

Eimeria pavaegyptica sp. nov. (Apicomplexa: Eimeriidae) in faeces of Indian peacocks, *Pavo cristatus* Linnaeus, 1758 (Galliformes: Phasianidae) from Egypt

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Coprological examination of 15 Indian peacocks, Pavo cristatus, revealed the presence of a coccidium species of the genus Eimeria, which apparently represents a previously undescribed species. Sporulation is exogenous and fully developed oocysts of Eimeria pavaegyptica sp. nov. are ellipsoidal, with a dimension of 15 (13-16) × 12 (10-12.9) μm and with a shape index of 1.25 (1-1.3). The sporulated oocysts have no micropyle but enclose one large rectangular-shaped polar granule and an oocyst residuum. The oocysts have a distinct two-layered wall, which is ~1.7 μm thick. The outer layer has a smooth texture; it fills ~3/4 of the total thickness and appears bicolored. The sporocysts are boat-shaped, of about 10 (9-11) × 4 (4-4.7) μm; their average shape-index is 2.5 μm with a small pointed Stieda body and a smooth, thin single-layered wall. No substieda body is detected. The sporocysts contain numerous, nearly uniform granular residua. The sporozoites are banana-shaped, 6 × 3 μm and each has two different-sized refractile bodies.

Key words: coccidia - apicomplexa - *Eimeria* - peacock - *Pavo cristatus* - Egypt

Although parasitic infections are among the most common sanitary problems affecting wild birds and can become either a subclinical condition or even a cause of death (Freitas et al. 2002), they have received attention only when they have threatened agriculture or human health (Daszak et al. 2000).

Indian peacocks, *Pavo cristatus* Linnaeus, 1758, are uniquely large colorful birds, particularly the males, and are among the most colorful and striking birds of the entire poultry world. Moreover, most people are familiar with them from visits to zoos and parks.

Unfortunately, like other captive birds, they are suffering from potential stress and frequent cases of parasitic infections, which are among the most prevalent diseases that afflict them. Among parasitic diseases, the ones caused by protozoa, especially coccidiosis, are common and cause the most severe health and economic problems worldwide. These infections result in poor growth, diarrhea and high mortality, particularly in young birds. This disease is caused by a species of protozoa in the genus *Eimeria* Schneider, 1875, which parasitize the intestinal mucosa.

Although South Asia, particularly India, is the area with the highest diversity of Indian peacock species, only five species of *Eimeria* have been described so far from their faeces in this region (Banik & Ray 1961, 1964, Mandal 1965, Bhatia & Pande 1966, Ray 1966). Amoudi (1988) described two new species of *Eimeria* from the faeces of

local Indian peacocks reared in the experimental agriculture station of King Saud University, Saudi Arabia. Similarly, Alyousif and Al-Shawa (1998) further examined several *Eimeria* species such as *Eimeria mayurai* (Bhatia & Pande 1966), *Eimeria pavonina* (Banik & Ray 1961) and *Eimeria pavonis* (Mandal 1965) (Indian species) and they also gave a description of a new Eimerian species from the faeces of the local green peacocks *Pavo muticus* of the Al-Kharj area in central Saudi Arabia.

During a survey of parasites in zoo birds, carried out in the zoological park of El-Gharbia governorate, Egypt, I discovered a species of *Eimeria* in the faeces of Indian peacocks, which is different from all known species and, therefore, is herein described as a new species.

MATERIALS AND METHODS

Freshly egested faecal samples of 15 identified, captive *P. cristatus* (Galliformes: Phasianidae) individuals were collected from the ground of their cages at the El-Gharbia city zoo and submitted to the parasitology laboratory of the Faculty of Veterinary Medicine, South Valley University, for a parasitological examination. The samples were preserved in a cold icebox and stored at 4°C until the day of the examination. A direct smear method and a flotation technique were used to detect oocysts. The samples that contained abundant unsporulated oocysts were placed in Petri dishes, forming a thin layer of liquid (~5 mm) of 2.5% (w/v) aqueous potassium dichromate solution (K₂Cr₂O₇) and incubated at room temperature (RT) (23°C) to promote sporulation. The oocysts were repeatedly examined over a period of one week and the sporulation time was recorded. Forty sporulated oocysts and their inner structures were examined after concentration by flotation using a saturated sodium chloride solution for 5 min at 1,500 RPM (Brown & Neva 1983). Morphological observations were performed ac-

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cording to Duszynski and Wilber (1997) and Wilber et al. (1998). These morphological observations included several oocyst characters such as length (L), width (W) and their ranges and ratio (L/W), micropyle (M), micropylar, oocyst residuum (OR) and polar granule (PG). In addition, the sporocyst characters observed included L, W and their L/W, Stieda body (SB), substieda body (SSB), sporocyst residuum (SR), sporozoites (SP), refractile bodies (RBs) and nucleus (N) in SP. The measurements were performed by using a binocular microscope Leica equipped with a calibrated ocular micrometer. All measurements in the text are given in micrometers (μm) and are means followed by the ranges in parentheses. Photomicrographs and line-drawings were made with a binocular microscope Leica Leitz BioMed and using a digital camera Wild MPS 32 and Wild M3X, respectively. The species identification was based on the complex morphology of the sporulated eimerian oocyst (Pellerdy 1965, Soulsby 1982, Levine 1985).

