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The coccidia of galliformes (Family: Phasianidae)

Bhimrao N Jadhav
Department of Zoology, Vinayakrao Patil Mahavidyalaya, Vaijapur, Chhatrapati Sambhajinagar, Maharashtra, India

Abstract
Family phasianidae consist chickens, turkey, quails, pheasants, partridges, peafowl, grouse and other relative birds found in variety of habitat. Majority species of gallinaceous birds are economically important for human. Some of the Gallus gallus species like chicken or red jungle fowl are reared for meat and eggs. Grouse, quail, pheasant and turkey are important game birds. Feathers of some species are collected for ornamentation and clothing purpose. Some species are becoming important for ecotourism.

Keywords: Coccidia, galliformes, game birds, *Eimeria sp*.

Introduction

Infraclass galloanserae of class aves consist a diverse order Galliformes consist of heavy bodied, ground feeding birds with short rounded wings for short distance flight. Worldwide 290 species of galliformes are distributed in to five families; phasianidae, odontophoridae, numididae, cracidae, and megapodiidae [8]. Family phasianidae consist chickens, Turkey, quails, pheasants, partridges, peafowl, grouse and other relative birds found in variety of habitat and becoming important for ecotourism [1, 2]. Macel Teixeira (2015) work on some gallinaceous meat birds in Brazil, it was found that partridges do not have any infection, grey quails showed mild infection of Emirian species [3]. R W Gerhold *et al*. (2016) observed field isolates of coccidia from 20 natural outbreaks in the chukar Partridge were received from game birds farms in 10 US states. Of 20 samples eighteen were Eimeria kofoidi, two were E legionensis and one was a mixture of two [4]. El-Shahawy I S (2010) recorded Eimeria pavoaegyptica species nov.in the faeces of Indian peacock Pavocristatus Linnaeus from Egypt during coprological examination of 15 Indian peacock [5]. Alyousif MS *et al*. 2010 recorded on new species Eimeria khobahensis from guinea fowl at and around Khobha area of southern border of Saudi Arebia [6]. MA Elmorsy 2020 observes 50 droppings of 10 Japanese quail farm from Bhubaneswar Odisha. Three Eimeria species were isolated E.bateri, E. uzura and E. tsunodai. [7].

Host Specificity

Eimeria is an intracellular parasite causes coccidiosis in different hosts. Different species of Eimeria can cause huge destruction in galliformes birds. Number of species has been reported to be pathogenic (Kahn, 2008). It is an adaptability of a species of parasite to certain species or group of hosts. Mechanism is not known exactly but it is very complex and varied. Degree of specificity differs from species to species. Some Eimeria species parasites have adapted themselves to variety of hosts. Some are shows adaptability to limited to small categories of hosts. The host specificity is need not genetic or physiological basis it may govern by ecological and structural basis. Host internal immunity plays an important role in host specificity.

Host range and infection

Though, percentage prevalence of coccidiosis is predominant in birds. But it also reported from Platyhelminthes, arthropod, Mollusca and all five classes of vertebrates. In the avian group anseriforms, charadiforms, columbiformes, galliformes and piciformes shows great threat of coccidia. Basically all the species of Eimeria parasitize the epithelial cell of the intestine, colon, rectum colon, rectum, caecum and its associated glands [18].

Life cycle

Outbreak of coccidiosis is species specific and site specific which may either cecal or small intestinal coccidiosis [20]. Multiplication of coccidian oocyst occurs in the intestinal tract causes tissue damage which interrupts the digestion process, blood loss, loss of skin pigmentation and increased susceptibility to other disease [19]. Genus Eimeria from sub kingdom Protozoa and phylum Apicomplexa causes coccidiosis in domestic and wild species of birds and other animals. Eimeria recorded from galliformes completed their fecal oral life cycle within 5-7 days depending on species. Life cycle starts with ingestion of unsporulated oocyst through oral route. Replication of unsporulated oocyst to sporulated oocyst and formation of sporozoite occurs inside the host's intestine cells. Asexual replication (merogony or schizogony) and sexual reproduction (gametogony) is completed inside the host cell. At the end of cycle number of oocysts are produced which is excreted with faeces and sporulated in environment outside the body. [21, 24, 25, 26].

