumpti, Yakimoff and Gousseff, 1936

Hosts: *Tetrao urogallus*, *Dryobates major*. Presumably intestine.

Oocyst description: Spherical, 20 μ ; sub-spherical (from *D. major*), 22–26 x 20–22 μ . Residual body: in oocyst, none, also no polar globule; in sporocyst, present. Sporocyst: broadly ovoid with no apparent (from figure) differences in poles. Sporulation time: not recorded.

Tissue Stages: Not recorded.

Prevalence and Geographical Distribution: Reported from one *I. urogallus* (from Polotzk district, Russia) out of 25 examined; also from 1 *D. major* (from Gomel district, Russia) out of 2 examined.

Pathogenicity and Host specificity: Not recorded.

E. caucasica Yakimoff & Buewitsch, 1932

Hosts: "Berghuhn," presumably *Alectoris graeca*, or mountain partridge. Presumably intestine.

Oocyst description: Elongate, rarely ovoid, 25–36 x 14–21 μ , mean 33 x 19 μ . Residual body: in oocyst, none, although polar globules may be present; in sporocyst, present. Sporocysts: pyriform, with "plug" at the more pointed pole. Sporulation time: 24 hours.

Tissue Stages: Not recorded.

Prevalence and Geographical Distribution: Found in unrecorded number of "Berghühnern" in Transcaucasia.

Pathogenicity and Host specificity: Not recorded.

E. columbarum Nieschulz, 1935

Hosts: *Columba l. livia*. Intestinal epithelium.

Oocyst description: Round, slightly elliptical, 19–21 x 17–20 μ , mean 20 x 19 μ . No micropyle. Residual body: in oocyst, none, but many small polar globules; in sporocyst, present. Sporocyst: elliptical, with "plug" at the more pointed pole. Sporulation time: not recorded.

Tissue Stages: Not recorded.

Prevalence and Geographical Distribution: Found in 3 out of 10 hosts examined in Holland.

Pathogenicity: Questionable.

Host specificity: Probably restricted to the pigeon; Nieschulz (1935) tried unsuccessfully to infect 16 chickens.

E. dispersa Tyzzer, 1929

Hosts: *Colinus v. virginianus*, *Phasianus colchicus torquatus*. Small intestine and caeca.

Oocyst description: Ovoid, 23 x 19 μ . Micropyle? Residual body: in oocyst, none, also no polar globules; in sporocyst, no information. Sporulation time: Approximately 48 hours.

Tissue Stages: Briefly described.

Prevalence and Geographical Distribution: Common in American quail.

Pathogenicity: Infection may persist for some months in mature birds with no apparent effects; but the younger the bird, the more damage. Heavy infection in a week-old bird is usually fatal.

Host specificity: Turkeys and chickens have been experimentally infected only in a few cases.

E. gruis Yakimoff and Matschoulsky, 1935

Hosts: *Anthropoides* (= *Grus*) *virgo*. Presumably intestine.

Oocyst description: Pyriform, 16-21 x 11-14 μ , mean 19 x 20 μ . No micropyle. Residual body: in oocyst, none, although a polar globule is present; in sporocyst, present, elongate. Sporocyst: elongate, with no evident differences in poles. Sporulation time: 3-4 days.

Tissue Stages: Not recorded.

Prevalence and Geographical Distribution: Found in 2 out of 2 gray cranes examined in the Leningrad Zoological Gardens.

Pathogenicity and Host specificity: Not recorded.

E. johnsoni, Yakimoff & Rastegaieff, 1931

Hosts: *Gallus d. domesticus*. Presumably intestine.

Oocyst description: Oval, 16-27 x 14-20 μ , mean 22 x 18 μ . No micropyle. Residual body: in oocyst, none; in sporocyst, not shown in drawings. Sporulation time: 24 hours.

Tissue Stages: Not recorded.

Prevalence and Geographical Distribution: Found in unrecorded number of chickens in Russia.

Pathogenicity and Host specificity: Not recorded.

E. kofoidi Yakimoff and Matikaschwili, 1934

Hosts: *Perdix perdix*, *Caccabis chucar*. Presumably intestine.

Oocyst description: Ovoid, 16-25 x 14-20 μ , mean 20 x 18 μ . Micropyle? Residual body: in oocyst, none, but polar globule may be present; in sporocyst, present. Sporocyst: ovoid, "pointed at one end." Sporulation time: not recorded.

