Coccidiosis in pigeons: host-parasite interactions and control

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Abstract. Coccidiosis in pigeons (*Columba livia*) is a widespread parasitic disease caused predominantly by *Eimeria columbarum* and *Eimeria labbeana*, leading to enteric pathology, impaired growth, and significant mortality in young birds. This mini-review synthesizes current knowledge on the biology, epidemiology, host–parasite interactions, and control strategies associated with pigeon coccidiosis. The life cycle of *Eimeria* spp., characterized by intracellular development within intestinal epithelial cells and environmental sporogony, underpins both disease pathogenesis and transmission dynamics. Host–parasite interactions are complex, involving mucosal immune responses, microbiota modulation, and age-dependent susceptibility, with juvenile pigeons being particularly vulnerable, while adults often serve as asymptomatic reservoirs. Chemotherapeutic control relies mainly on anticoccidial agents such as toltrazuril, although concerns regarding resistance and sustainability highlight the need for alternative approaches. Emerging strategies, including phytochemicals and targeted disruption of parasite sporogony, offer promising avenues for future control. Effective management requires an integrated approach combining pharmacological treatment, environmental hygiene, and improved husbandry practices. Understanding these multifactorial interactions is essential for reducing disease burden and improving pigeon health and productivity.

Key Words: anticoccidial drugs, avian parasitology, coccidiosis, disease control, *Eimeria columbarum*, *Eimeria labbeana*, host–parasite interactions, pigeons, sporogony, toltrazuril.

Introduction. The importance of pigeons (*Columba livia*) as a model organism in biological sciences stems from their advanced navigational mechanisms, phenotypic variability, and extensively documented physiological features, facilitating integrative approaches to the study of behavior, morphology, and metabolism (Ionescu & Oroian 2015; Ionescu et al 2015; Ionescu & Oroian 2019; Popescu & Cimpean 2026; Popescu et al 2026).

Coccidiosis in domestic pigeons is caused mainly by *Eimeria columbarum* and *Eimeria labbeana*, leading to enteric disease, reduced performance, and marked juvenile mortality (Krautwald-Junghanns et al 2009; Al-Agouri et al 2021; Abdel-Gaber et al 2023; He et al 2024). Integrating parasitology, epidemiology, and modern control strategies is essential to reduce losses in intensive and hobby pigeon systems (Krautwald-Junghanns et al 2009; Balicka-Ramisz & Pilarczyk 2014; Al-Agouri et al 2021; He et al 2024).

The aim of this mini-review is to provide a comprehensive and integrative analysis of coccidiosis in pigeons, with particular emphasis on host–parasite interactions and current control strategies. The study seeks to (i) characterize the main *Eimeria* species infecting pigeons and their biological and pathological features, (ii) elucidate the mechanisms underlying host susceptibility, immune responses, and parasite persistence, and (iii) evaluate conventional and emerging approaches for the prevention and control of coccidiosis. Additionally, the review aims to highlight the role of environmental and management factors in disease transmission and to identify future directions for research and sustainable control.

Parasite Species, Life Cycle and Pathology in Pigeons. In pigeons, infections are typically mixed, most often involving *E. columbarum* and *E. labbeana*, with reported prevalence from about 5% up to over 70% and juvenile mortality of 5–70% worldwide (Krautwald-Junghanns et al 2009). Field surveys show very high detection of *Eimeria* oocysts in lofts: 72–73% overall in Libyan and Chinese domestic pigeons, with *E. labbeana* and *E. columbarum* dominating, particularly in young birds (Balicka-Ramisz & Pilarczyk 2014; Al-Agouri et al 2021; He et al 2024). Young squabs between 4 weeks and 4 months, especially under poor hygiene and intensive rearing, are most susceptible, whereas adults often act as asymptomatic carriers (Krautwald-Junghanns et al 2009; Abdel-Gaber et al 2023; He et al 2024).