Coccidia of Turkey

1. *Eimeria adenoeides*, ellipsoidal in shape (19 – 31.3 (25.6) x 12.6- 16.6 (16.6)). This species was reported by Moore and Brown (1951),Edger (1955), Clarkson (1960), Golemansky (1962, 64), Warren and Ball (1963), Hein (1969), Svanbaev (1972), Yvore *et al*. (1978), Madden and Ruff (1979), Bemrick and Hammer (1979),Thomas *et al*. (1981), Ruff *et al*. (1981,88), Lozanov and Koinarski (1984,85), Ozer *et al*. (1990), Ahemad *et al*. (1992), Augustin (1993,95,98) [27].

2. *Eimeria dispersa* Tyzzer (1929) broadly ovoidal 17.2 x 26.4 (22.8) 15.4-22.4 (18.8). this species was reported by Moore and Brown (1952), Doran (1978), Hawkins (1978), Long and Millard (1979), Madden and Ruff (1979), Millard and Lawns (1982), Ruff *et al*.(1981,88), Hopkins *et al*. (1990) [27].
3. *Eimeria gallopavonis* Hawkins (1952) ellipsoidal 22.2-32.7 (27.1) x 15.2-19.4 (17.2). This species of Eimeria reported by Hawkins (1952), Gill (1955), Svanbaev (1972), and Ruff *et al*. (1988) [27].
4. *Eimeria innocua* Moore and Brown (1952) Subspherical 18.6-25.9 (22.4) x 17.3-24.5 (20.9). Moore and Brown (1952), Golemansky (1964), Ruff *et al*. (1988) [27].
5. *Eimeria meleagridis* Tyzzer 1929 broadly ovoidal 19.1-29.1 (23.8) x 14.5-23.1 (17.3). This species was recorded by Tyzzer (1927, 29), Yakimoff and Buewitsch (1933), Hawkins (1952), Edger and Gill (1955), Clarkson (1960), Golemansky (1962,64), Svanbaev (1972), Long etal. (1977), Koinarsky and Kamburov (1984), Ruff *et al*. (1988), Ozer *et al*. (1990).
6. *Eimeria meleagrimitis* Tyzzer (1929) Subspherical 16.5-20.5 (18.1) x 13.2-17.2(15.3). This species was recorded by Tyzzer (1929), Yakimoff and Buewitsch (1933), Hawkins (1952), Gill (1955), Clarkson (1960), Golemansky (1962), Warren *et al*. (1963, 64), Svanbaev (1972), Long (1977), Koinarsky and Kamburov (1984), Ruff *et al*. (1988), Ozer *et al*. (1990) [27].
7. *Eimeria subrotunda* Moore Brown and Carter (1954), Ruff e al. (1988) and Ozer *et al*. (1990) reported nearly spherical species of *E. subrotunda* [27].

Coccidia of Chicken (*Gallus gallus domesticus*)

