

## ISOSPORA HERPESTEI N. SP. (PROTOZOA, APICOMPLEXA) AND OTHER NEW SPECIES OF ISOSPORA FROM MONGOOSES

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The reports of *Isospora* from various species of mongoose are reviewed and revised. *I. herpestei* n. sp. is described from the small Indian mongoose *Herpestes auropunctatus* imported from India to the Virgin Islands and thence to Georgia. It has subpherical to ellipsoidal oocysts 18-24 x 13-18  $\mu$ m with a mean of 19.9 x 15.4  $\mu$ m, with a delicate, single-layered wall; they contain ellipsoidal sporocysts 11-15 x 8-11  $\mu$ m with a mean of 12.9 x 9.3  $\mu$ m. Other *Isospora* species seen by other workers in mongooses are *I. dasguptai* n. sp. from *H. auropunctatus* and *H. edwardsi* in India, *I. ichneumonis* n. sp. from *H. ichneumon* in Tunisia, *I. mungoi* n. sp. and *I. pellérdyi* Dubey & Pande, 1963 from *H. edwardsi* in India, *I. garnhami* Bray, 1954 from *Helogale undulata rufula* in Kenya and *Crossarchus obscurus* in Liberia, and *I. boarei* Bray, 1954 from *H. undulata rufula* in Kenya.

Little is known about the coccidia of mongooses, and the names given to the various species are largely incorrect. Earlier workers thought that the dog, cat and other carnivores all had the same species of *Isospora*. Some of the earlier descriptions were incomplete, and some workers were not aware that there are quite a few species and several genera of mongooses. An outbreak of diarrhea in a colony of the small Indian mongoose *Herpestes auropunctatus* imported from India to the Virgin Islands and thence to Georgia gave us the opportunity of reviewing the literature on mongoose coccidia and revising the nomenclature.

### MATERIALS AND METHODS

Fecal samples from small Indian mongooses *Herpestes auropunctatus* were processed by one of us (GRH) after having been sent in by Dr. Samuel Adams from the Lawrenceville, Ga. facility of the Center for Disease Control. Part of the fecal material was placed immediately in 10% formalin solution and part was incubated for 5 days at room temperature in 2% potassium dichromate solution to facilitate sporulation and then placed in 10% formalin solution. The oocysts sporulated in both solutions. They were then mailed to Urbana for further examination.

### RESULTS

*Isospora dasguptai* n. sp.  
Syns., *Isospora rivolta* (Grassi, 1879) of Knowles and Das Gupta (1931)  
small *Isospora garnhami* Bray, 1954 of Dubey and Pande (1963)  
[non] *Isospora rivolta* (Grassi, 1879) Wenyon, 1923  
[non] *Isospora garnhami* Bray, 1954

This was the first *Isospora* to be reported from mongooses. It was seen by Knowles and Das Gupta (1) in the small Indian mongoose *Herpestes auropunctatus* in India, and was later reported from the Indian grey mongoose *H. edwardsi* (syn., *H. mungo*) in India by Dubey and Pande (2). The former called it *I. rivolta*, while the latter called it the small form of *I. garnhami*. Its location in the host is unknown; its oocysts were found in the feces. Nothing is known of its pathogenicity. The following description of the oocysts is based on the drawing and text of Knowles and Das Gupta (1): Oocysts ellipsoidal or ovoid, without micropyle, with a mean of 20.6 x 17.2  $\mu$ m, without a residuum or polar granule. Sporocysts apparently ellipsoidal; we could not determine whether a Srieda body or sporocyst residuum was present. Sporozoites elongate, with one end pointed, apparently with a clear globule at the broad end. The oocysts seen by Dubey and Pande (2) were spherical to ellipsoidal, 19-22 x 16-19  $\mu$ m, with a 2-layered wall and without a micropyle,

polar granule or oocyst residuum. The sporocysts were 14-17 x 8-11  $\mu$  m, without a Stieda body but with a residuum.