Experimental infection with *E. labbeana* like oocysts in coccidia free pigeons produces ruffled feathers, greenish watery or blood tinged diarrhea, weakness, weight loss, and high oocyst shedding, with a prepatent period around 5 days and patent period up to 10–14 days (Abdel-Gaber et al 2023; He et al 2024). Histopathology reveals destruction of intestinal mucosa and endogenous stages developing mainly in epithelial cells of the duodenum, jejunum, ileum and rectum, with at least two generations of merogony followed by gametogony and oocyst formation (Abdel-Gaber et al 2023; He et al 2024). Similar biology has been detailed for *E. columbarum*, including oocyst and sporocyst morphometrics and a prepatent period of about 105 hours (Krautwald-Junghanns et al 2009; He et al 2024). Molecular work using ITS1 sequences indicates that pigeon *Eimeria* are phylogenetically close to turkey and chicken *Eimeria*, but classical 18S markers may be too conserved for reliable species differentiation (He et al 2024) (Table 1).

Table 1

Major *Eimeria* species and epidemiology in pigeons

Aspect	*Key details in pigeons*	*References*
Dominant species	*E. columbarum*, *E. labbeana* (often mixed infections)	Krautwald-Junghanns et al 2009; Balicka-Ramisz & Pilarczyk 2014; Al-Agouri et al 2021; Abdel-Gaber et al 2023; He et al 2024
Typical hosts most affected	Young squabs 4 weeks–4 months; adults mainly carriers	Krautwald-Junghanns et al 2009; Al-Agouri et al 2021; Abdel-Gaber et al 2023; He et al 2024
Reported prevalence (overall)	~5–71.9% across studies/regions; 72–73% in some local surveys	Krautwald-Junghanns et al 2009; Balicka-Ramisz & Pilarczyk 2014; Al-Agouri et al 2021; He et al 2024

Host–Parasite Interactions and Immunobiology. Coccidia are obligate intracellular apicomplexan parasites. Their intestinal stages trigger inflammation, reduced nutrient absorption, and impaired growth (Krautwald-Junghanns et al 2009; Attree et al 2021; Lee et al 2022; Ahmad et al 2023). In pigeons, acute disease in young birds causes stunting, poor body condition, and sometimes reproductive problems and mortality, while older pigeons maintain low grade infections and act as reservoirs (Krautwald-Junghanns et al 2009; Abdel-Gaber et al 2023; He et al 2024). Work in poultry demonstrates that outcome is shaped by complex interactions between parasite, gut mucosa, local intestinal immunity, microbiota, and enteroendocrine signals; protective control depends heavily on effective local mucosal immune responses and effector molecules targeting intracellular stages (Lee et al 2022). Repeated low level exposure permits the development of species specific immunity, which is the rationale for allowing controlled cycling of parasites under chemoprophylaxis or vaccination in chickens and is likely relevant for long term control in pigeons as well (Krautwald-Junghanns et al 2009; Attree et al 2021; Lee et al 2022; Ahmad et al 2023).

Chemotherapeutic and Alternative Control Strategies in Pigeons. Classical chemotherapeutics for pigeon coccidiosis include amprolium, sulfonamides, clazuril, and especially toltrazuril (Krautwald-Junghanns et al 2009; Balicka-Ramisz & Pilarczyk 2014; Attree et al 2021). In loft studies, toltrazuril (Baycox) given at 20 mg kg^{-1} for two days, repeated after three days, was highly effective against mixed infections with *E. labbeana*, *E. columbarum* and *E. columbae* and suitable for both therapy and prophylaxis (Balicka-Ramisz & Pilarczyk 2014). A broader clinical review emphasizes toltrazuril because of emerging resistance to sulfonamides and amprolium and its extended efficacy compared with clazuril, while still allowing pigeons to develop immunity during treatment (Krautwald-Junghanns et al 2009).