Prevalence and Geographical Distribution: Reported from mixed faecal sample from cage in Leningrad Zoological Gardens containing unrecorded numbers of individuals of both host species.

Pathogenicity and Host specificity: Not recorded.

E. labbeana Pinto, 1928

Hosts: *Columba l. livia*. Intestinal epithelium.

Oocyst description: Spherical, 15-26 x 14-24 μ , mean 20 x 18 μ . No micropyle. Residual body: in oocyst, none; in sporocyst, present. Sporocyst: oval, with "plug" at the more pointed pole. Sporulation time: 3 days.

Tissue Stages: Fully described by Nieschulz, 1925.

Prevalence and Geographic Distribution: Common in pigeons in Europe and America.

Pathogenicity: A severe outbreak may wipe out an entire loft in a few days.

Host specificity: Questionable.

Relevant papers: Nieschulz (1925, 1935), Hofkamp (1931).

E. lagopodi Galli-Valerio, 1929

Hosts: *Lagopus mutus*. Presumably intestine.

Oocyst descriptions: Cylindrical, with one pole slightly flattened, 24 x 15 μ . Micropyle "scarcely visible." Residual body: in oocyst, none (?); in sporocyst, none. Sporocyst: ovoid. Sporulation time: not recorded.

Tissue stages: Not recorded.

Prevalence and Geographical Distribution: Abundant in unrecorded number of hosts examined in Switzerland.

Pathogenicity: Probably severe in young hosts.

Host specificity: Not recorded.

E. langeroni Yakimoff & Matschoulsky, 1937

Hosts: *Phasianus chrysomelas*. Presumably intestine.

Oocyst description: Ovoid, 30–36 x 16–20 μ , mean 32 x 18 μ . No micropyle. Residual body: in oocyst, none, also no polar globule; in sporocyst, present. Sporocyst: ovoid, with no marked differences in the poles. Sporulation time: not recorded.

Tissue Stages: Not recorded.

Prevalence and Geographical Distribution: Reported from faecal sample of 1 out of 2 hosts examined in Russia.

Pathogenicity and Host specificity: Not recorded.

E. lyruri Galli-Valerio, 1927

Hosts: *Lyrurus tetrix*, *Tetrao urogallus*, *Dryobates major*. Presumably intestine.

Oocyst description: Cylindrical 24–27 x 15 μ . Micropyle? Residual body: in oocyst, none, but polar globule present (Yak. & Gouss., 1936); in sporocyst, present, according to Yak & Gouss. (1936). Sporulation time: not recorded.

Tissue Stages: Not recorded.

Prevalence and Geographical Distribution: Found once out of "numerous examinations" of *L. tetrix* presumably from Switzerland; reported later by Yak. & Gouss. from 11 out of 25 *L. tetrix*, 1 out of 1 *T. urogallus*, and 1 out of 16 *D. major* from Russia.

Pathogenicity and Host specificity: Not recorded.

Relevant papers: Yakimoff and Gousseff (1936).

E. maxima Tyzzer, 1929

Hosts: *Gallus d. domesticus*. Small intestine, chiefly in lower two-thirds.

Oocyst description: Ovoid, 21–42 x 16–30 μ , mean 29 x 22 μ . Micropyle? Residual body: in oocyst, none, although a coarse globular inclusion may be present; in sporocyst, apparently none. Sporocyst: oval, with "plug" at one pole. Sporulation time: 48 hours.

Tissue Stages: Fully described.

Prevalence and Geographical Distribution: Evidently fairly common in chickens.

Pathogenicity: Marked in heavy infections.

Host specificity: Evidently specific for chicken.

E. meleagridis Tyzzer, 1927

Hosts: *Meleagris mexicana*. Caeca, and often nearby portions of small and large intestine.

Oocyst description: Ellipsoidal, 19–30 x 14–23 μ , mean 24 x 17 μ . Micropyle? Residual body: in oocyst, none, but polar globules may be present; in sporocyst, no information. Sporulation time: 24 hours.

Tissue Stages: Incompletely described.

Prevalence and Geographical Distribution: Occasionally found in turkeys.

Pathogenicity: Low. Hinshaw (1937) reported "coccidiosis" as the cause of death in 2% of 4020 poultz examined over a period of three years in California.

Host specificity: Attempts to infect chickens have failed.

Relevant papers: Tyzzer (1929), Hinshaw (1937).

E. meleagrimitis Tyzzer, 1929

Hosts: *Meleagris mexicana*. Small intestine, mostly lower portion.