Knowles and Das Gupta (1) said that the oocysts were unsporulated when passed. Dubey and Pande (2) reported that the sporulation time was one day.

Knowles and Das Gupta (1) said that this parasite's dimensions "fit in" with those of *I. rivolta* of cats and dogs. However, it does not appear to resemble the descriptions given by Levine and Ivens (3) from the dog or Shah (4, 5) from the cat. It differs from all other *Isoospora* species from mongooses in size, and it may also differ in other characters, but this cannot be determined from Knowles and Das Gupta's paper. This is also the small form of "*Isoospora garnhami*" reported by Dubey and Pande (2) from *H. edwardsi*. It is smaller than *I. garnhami* Bray, 1954 from the African mongoose *Helogale undulata rufula* and differs from it not only in host genus but also in oocyst and sporocyst shape and in having a thick instead of a thin outer oocyst wall. According to Dubey and Pande (2), Singh (6) thought that Knowles and Das Gupta's form was probably *I. garnhami*. We think that the two forms described above are probably the same and are different from *I. garnhami*. We are therefore naming them *Isoospora dasguptai* n. sp.

*Isoospora ichnemonis* n. sp.

Syn., *Isoospora rivolta* (Grassi, 1879) of

Balozet (1933)

[non] *Isoospora rivolta* (Grassi, 1879)

Wenyon, 1926

This species was described from the feces of two Egyptian mongooses *Herpestes ichnemon* in Tunisia by Balozet in 1933 (7), and the following description is taken from his report: Oocysts subspherical, 19-26 x 16-20  $\mu$  m with a mean of 22 x 19  $\mu$  m. Oocyst double-contoured, colorless, transparent, easily deformed, with a poorly visible micropyle. Sporocysts rounded, slightly ovoid, with a wall thinner than that of the oocyst. Sporocyst residuum present. Sporozoites lie parallel like four bananas placed side by side. Sporulation time at 20 C on filter paper impregnated with potassium dichromate solution, four days.

Balozet (7) said that he gave fecal material by stomach tube to a puppy some days

old; he gave a second dose to the puppy 9 days later. Four days after the second dose he found two coccidia in the puppy's feces, and their number increased progressively for 9 days. They were extremely numerous from 11 to 15 days after the second dose. During this time the puppy had dysentery. In the course of the next three days the oocysts became rare, and no intestinal lesions were seen when the puppy was killed 21 days after the second dose. It is impossible to say whether Balozet actually succeeded in transmitting this coccidium to the puppy or whether the puppy had its own infection with *I. rivolta*. The true *I. rivolta* oocysts do not have a micropyle, and their wall is thinner (not thicker) than the sporocyst wall. We are uncertain what Balozet meant by "double-contoured"; if it means that the oocyst wall is composed of two layers, this is another difference between *I. rivolta* and Balozet's form. At any rate, the difference in micropyle is enough to justify giving his form a new name.

#### *Isoospora garnhami* Bray, 1954

Bray (8) described the oocysts from the feces of the dwarf mongoose *Helogale undulata rufula* from Kenya, Africa. The oocysts are ellipsoidal, with a 2-layered wall composed of a thin, fragile outer layer and a thick, tough elastic inner one. They are 26-32 x 22-28  $\mu$  m with a mean of 28.6 x 24.5  $\mu$  m and have no micropyle, polar granule or residuum. Sporocysts are spherical to ellipsoidal, 12-15 x 11-12  $\mu$  m with a mean of 13.8 x 11.5  $\mu$  m, and have a residuum but no Stieda body. The sporozoites are sausage-shaped, slightly tapered at one end, with a central nucleus and a clear globule at the broader end; they average 13.7 x 2.3  $\mu$  m. The sporulation time at room temperature (22 C) in 0.25% chromic acid or 4% sodium dichromate solution was 3 days.