RESULTS

Out of the 15 adult caged Indian peacocks examined, four of them (26.66%) had coccidian oocysts. A morphological comparison of the coccidian species revealed differences between them and one of them is a new species in the genus *Eimeria* described below.

Eimeria pavaegyptica sp. nov. (Figs 1, 2)

Description of sporulated oocyst - The oocyst shape is ellipsoidal, the oocyst dimensions are $L \times W$ (40) 15 (13-16) \times 12 (10-12.9); L/W ratio, 1.25 (1-1.3); number of walls: two; wall thickness 1.7 (1.1-1.8); wall characteristics: outer wall smooth, $\sim\frac{3}{4}$ of total thickness and appears bicolored, the outermost portion is red-brown, the innermost portion yellowish to green. The inner wall is dark brown, $\sim\frac{1}{4}$ of total thickness and separated from outer wall by a dark brown line. The M is absent. One large, prominent, refractile PG is present. It lies underneath the narrow end of the oocyst and is usually rectangular in shape with a dimension of $\sim 0.3 \times 0.6$. An OR is present with an average diameter of ~ 2 and it consists of one to three small homogenous globules scattered throughout the oocyst; one of the globules is near the middle part of the oocyst and the others are found near the bottom of the oocyst and above the sporocyst.

Distinctive features of the oocyst - It is a considerably small oocyst, the M is absent, with prominent PG, distinct OR and thick bicolored outer wall, with red-brown outer portion and yellowish to green inner portion.

Description of sporocyst and SP - The genus *Eimeria* is, among others, characterized by four sporocysts within the oocyst; each of them is boat-shaped, $L \times W$ (40) 10 (9-11) \times 4 (4-4.7); L/W ratio, 2.5 (1.9-2.8). The SB is present and is small and pointed, of ~ 0.8 high and 1.2 wide, but the SSB is not detected. The SR is present and consists of numerous, nearly uniform granules covering the SP. The SP are banana-shaped, broad at one end (posterior) and slightly tapering at the other, $L \times W$



Fig. 1: photomicrographs of living, sporulated oocyst of *Eimeria pavaegyptica* sp. nov. recovered from the faeces of peacocks in Egypt. Oocyst showing polar granule (black arrow), residuum (red arrow), large refractile body (yellow arrow), small refractile body (brown arrow) and Stieda body (blue arrow). Bar = 10 μm .

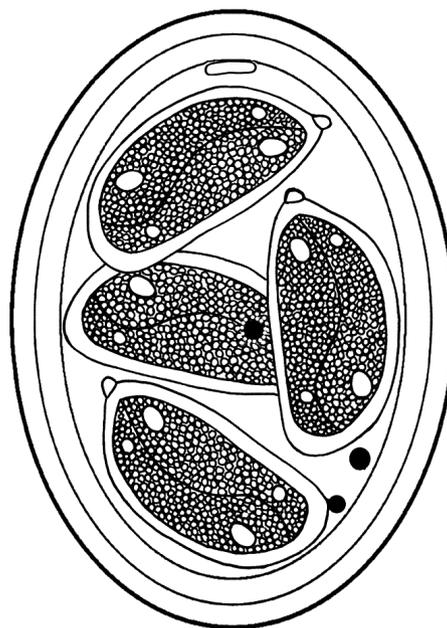


Fig. 2: composite line drawing of a sporulated oocyst of *Eimeria pavaegyptica* sp. nov. Bar = 10 μm .

6×3 , lying lengthwise in a head to tail pattern. Each SP has a large, clear subspheroid RB in the posterior end and a smaller, rounded anterior one in the opposite end. The N of SP is not discernible. A thin membrane encloses the contents of each sporocyst. Sporocysts fill the oocysts almost entirely.

Characteristic features of the sporocyst - Boat-shaped with a rounded end and in the opposite end, a pointed SB; it has large granular SR and two RBs; one of them is large and subspheroid, while the other one is smaller and round.