Oocyst description: Oval, 16–20 x 13–17 μ , mean 18 x 15 μ . Micropyle? Residual body: in oocyst, none, but polar globules present; in sporocyst, no information. Sporulation time: Not recorded.

Tissue Stages: Described briefly.

Prevalence and Geographical Distributions: A few cases have been reported from birds examined at autopsy.

Pathogenicity: Probably not marked.

Host specifically: Attempts to infect chickens have failed.

E. meservei Coatney, 1935

Hosts: *Sterna forsteri*. Presumably intestine.

Oocyst description: Oval or round, 16–19 x 14–18 μ , mean 18 x 17 μ . Micropyle present. Residual body: in oocyst, present; in sporocyst, present, elongate. Sporocyst: elongate, with no evident differences in poles. Sporulation time: 24 hours.

Tissue Stages: Not recorded.

Prevalence and Geographical Distributions: Found in 4 out of 4 terns from Iowa, U. S. A.

Pathogenicity and Host specificity: Not recorded.

E. mitis Tyzzer, 1929

Hosts: *Gallus d. domesticus*. Small intestine, heaviest in the upper portion.

Oocyst description: Sub-spherical, 16 x 15 μ . Micropyle? Residual body: in oocyst, none, but polar globule present; in sporocyst, none shown in drawings. Sporocyst: oval, with "plug" at one end. Sporulation time: 48 hours.

Tissue Stages: Fully described.

Prevalence and Geographical Distribution: Probably common in chickens.

Pathogenicity: *E. mitis* is considered non-pathogenic.

Host specificity: Evidently specific for chicken. However, *E. meleagridis* of the turkey is quite similar in some respects.

E. nadsoni Yakimoff & Gousseff, 1936

Hosts: *Lyrurus tetrrix*. Presumably intestine.

Oocyst description: Spherical, 20 x 26 μ , mean 22 μ ; sub-spherical 17–24 x 21–29 μ , mean 21–25 μ . No micropyle. Residual body: in oocyst, none, but polar globule present; in sporocyst, probably none. Sporocyst: elliptical, with one pole pointed. Sporulation time: not recorded.

Tissue Stages: Not recorded.

Prevalence and Geographical Distribution: Reported from 3 out of 25 hosts examined in Russia.

Pathogenicity: Questionable.

Host specificity: Not recorded.

E. necatrix Johnson, 1930

Hosts: *Gallus d. domesticus*. Duodenal epithelium and caeca.

Oocyst description: Broadly oval, 13–23 x 11–18 μ , mean 17 x 14 μ . No evident micropyle. Residual body: in oocyst, none, although a polar globule is regularly present; in sporocyst, none shown in drawings (Tyzzer *et al.*, 1932). Sporocyst: elliptical, with "plug" at one pole. Sporulation time: 36–48 hours.

Tissue Stages: Fully described by Tyzzer *et al.* (1932). Schizonts characteristically large and containing many merozoites.

Prevalence and Geographical Distribution: Common in chickens.

Pathogenicity: Pronounced, severe infections producing prolonged coccidiosis characterized by hemorrhage and dilation of the intestine.

Host specificity: Apparently specific for chicken.

Relevant papers: Tyzzer, Theiler, & Jones (1932).

E. nocens Kotlán, 1933

Hosts: *Anser a. anser*. Epithelium of lower small intestine.

Oocyst description: Ovoid, 26–28 x 19–21 μ , mean 27 x 20 μ . Micropyle present. Residual body: no information. Sporulation time: not recorded.

Tissue Stages: Briefly described. Schizonts with 15–35 merozoites.

Prevalence and Geographical Distribution: Found in unrecorded number of geese in Hungary.

Pathogenicity and Host specificity: Not recorded.

E. paludosa (Léger & Hesse, 1922)

(Syn. *Jarrina paludosa* Léger & Hesse, 1922)

Hosts: *Fulica atra*, *Gallinula chloropus*. Intestine.

Oocyst description: Ovoid, with neck at one pole, 14–15 x 11 μ . Wall perforated. Micropyle (“pseudomicropyle”?) present. Residual body: in oocyst, none, but polar globule may be present; in sporocyst, small and granular. Sporocyst: elliptical, with no evident differences in poles. Sporulation time: 15 days.

Tissue Stages: Described and figured.

Prevalence and Geographical Distribution: Found often in unrecorded number of coots and less frequently in unrecorded number of moor-hens in Southern France and Tunis.