1. *Eimeria tenella* Railliet and Lucet (1891) ovoidal oocyst 21-25 x 17-19 recorded from chicken. Label 1893,Gerard 1913,Yakimoff and Rastegaieff 1931, Tyzzer 1932, Johnson 1932, Levin and Becker 1933, Johnson 1938, Edger 1955,Scholtyseck *et al*. 1969, Utebaeva 1972, Yvore and Coudert 1972, Vervelde *et al*.1993, BN Jadhav 2009, SV Nikam 2013 recorded *Eimeria tenella* from various places of world [27].
2. *Eimeria necatrix* Johanson 1930 first observe the oocyst and Tyzzer *et al*. 1932 gives measurement of oocysts 13.2-22.7 (16.7) x 11.3-18.7(14.2). It was also recorded byJohnson 1930, Utebaeva 1972, Yakimoff and Rastegaieff 1931, Van Doorninck and Becker 1957, and Al- Attar and Fernando 1987, BN Jadhav 2009, SV Nikam 2013 in chicken [26, 27].
3. *Eimeria acervulina* Tyzzer 1929, observed ovoidal oocyst measured 17.7-20.2 x 13.7-16.3 from chicken. Yakimoff and Rastegaieff 1931, Tyzzer 1932, Patterson 1933, Johnson 1938, Edger 1955, Utebaeva 1972, Long and Millard 1976, Senauld 1980, McDougald *et al*. 1997, BN Jadhav 2009, SV Nikam 2013 recorded *Eimeria acervulina* from chicken [26, 27].
4. *Eimeria brunetti* Levin 1942 recorded ovoid oocyst measured 20.7-30.3 (26.8) x 18.1-24.2 (21.7). Edgar 1955, Fernando *et al*. 1987, BN Jadhav 2009, SV Nikam 2013 recorded it in chicken [26, 27].
5. *Eimeria maxima* Tyzzer 1929 observed ovoidal oocyst measured 21.5-42.5 (29.3) x 16.5-29.8 (22.6). Such oocyst also recorded in Gallus gallus domesticsby Yakimoff and Rastegaieff 1931, Patterson 1933, Johnson 1938, Ray 1945, Edger 1955, Pande Bhatia, Chuhan and Garg 1970, Mehlhorn 1972,Utebaeva 1972, Fernando and Remmler 1973, Long 1974, Long and Millard 1976, Ball *et al* 1981, Edger 1981, Elwasila 1984, BN Jadhav (2009) and SV Nikam *et al*. (2013). [26, 27].
6. *Eimeria mitis* Tyzzer 1929, Yakimoff and Rastegaieff 1931, Fernando and Remmler 1973, observe spherical to sub spherical oocyst 13-18 (15) x 12-16 (13.7). Patterson 1933, Johnson 1938, Misra 1944, Edger 1955, Joynor and Norton 1986, Mielke 1992, McDougald *et al*. 1997, BN Jadhav 2009, SV Nikam 2013 also recorded this species from the Gallus gallus domesticus [26, 27].
7. *Eimeria Praecox* Johnson 1930, Fernando and Remmler 1973observed spherical to sub spherical oocyst measured as 19.8-24.7 (21.3) x 15.7-19.8 (17.1). Tyzzer 1932, Long and Horton Smith 1968, Utebaeva 1972, Long *et al*. 1974, Long and Millard 1976, Gore and Thomas 1982, BN Jadhav 2009, SV Nikam 2013 recorded this species from Gallus gallus domesticus [26, 27].
8. *Eimeria mivati* Edger Seibold 1964, Long 1973, Fernando and Remmler 1973, Pande Bhatia, Chuhan and Garg 1970 recorderd ellipsoidal oocysts measured 10.7-20 (15.6) x 10.1- 15.3 (13.4). Long and Horton Smith 1968, Pande *et al*. 1970, Wheat *et al*. 1976, Shirley 1982 recorded this species from chicken [26, 27].
9. *Eimeria hagani* Levine 1938, oocyst measured 15.8-20.9 x 14.3-19.5 (19.1 x 17.6). Gill 1954, and Patnaik 1963, from UP, MP and Bombay. Pellerdy 1974, Edger 1977, and Ruff and Reid 1977 also studied this from chicken.

Coccidia of Guinea fowl

Yvore and Aycradi 1967, Giorgetti and Bertocchi 1971, Golemanski *et al*. 1986, recorded *Eimreia grenieri* from helmeted guinea fowl. Pellerdy 1962, 65, Bhatia and Pande 1967, Allmacher 1968, Giorgetti and Bertocchi 1971, Okaeme 1983, Golemanski *et al*. 1986, recorded *Eimeria numidae* from helmeted guinea fowl [27].