Bray (8) found only 3 meronts. They were in a single patch of tissue from the ileum, and contained 12-24 merozoites. He found all stages of gametogony in the lower part of the small intestine and in the large intestine. The gamonts were in the villar epithelial cells above the host cell nucleus. The macrogametes bulged into the subepithelial tissue when mature, and averaged 24 x 22  $\mu$  m in fixed tissue. The microgametocytes averaged 23 x 22  $\mu$  m in fixed tissue and contained several hundred micro-

gametes. He found no evidence of pathogenicity.

Bray (8) was unable to infect a ferret *Mustela putorius furo* or a domestic kitten with this species.

Later, Bray (9) found what he considered to be the same species in a mongoose *Crossarchus obscurus* in Liberia, Africa. Its oocysts were 22-30 x 18-22  $\mu\text{m}$  with a mean of 26.6 x 19.7  $\mu\text{m}$ , and had a 2-layered wall. He said that these oocysts were indistinguishable in general structure from those of *I. garnbami* except for one feature: when the oocysts were released into the lumen of the intestine their outer wall was ellipsoidal and their inner wall flattened at both ends, but by the time they were voided both walls were ellipsoidal. He gave no other structural data.

*Isospora boarei* Bray, 1954

Bray (8) described the oocysts of this species from the feces of the dwarf mongoose *Helogale undulata rufula* from Kenya. They are ellipsoidal, 16-19 x 13-17  $\mu\text{m}$  with a mean of 17.3 x 14.8  $\mu\text{m}$ , with a 2-layered wall composed of a colorless outer layer and a dark inner one; Bray said that the oocyst wall of this species is more fragile than that of *I. garnbami*. The oocysts have no micropyle, polar granule or residuum. The sporocysts are almost spherical, 9-10 x 8.9  $\mu\text{m}$  with a mean of 9.1 x 8.6  $\mu\text{m}$ , and have a large residuum but no Stieda body. The sporozoites are sausage-shaped, slightly tapering at one end, 7 x 2  $\mu\text{m}$ , illustrated without a clear globule. Sporulation time at room temperature (22 C) in 0.25% chromic acid or 4% sodium dichromate solution was 4 days.

Bray (8) found no meronts, but did find mature macrogametes measuring 16 x 14  $\mu\text{m}$  and mature microgametocytes measuring 17 x 16  $\mu\text{m}$ , both in fixed tissue. He counted 117 microgametes in one microgametocyte. This species is presumably non-pathogenic. He was unable to infect a ferret or a kitten with it (8).

*Isospora mungoi* n. sp.  
Syn., Large *Isospora garnbami* Bray, 1954  
of Dubey and Pande (1963)  
[non] *Isospora garnbami* Bray, 1954

This species was described from the feces of *Herpestes edwardsi* (Syn. *H. mungo*) in

India by Dubey and Pande (2) under the name *Isospora garnbami*. According to them the oocysts are ellipsoidal with rounded ends, 27-34 x 23-27  $\mu\text{m}$  with a mean of 34 x 27  $\mu\text{m}$  [sic], with a wall 1-2  $\mu\text{m}$  thick, composed of 2 layers of which the outer is the thicker and light yellowish green to pale yellow, and the inner one is darker. The oocysts have no micropyle, polar granule or residuum. The sporocysts are ellipsoidal, and said to be 19-21 x 12-14  $\mu\text{m}$  with a mean of 21 x 14  $\mu\text{m}$  [sic], with a residuum but no Stieda body. Sporozoites are sausage-shaped, one end narrower than the other, with a clear globule at the broader end. The oocyst shape after sporulation varies with the position of the sporocysts. They reported that the sporulation time was one day.

This is Dubey and Pande's (2) large form of "*Isospora garnbami*". However, it differs from *I. garnbami* Bray, 1954 not only in host genus but also in having a thick instead of a thin oocyst wall and in having larger sporocysts. We do not believe that it is the same species and are therefore giving it a new name.