Pathogenicity and Host specificity: Not recorded.

Relevant papers: Hoare (1933).

E. parvula Kotlan, 1933

Hosts: *Anser a. anser*. Epithelium of lower small intestine.

Oocyst description: Nearly spherical, 10–15 x 10–14 μ , mean 13 x 12 μ . No micropyle. Residual body: no information. Sporulation time: not recorded.

Tissue Stages: Briefly noted.

Prevalence and Geographical Distribution: Found in unrecorded number of geese in Hungary.

Pathogenicity: Non-pathogenic. Superinfection possible.

Host specificity: Not recorded.

E. phasiani Tyzzer, 1929

Hosts: *Phasianus colchicus torquatus*. Lower small intestine and caeca.

Oocyst description: Ellipsoid, 23 x 16 μ . Micropyle? Residual body: none, but polar globules may be present; in sporocyst, no information. Sporulation time: 24 hours.

Tissue Stages: Briefly described.

Prevalence and Geographical Distribution: Not recorded.

Pathogenicity: Questionable; apparently harmless.

Host specificity: Non-infective to chickens, quail and turkeys.

E. praecox Johnson, 1930

Hosts: *Gallus d. domesticus*. Epithelium of upper third of small intestine.

Oocyst description: Ovoid, 20–25 x 16–20 μ , mean 21 x 17 μ . Residual body: in oocyst, none, although a polar globule is present; in sporocyst not recorded. Sporulation time: 48 hours.

Prevalence and Geographical distribution: Probably common in chickens.

Pathogenicity: Harmless. Infections usually of a short duration.

Host specificity: Probably specific for chickens.

Relevant papers: Tyzzer Theiler and Jones (1932).

E. reichenovi Yakimoff and Matschoulsky, 1935

Hosts: *Anthropoides* (= *Grus*) *virgo*. Presumably intestine.

Oocyst description: Two types reported. Oval, 14–23 x 12–18 μ , mean 18 x 13 μ ; round, 12–21 μ , mean 16 μ . No micropyle. Residual body: in oocyst, none, although a polar globule is present; in sporocyst, present, elongate. Sporocyst: elongate, with no evident differences in poles. Sporulation time: 5–6 days.

Tissue Stages: Not recorded.

Prevalence and Geographical Distribution: Found in 2 out of 2 gray cranes examined in the Leningrad Zoological Gardens.

Pathogenicity and Host specificity: Not recorded.

E. roscoviensis (Labbe, 1893)

Hosts: A variety of hosts, mainly shore birds. (*Vide* Host List). Epithelium and sub-epithelial tissues of intestine.

Oocyst description: Pyriform, truncated at narrower pole, 16–18 x 14–16 μ .

Micropyle ("pseudomicropyle"?) present. Residual body: in oocyst, none, but polar globules present; in sporocyst, present. Sporocyst: pyriform, with "plug" at the more pointed pole. Sporulation time: not recorded.

Tissue Stages: Described briefly and figured by Labbe (1896).

Prevalence and Geographical Distribution: Found in 2 out of 4 *Phalacrocorax aristotelis* (= *cristatus*) and in an unrecorded number of other hosts examined in France.

Pathogenicity and Host specificity: Not recorded.

Relevant papers: Labbe (1896), Hoare (1933).

E. sp.

The following hosts of the family Columbidae were found, by microscopic examinations of their fecal material, to harbour infections with undetermined species of *Eimeria*: *Columba leucocephala*, *Zenaidura macroura carolinensis*, *Melopelia a. asiatica*, and *Oreopeleia chrysis*. The examinations were made possible through the courtesy of Mr. H. H. Bailey of Miami, Fla., who permitted the senior author to examine a number of living, captive birds. No attempt was made to identify the Coccidia beyond the genus. All of the two or three birds of each species examined harboured apparently non-pathogenic infections. No Isosporan oocysts were encountered in any of these hosts.

E. tenella (Railliet and Lucet, 1891)

Hosts: *Gallus d. domesticus*. Caeca; in lower small and entire large intestine in some cases.

Oocyst description: Oval, 19–26 x 16–23 μ , mean 23 x 19 μ . No micropyle. Residual body; in oocyst, none, but polar globules may be present; in sporocyst, none.

Sporocyst: oval, with "plug" at one end. Sporulation time: 48 hours.

Tissue Stages: Fully described by Tyzzer (1929).