1. *Eimeria gorakhpurinensis* Bhatia and Pande 1967, Bhatia, Chauhan, Arora, Agrawal and Ahluwalia 1972,73. ellipsoidal or ovoid oocyst measuring 16-24 x 13-17 (20-14) [13].

Eimeria of Peafowl

1. *Eimeria Arabica Amoudi* 1988 observed spherical oocyst 17.5-21.5 (19.2) um from common peafowl.
2. *Eimeria mayurai* Bhatia and Pande1966, Muraleedharan 1988 Bhatia Chauhan and Gerg (1970), Chauhan Arora and Agrawal (1972,73), Chauhan Arora, Agrawal and Ahluwalia (1973) measured oocyst 16-22 (19) x 13-17 (14) from common peafowl [13, 27].
3. *Eimeria mandala* Banik and Ray 1964 observed oocyst measured 14-20 (17.7) x 14-18 (16.6) from common peafowl.
4. *Eimeria patnaiki* Patnaik 1965 and Ray 1966 observed spherical to sub spherical oocyst measured 17-19 (18.5) x 13-17 (15.5) from common peafowl from Bhubaneswar Orissa India [27].
5. *Eimeria pavonis* Mandal 1965 observed oocyst measured 159.8-25.4 x 17.6 um and Allmacher 1968,

Hillarth *et al*. 1989, Patnaik 1965a, 1966. Also recorded this species from common peafowl from Mau UP and Delhi India [27].

6. *Eimeria riyadhae Amoudi* 1988 (27-30.5 (28.2) x 20.5-25 (22.4) recorded from common peafowl. *Eimeria* species of Mukherjea 1965 spherical 14-20 um from pavocristatus (Indian Peacock) [27].
7. *Eimeria arabica*: spherical (17.5-21.5 x 17.5 – 21.5) without micropyle and micropylar cap. Oocystic residdum is absent. Sporocyst is ovoid in shape measured about 9.5 – 1.2 X 4-6.5 um. From Saudi Arebia. [27].
8. *Eimeria mandali***:** Oocyst (14-20 (17.7) X 14-18 (16.6)) is spherical in shape. Oocyst having Micropyle but micropylar cap and residuum are absent. Sporocyst is 6-12X 4-8 um in length [27].
9. *Eimeria mayurai* ellipsoidal in shape measured about 23-27 X 13-16 (23 X 14) micropyle is present but micropylar cap and residuum is absent. Sporocyst is ovoid in shape measured about 10-13 X 5 -7 um from India.
10. *Eimeria pavonina* Baink and Ray 1961 ovoid (20-28 X16-20). Micropyle is present but micropylar cap is absent. oocystic residuum is present. Sporocyst (6-16 X 4-8) is boat shaped from India [27].
11. *Eimeria pavota n.sp.* El-Shahawy I.S. 2016 ellipsoidal, doubled layered measuring 23.9 - 16.5 X 19.5-14.5, length width ratio 1.5, Sporocyst ovoidal and round at the end. from the zoological park of EL-Gharbia governorate, in central Egypt [17, 27].
12. *Eimeria egyptica n.sp*. El-Shahawy I.S. 2016 double layered, subspherical 12-17 X 18-22 (14 x 20). Sporocyst ovoidal rounded at the end. This species was recorded by El-Shahawy I.S. 2016 from the zoological park of EL-Gharbia governorate, in central Egypt [17, 27].