According to Duszynski and Wilber (1997), a new coccidian species should be compared in details with coccidian species that are the most feature-similar to it and that belong to the same host family. Therefore, the morphological characteristics of *E. pavoegyptica* sporulated oocysts were compared to those of other *Eimeria* spp previously described in Galliformes and family Phasianidae. Only *Eimeria patnaiki* found parasitizing the same host species from India (Ray 1966), closely resembles the aforementioned, newly discovered species, which shows the presence of OR and the absence of M. However, we can differentiate these two species based on several significant morphological characteristics. With respect to *E. pavoegyptica*, its oocysts are ellipsoidal in shape, significantly smaller in size (15×12) and enclose a single, large, rectangular PG, whereas those of *E. patnaiki* are spherical in shape, larger in size ($17-19 \times 13-17$) and have a single, spherical PG. In addition, the shape of sporocysts also differentiates the newly discovered species because those of *E. patnaiki* are lemon-shaped, while the ones of *E. pavoegyptica* are boat-shaped. Similarly, the presence of a small pointed SB with two different-sized RB in each SP and a uniformly granular SR covering the entire SP can easily differentiate the new parasite from *E. patnaiki*, which possess a vestigial SB with several small scattered SR granules within the sporocysts.

Eimeria indiana from *Gallus gallus domesticus* Linnaeus, 1758 (Bandyopadhyay et al. 2006) also closely resembles this new species in terms of the shape of the oocysts and in the absence of M, but it mainly differs from this newly described species in having a single ovoid PG and by the absence of OR. These aforementioned morphological distinctions and the different host genus make *E. pavoegyptica* a distinctly separate form.

Moreover, *E. pavoegyptica* can be distinguished from *E. mayurai* because it has much smaller oocysts, smaller sporocysts, presence of an OR and absence of an M. Similarly, it has a single large, rectangular PG rather than a small M and spherical PG. In addition, it can be differentiated by the character of the oocyst wall. The oocyst wall of *E. pavoegyptica* appears bicolored, the outermost portion is red-brown and the innermost portion is yellowish-green, whereas the outer layer of the oocyst wall of *E. mayurai* is light blue.

The ovoidal-shaped oocyst form of *E. pavonina* and *E. pavonis* distinguishes these species from the ellipsoidal-shaped oocyst form of *E. pavoegyptica*. Furthermore, the absence of M also differentiates *E. pavoegyptica* from *E. pavonina* and *E. pavonis*, which all have an M. Moreover, the measurements of *E. pavoegyptica* oocysts and sporocysts do not overlap with the size ranges reported for both of the abovementioned species.

The primary differences between *E. pavoegyptica* and *Eimeria mandali* revolve around the morphological

features of the oocysts (ellipsoidal for *E. pavoegyptica* vs. spherical for *E. mandali*), in the presence of an OR and in the shape of the PG.

E. pavoegyptica can be easily distinguished from *Eimeria arabica* and *Eimeria riyadhae* because it has an OR and due to its smaller size (15×12). Furthermore, the oocyst wall characters differentiate the abovementioned two species from the new species. The outer layer of the oocyst wall of *E. pavoegyptica* appears bicolored, the outermost portion is red-brown, the innermost portion yellowish-green and thick; whereas the outer layer of the oocyst wall of *E. arabica* and *E. riyadhae* is thin and yellowish and pale yellow, respectively. Furthermore, the new species is distinguished from *E. arabica* and *E. riyadhae* by the shape of the sporocysts. The sporocysts of the new species are boat-shaped with two different-sized RBs in each SP, but those of *E. arabica* and *E. riyadhae* are elongate-ovoid with two same-sized RBs in each SP and ovoid with large globules at each end of the SP, respectively. Furthermore, *Eimeria mutica* is also distinct by the presence of M, bi-lobed PG and the absence of OR, while *Eimeria kharjensis* is characterized by the presence of M with a dome-shaped cap and a single spherical PG (Table). In spite of the different geographic origin, I included them in the differential diagnosis to avoid possible conspecificity potentially caused by the recent extensive international trade.

On the basis of the abovementioned differences, in addition to the geographic isolation of the hosts, I consider this newly discovered species, described here for the first time, to be a new coccidian and I propose to name it *E. pavoegyptica*.

Type host - Indian peacock (*P. cristatus*).

Site of infection - Unknown, oocysts collected directly from host faeces.

Type locality - El-Gharbia Governorate, Egypt.

Type data and depository - El-Gharbia city zoo, Egypt. Phototypes of oocysts are deposited in the collection of the Museum of the Department of Parasitology in the Faculty of Veterinary Medicine, South Valley University, Egypt (Pavo 1).

Host-parasite data - Prevalence: four out of 15 (26.66%).

Time of sporulation - Seventy two hours at RT (23°C).

Etymology - The specific name was derived from the generic name of the host and the epithet "aegyptica" was given after the name of the country, Egypt, where the species was discovered.