*Isospora pellerdyi* Dubey and Pande, 1964  
Syn., *Isospora knowlesi* Dubey and Pande, 1963

[non] *Isospora knowlesi* Ray and Das Gupta, 1937

This species was also described from the feces of *Herpestes edwardsi* (syn., *H. mungo*) in India by Dubey and Pande (2). They first gave it the name *I. knowlesi*, but changed it to *I. pellerdyi* (10) when they found that their first name had already been used. The oocysts are ovoid, 27-30 x 20-25  $\mu\text{m}$  with a mean of 28 x 23  $\mu\text{m}$ , with a 2-layered wall of which the outer layer is the thicker and yellowish to orange while the inner layer is darker. Oocyst micropyle, polar granule and residuum are absent. The sporocysts are ellipsoidal, 17-19 x 12-14  $\mu\text{m}$  with a mean of 15 x 11 [sic]  $\mu\text{m}$ , without a Stieda body but with a residuum. The sporozoites are elongated, with one end pointed, 13-15 x 2-3  $\mu\text{m}$ . The sporulation time is 1-2 days (2).

*Isospora berpestei* n. sp.

This is the species that we found in the feces of the small Indian mongoose *Herpestes auropunctatus* from Georgia. The oocysts (Fig. 1) are subspherical to ellip-

oid with a thin (less than  $0.4 \mu\text{m}$ ), smooth, colorless, delicate, easily collapsed wall composed of a single layer (confirmed by breaking the oocyst). Fifty oocysts were  $18\text{--}24 \times 13\text{--}18 \mu\text{m}$  with a mean of  $19.9 \times 15.4 \mu\text{m}$  and a mean length-width ratio of 1.29. Micropyle, polar granule and oocyst residuum are absent. The sporocysts are ellipsoidal, with a slightly yellowish wall about  $0.5 \mu\text{m}$  thick (i.e., slightly thicker than the oocyst wall), without a Stieda body but with some residual material in the form of a number of relatively large, more or less separated granules. Fifty sporocysts were  $11\text{--}15 \times 8\text{--}11 \mu\text{m}$  with a mean of  $12.9 \times 9.3 \mu\text{m}$  and a mean length-width ratio of 1.39. The sporozoites are sausage-shaped, with both ends of equal diameter, without clear globules, and lie at random in the sporocysts. The general impression one gets in looking at the oocysts is one of translucency and delicacy.

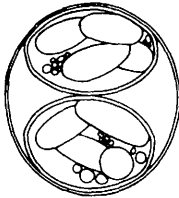


FIGURE 1. Oocyst of *Isospora herpestei* n. sp. X 1,500.

It is believed that this coccidium is pathogenic, since some of the mongooses passing it had diarrhea.

These oocysts differ in structure from those of all other species of *Isospora* reported from mongooses. They differ from all the species but *I. ichneumonis* and *I. dasguptai* in shape and size, from all but possibly *I. ichneumonis* in having a 1-layered rather than a 2-layered wall, from *I. ichneumonis* in not having a micropyle, from all other species in having a sporocyst wall thicker than the oocyst wall and in having sausage-shaped sporozoites which

are not narrower at one end than the other, from *I. ichneumonis* and most of the others in the arrangement of the sporozoites, from all the other species except possibly *I. ichneumonis* (for which this feature is unknown), *I. boarei* and *I. pellerdyi* in lacking a clear globule in the sporozoites, and from these latter three in the shape of the sporocysts. This species differs, too, from *I. garnhami* and *I. boarei* in host genus. We therefore consider it a new species and name it *Isospora herpestei* n. sp.

## DISCUSSION

In addition to the 7 species of *Isospora* described above, a single species of *Eimeria*, *E. newalai* Dubey and Pande, 1963 has been reported from *H. edwardsi*.

Markus (11) found coccidia in a yellow mongoose (red or bush-tailed meerkat) *Cynictis penicillata* in the Transvaal, but did not describe them.

It is hoped that the present review of mongoose coccidia will stimulate others to make a more thorough study of them.

## ACKNOWLEDGMENT

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