Eimeria from Quail

1. *Eimeria bacteria* Bhatia, Pande and Pande 1965 reported this species from *Coturnix coturnix* (*European quail*), *Coturnix japonica (Japanease quail)* Shah and Johnson 1971 measure 14-28 (20.5) x 12-19 (15.3), same species also recorded by Navarret *et al*. 1982, Norton and Peirce 1971, Rao and Sharma 1992, Rodriguez *et al*. 1984 Svanbaeva and Utebaeva 1973, Zuo *et al*. 1986 [27].
2. *Eimeria colini* Fisher and Kelley 1977, oocyst (22.4-28.0 (24.8) x 17.9-22.4 (20.9)) recorded from Bobwhite quail [27].
3. *Eimeria coturnicis* Chakravarty and Kar 1946, oocyst 26.4-38.8 x 19.8 -26.4, Lizcano Herrera and Romero Rodriguez 1972, and Svanbaeva and Utebaeva 1973 reported this species from *Coturnix coturnix* (European quail).
4. *Eimeria crusti* (24-28 (26) x 20-23 (21.2)) recorded by Duzynski and Gutierrez 1981 from Oreortyxpictus (Mountain quail) [27].
5. *Eimeria dispersa* Tyzzer 1929 recorded Broadly ovoidal oocyst 17.2-26 (28.8) x 15.4-22.4 (18.8) from quail. This species also recorded by Hwakins 1952, Doron 1978 a b, Hopkins *et al*. 1990, Long and Millard1979, Madden and Ruff 1979, Millard and Lawn 1982, Moore and Brown 1952, Ruff *et al*. 1981.
6. *Eimeria lerryae* Ruff 1985, Ruff and Wilkins (1987) measured oocyst 16.4-25.8 (21.2) x 14.1-21.2 (17.2) from Bobwhite quail.
7. *Eimeria lophortygis* Liburd and Mahrt 1970, Oocyst 19-26 (22.5) x 18-20.5 (18.7) recorded by Duszynski and Gutierrez 1981 in Calfornia quail and Mountain quail.
8. *Eimeria akanoganensis* recorded by Herman and Janiewicz 1942 recorded this species from Calfornia quail and Mountain quail.
9. *Eimeria tahamensis* Amoudi1987 from African harlequin quail, *Eimeria taldykurganica* Svanbaeva and Utebaeva 1973 from European quail, Tsutsumi 1972 recorded *Eimeria tsunodai* and Tsunoda and Muraki 1971 recorded *Eimeria uzurafrom Coturnix japonica*.
10. *Wenyonella bahli* Misra 1944, Mandal 1976 from common quail reported subspherical to ovoidal oocyst measuring 15.5-17.5 x 14.5-15.5 (16.5- 14.9) in size in Lucknow, UP. Shillong and Meghalaya of India.
11. *Eimeria bateri* Bhatia Pande and pande (1965), Norton and Pierce (1971), Shah and Johnson (1971) in US reported ovoid oocyst 16.5-29.8 and 13.5-24.5.

Eimeria in Grouse

These galliformes birds inhibits in temperate and subarctic regions of the northern hemisphere. Unlike other Galliformes, they have no spurs [9].

1. *Eimeria angusta* Allen, 1934 observed oocyst (27-33 x 16.5-17.5) from host Bonas Umbellus Ruffed Grouse, Sage Grouse, Canachits Canadensis (Spruce Grouse), Sharp tail Grouse. This was also recorded by Barker *et al*. 1984, Boughton 1937, Scott 1940, Simson 1940, Scott and Honess 1933,37, Honess and Post 1955, Honess 1968, Todd *et al*. 1970, Yakimoff and Gousseff 1936 [27].
2. *Eimeria despersa* (Tyzzer 1929) ovoidal oocyst 22.8 x 20.4 and 18 x 16.8 with quite delicate light grayish to light metallic shell [12].
3. *Eimeria oviformis* Fantham,1911 oocyst ovoidal to ellipsoidal measuring 26 x 40 in length and 16 x 24 um in width (35 x 21) [27].

   Rajmund Sokot (2018) observe three different species from black grouse bred in northern Poland *Eimeria lyruri* (23.8 x 13.9), *Eimeria nadsoni* (19.6 x 19.3) and *Eimeria nonbrumpti* (18.5 x 18.4) [11, 27].