Prevalence and Geographical Distribution: Common in chickens.

Pathogenicity: Marked. Fatal infections common in chicks 4 to 10 weeks old.

Host specificity: Presumably limited to chickens.

Relevant papers: Tyzzer (1929).

E. truncata (Railliet & Lucet, 1891)

Hosts: *Anser a. anser*. Epithelium of kidney tubules.

Oocyst description: Ovoid, with one pole flattened, 20–22 x 13–16 μ . Residual body: in oocyst, "sometimes a refractile residual body lying among the sporocysts" (Becker, 1934); in sporocyst, present. Sporulation time: 5 days.

Tissue Stages: Described in part by subsequent authors.

Prevalence and Geographical Distribution: Often found in young geese in Europe and reported in Iowa by McNutt (1929).

Pathogenicity: Marked, causing early death in young geese according to some accounts; light infections apparently harmless.

Host specificity: Apparently specific for goose.

Relevant papers: Lerche (1923, 1929), McNutt (1929), Kotlán (1933), and Hoare (1933). See review in Becker (1934).

E. tyzzeri Yakimoff & Rastegaieff, 1931

Hosts: *Gallus d. domesticus*. Presumably intestine.

Oocyst description: Ovoid, 24–35 x 18–24 μ , mean 32 x 24 μ . Micropyle present. Residual body: in oocyst, none, but a light-refractile body present; in sporocyst, none recorded. Sporulation time: 36–48 hours.

Tissue Stages: Not recorded.

Prevalence and Geographical Distribution: Found in unreported number of chickens from two places in Russia.

Pathogenicity and Host specificity. Not recorded.

E. urnula Hoare, 1933

Hosts: *Phalacrocorax carbo lugubris*. Epithelium and sub-epithelial tissues of small intestine.

Oocyst description: Ovoid or pyriform, 18–23 x 13–14 μ . Micropyle (pseudomicropyle?) present. Residual body: in oocyst, none, but polar globules may be present; in sporocyst, present. Sporocysts: elliptical, with “plug” at one pole. Sporulation time: 48–72 hours.

Tissue Stages: Briefly described and figured.

Prevalence and Geographical Distribution: Found in 3 out of 6 young hosts examined near Lake Victoria, Uganda.

Pathogenicity and Host specificity: Not recorded.

SUMMARY

A classified list of avian hosts and their respective species of the coccidian genus *Eimeria* is presented. The list of hosts includes 37 species of birds, which represent 31 genera, 13 families, and 8 orders. For each of the 34 species of *Eimeria* which have been reported from these hosts brief notes are given on the following: oocyst characteristics, tissue stages, prevalence and geographical distribution, pathogenicity, host specificity, and pertinent references. Of the 37 species of birds 4 are reported here for the first time as hosts of *Eimeria* sp.; these are: *Columba leucocephala*, *Zenaidura macroura carolinensis*, *Melopelia a. asiatica*, and *Oreopeleia chrysis*.

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A TECHNIQUE FOR BANDING WOODCOCK

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As one of the projects of the Maine Cooperative Wildlife Station,¹ studies are being carried on relative to the management of the American Woodcock, *Philohela minor*. Pettingill's extensive life history of this species (1936—Memoirs Boston Society of Natural History, 9:2) has rendered unnecessary much of the preliminary research that must precede management practices. Nevertheless, a certain amount of such data still remains to be gathered, including information on movements and migratory habits, longevity, tendencies to return to the original breeding area, and plumage changes. Solutions to these problems will be facilitated through banding operations; consequently efforts were made during the spring of 1937 to mark as many individual birds as possible.

Although we are securing data from the entire State, most of our field research is being conducted on or in the vicinity of the Moosehorn Migratory Bird Refuge of the Biological Survey, located near Calais in Washington County, the northeasternmost portion of the State. This is an admirable location for such work since Maine is the most important Woodcock producing state in the country and the birds are especially common in Washington County. Moreover, the Moosehorn Refuge lies in the path of the principal flight lane to and from Nova Scotia and New Brunswick.

Dr. Gustav Swanson of the University of Minnesota, who was formerly in charge of the Woodcock studies here, tried several different banding methods in attempting to arrive at a technique suitable for conditions in Maine and it may be of interest to mention them at this time.

One method was that practiced by L. J. Merovka, Federal game

¹ Established through a cooperative agreement between the University of Maine, the State Department of Inland Fisheries and Game, the American Wildlife Institute, and the United States Biological Survey.