Natural products are an emerging area. In pigeons, thymol has been evaluated both *in vitro* and *in vivo*: concentrations ≥1.25% damaged unsporulated and sporulated oocysts more than eucalyptus oil or amprolium, and dietary thymol at 40 mg kg^{-1} body weight reduced clinical severity, oocyst output, and growth depression after experimental *E. labbeana* infection, with preserved liver and kidney function, antioxidant effects, and largely intact intestinal villi containing degenerated coccidial stages (Williams & Chiller 2022). In chickens, multiple phytochemicals, including *Artemisia*, *Bidens pilosa*, and garlic, reduce oocyst shedding by inhibiting *Eimeria* proliferation and support barrier function via enhanced epithelial turnover, illustrating general mechanisms that may translate to columbids (Ahmad et al 2023) (Table 2).

Table 2

Pharmacological and phytochemical options for controlling coccidiosis

Strategy / agent	*Main target / effect in avian coccidiosis*	*References*
Toltrazuril	Broad activity against intestinal stages; effective in pigeons; supports immunity development	Krautwald-Junghanns et al 2009; Balicka-Ramisz & Pilarczyk 2014; Attree et al 2021
Amprolium, sulfonamides, clazuril	Older anticoccidials; resistance increasingly reported in poultry; still used in pigeons	Krautwald-Junghanns et al 2009; Balicka- Ramisz & Pilarczyk 2014; Attree et al 2021; Ahmad et al 2023
Thymol	Damages oocysts, reduces clinical signs and oocyst shedding, antioxidant and gut-protective effects in pigeons	Williams & Chiller 2022
Phytochemicals (chickens)	Reduce oocyst output, inhibit parasite proliferation, improve epithelial integrity	Ahmad et al 2023

Environmental Control, Novel Targets and Future Directions. Husbandry and hygiene are central to interrupting the fecal–oral transmission cycle. Poor loft hygiene and high stocking density are repeatedly linked to high prevalence and acute disease in young pigeons, while environmental contamination with oocysts maintains infection pressure (Balicka-Ramisz & Pilarczyk 2014; Al-Agouri et al 2021; Abdel-Gaber et al 2023; He et al 2024). From a broader avian perspective, good litter management, dry conditions, and rotation or fallowing of contaminated areas are core components of control programs (Attree et al 2021; Ahmad et al 2023).

At the parasite level, all *Eimeria* share a life cycle with environmental sporogony, during which the unsporulated oocyst becomes infective. Recent work in poultry shows that focusing on sporogony offers new opportunities: identifying regulatory genes and pathways in the sporulation process, aided by bioinformatics and CRISPR/Cas9 gene editing, could enable vaccines using sporogony deficient strains and highly specific sporogony inhibitors that block environmental maturation without affecting other organisms (Zhao et al 2024). Such approaches, combined with improved molecular diagnostics (e.g., ITS1 based tools

for pigeon *Eimeria*) (He et al 2024) and immune based strategies being developed in chickens (recombinant vaccines, immunomodulatory feed additives) (Attree et al 2021; Blake et al 2021; Lee et al 2022), indicate a trajectory towards integrated, drug sparing control that could be adapted for pigeons in the future.

Conclusions. Coccidiosis remains a significant parasitic disease in pigeons, particularly affecting young birds under suboptimal management conditions. The main etiological agents, *Eimeria columbarum* and *Eimeria labbeana*, exhibit complex life cycles and host interactions that facilitate persistence and transmission within pigeon populations. Disease expression is influenced by a combination of parasite burden, host immunity, age, and environmental factors, with subclinical infections in adult birds contributing to ongoing infection pressure. While anticoccidial drugs such as toltrazuril remain effective, the emergence of resistance and the need for sustainable practices necessitate the development of alternative strategies, including phytochemicals and targeted interventions at the level of parasite development. Integrated control measures that combine pharmacological, environmental, and management approaches are essential for effective disease mitigation. Future research should focus on molecular diagnostics, host immunity, and innovative control methods to support long-term health and productivity in pigeon populations.

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Conflict of Interest. The authors declare that there is no conflict of interest.

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