Coccidia of Partridge birds

Partridges are distributed throughout Europe, Africa and Asia. These are small sized non migratory birds. Some of them also introduced as a game birds. Chukar, Himalayan Snowcock, Red legged partridge, Rock partridge, and Common hill partridges are the some of important galliformes. The most common species of partridge found in UK are *Eimeria kofoidi*, *Eimeria caucasica* and *Eimeria legionesis* [9].

1. *Eimeria kofoidi*, oocyst is ovoid almond shaped found in jejunum, measured 14.04-19.5 X 10.5-14.8 Pellerdy 1974, Levin 1988, Naciri *et al* 2011, Cordero

Delcampillo and pla Hernandez 1966, Bolognesi *et al*. 2006, Yakimoff and Matikaschwili 1936, LitzcanoHerrera and Romero Rodriguez 1972 [16].

2. *Eimeria caucasica* oocyst is ellipsoid to ovoid measuring 26-33.5 X 16.7-23.3 (29.8 x 19.5) originally described by Yakimoff and Buewitsch 1932 [16].
3. *Eimeria legionesis* elliptic to almond shaped measured 15.6-27.3 X 12.4-17.9 found in caecum recorded by Cordero Delcampillo and pla Hernandez 1966, LitzcanoHerrera and Romero Rodriguez 1972. Naciri *et al* 2011 [16].

Coccidia of Pheasants

Pheasants are characterised by strong sexual dimorphism, males are usually larger than females and have longer tails. They usually eat seeds and some insects [9].

Eimeria colchici sp.n. recorded by C.C. Norton (1967) from English pheasant, oocyst measuring 19-33.5 (27.4) X 13-21 (16.7) having micropyle and polar granule.

Ten species of *Eimeria* known to parsitise pheasant ie. *Eimeria colchici* is pathogenic and common species in pheasant. Oocysts are oblong ellipse shape hard to notice micropyle and polar granules. Oocyst measurements are 19-33.5 (27.4) X 13-21 (16.7), were found in England and USA. Fisher 1983, William 1978, Fuller *et al*.2008. *Eimeria duodenalis* oocyst are round or short oval without micropyle, measuring (20-22.9 X 17.4-19.2) and *Eimerisa phasiani* oocysts measurements are 23.5-32.40 X 16.19-18.99 were found in Germany. *Eimeria dispersa* 15.3-22.8 X 13.9-19.7), *E. gennaeuscus*, *E. Langeroni* (30-36 X 16-20), *E. Megalostomata* 21-29 X 16-22), *E. Pacifica* (17-26 X 14-20), *E picta*, *E. Tetartooimia* and *E. Iyoensis* (14.7-20 X 13.3-16.7). Reported by Tyzzer 1929, Fisher 1973, Norton 1976, Willium 1978, Mcquiston 1987, Vanparijs *et al*. 1990, Musaev, Alieva 1983, Gerhald *et al*. 2010, Lilic *et al*.2013, Golemansky 2017, Malikova *et al*. 2023. Baynzul Arjamjav *et al*. 2024 [14, 15].

Coccidia of *Francolinus francolinus*

These are the members of pheasant family mostly restricted to Africa and Asia. They are often called spurfows [9].

1. *Eimeria francolinin* Swaup and Chauhan (1976) and Vinayak Bhosale (1977) identify subspherical to ovoid *Eimeria francolinin.sp.* 14.7-23.1(19.1) x 13.3-20.3 (15.6) from black Partridge from Delhi and Aurangabad, *Eimeria chakravartyin.sp.* 16.1-21 (18.3) x 14-18.2 (16.3) from gray quail and *Eimeria perdiculaen.sp.* 21-23 (22.2) x 17.5-21 (19.2) from jungle bush Quail in Aurangabad district of Marathwada, India [10, 13].
2. *Eimeria teetari* Bhatia Chauhan and Gerg (1970), Chauhan Arora and Agrawal (1972,73), Chauhan Arora, Agrawal and Ahluwalia (1973) reported ellipsoidal ovoidal oocyst measuring 21-29 x 19-23 (24- 20). from Mathura Zoological Garden UP. And Delhi. [13]

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