DISCUSSION

Eimerian parasites of the genus *Pavo* are limited to the reports of *E. pavonina* (Banik & Ray 1961); *E. mandali* (Banik & Ray 1964); *E. pavonis* (Mandal 1965); *E. mayurai* (Bhatia & Pande 1966); *E. patnaiki* (Ray 1966); *E. riyadhae* and *E. arabica* (Amoudi 1988) and all these species of *Eimeria* were recorded from Indian peacocks *P. cristatus*. In addition, *E. mutica* and *E.*

TABLE
Comparative studies of *Eimeria pavaegyptica* sp. nov. along with its related species

Eimeria species	Host	Oocyst				Sporocyst				Locality	Authors
		Shape	Size (µm)	M	MC	OR	Shape	Size (µm)	Locality		
<i>Eimeria mandali</i>	<i>Pavo cristatus</i>	Spherical	14-20 × 14-18	+	-	-	No data	6-12 × 4-8	India	Banik and Ray (1964)	
<i>Eimeria mayurai</i>	<i>P. cristatus</i>	Ellipsoidal	23-27 × 13-16	+	-	-	Ovoid	10-13 × 5-7	India	Bhatia and Pande (1966)	
<i>Eimeria pavonina</i>	<i>P. cristatus</i>	Ovoid	20-28 × 16-20	+	-	+	Boat shaped	6-16 × 4-8	India	Banik and Ray (1961)	
<i>Eimeria pavonis</i>	<i>P. cristatus</i>	Ovoid	20-25 × 18	+	-	-	Ellipsoidal	12.1-15 × 6.6	India	Mandal (1965)	
<i>Eimeria patnaiki</i>	<i>P. cristatus</i>	Spherical	17-19 × 13-17	-	-	+	Lemon shaped	6.4-8.5 × 3.2-4.8	India	Ray (1966)	
<i>Eimeria riyadhae</i>	<i>P. cristatus</i>	Ellipsoidal	27-30.5 × 20.5-25	-	-	-	Ovoid	11-14.5 × 6.5-8	Saudi Arabia	Amoudi (1988)	
<i>Eimeria arabica</i>	<i>P. cristatus</i>	Spherical	17.5-21.5 × 17.5-21.5	-	-	-	Ovoid	9.5-12 × 4-6.5	Saudi Arabia	Amoudi (1988)	
<i>Eimeria mutica</i>	<i>Pavo muticus</i>	Subspherical	22.4-25 × 16.2-18.7	+	-	-	Elongate-ovoid	12-14.2 × 5.4-6.7	Saudi Arabia	Alyousif and Al-Shawa (1998)	
<i>Eimeria kharjensis</i>	<i>P. muticus</i>	Broadly ellipsoidal	19-21.5 × 16.2-18.7	+	+	-	Elongate-ovoid	11.9-13.5 × 5.4-6.8	Saudi Arabia	Alyousif and Al-Shawa (1998)	
<i>Eimeria pavaegyptica</i>	<i>P. cristatus</i>	Ellipsoidal	13-16 × 10-12.9	-	-	+	Boat-shaped	9-11 × 4-4.7	Egypt	This paper	
<i>Eimeria indiana</i>	<i>Gallus gallus domesticus</i>	Egg shaped/ellipsoidal	20.8-25.2 × 16.2-21.6	-	-	-	Elongated to ovoid	6.4-10.8 × 4.6-7.2	India	Bandyopadhyay et al. (2006)	

M: micropyle; MC: micropylar cap; OR: residuum.

kharjensis have been reported from green peacock *P. muticus* in Saudi Arabia (Alyousif & Al-Shawa 1998).

Interestingly, Eimerian parasites of birds are generally considered to be highly host specific not only under natural conditions (Hiepe & Jungmann 1983) but also in farmed birds (Rommel 2000). Therefore, host systematic and geographic origin are commonly used criteria in their taxonomy.

The genus *Eimeria* represents the most specious genus within both protozoan and metazoan organisms. Until recently, more than 1,700 named *Eimeria* species have been described based on qualitative and quantitative traits of their sporulated oocyst and their host specificity (Duszynski & Upton 2001).

Until recently, little data was available on eimeriid parasites of galliformes that infect game birds, such as peafowl, particularly regarding the African biodiversity. This dearth of information involves not only the classification of the species concerned but also the consequences of infection by the usually different types of pathogens on the health status of the hosts both at individual and population levels. Likewise, almost nothing is known on the seasonality and biology of coccidian infections in galliform captive birds. However, knowing how severe disease and high mortality can be caused in galliform birds in captivity (Rommel 2000). More detailed parasitological studies are needed and future research on game-bird population dynamics should not neglect protozoan infections, particularly the ones caused by coccidian parasites, which are of great importance for species conservation.

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