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Investigation the Prevalence of Common Parasitic Infections in Farmed Quails in Upper Egypt

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Abstract

The present study was conducted to investigate the prevalence and identification of most common parasitic infections of quails and to determine their seasonal variation. One hundred diseased quails (60 quails in summer and 40 quails in winter) were obtained from quail farms in different localities of Assiut and El-menia Governorates and were examined for the presence of ectoparasites, endoparasites, intestinal protozoa, blood protozoa and parasites of other organs (lungs, brain and liver). Results revealed that neither ectoparasites nor macroscopic parasites were observed in the examined quails. Mainly, the encountered parasites were intestinal protozoa (44%), blood protozoa (25%) and parasites of other organs (28%). The overall parasitic infection rate in the examined quails was higher in cold season (57%) than warm season (53%). The intestinal protozoa were identified including *Eimeria* spp. (30%), *Cryptosporidium* spp. (19%), *Tetratrichomonas galinarum* (15%), *Cyclospora* spp. (4%), *Isospora* spp. (3%) and *Microsporidia* spp. (3%). The prevalence rate of intestinal protozoal infection was higher in warm season 46.6% (28 out of 60 examined birds) than cold seasons 40% (16 out of 40 examined birds). The incidence rate of mixed intestinal protozoal infection was higher (24.8%) than the single infection (18.8%). The blood protozoa were reported including *Leucocytozoon* spp. (9%), *Babesiosoma* spp. (8%), *Aegyptianella* spp. (7%), *Plasmodium gallinaceum* (4%), *Haemoproteus* spp. (4%), *Atoxoplasma* spp. (1%) and *Ehrlichia* spp. (1%). The prevalence of parasitic infection in other organs showed that respiratory tract (trachea and lung) infection with Cryptosporidium spp. (24%), hepatic histomoniasis (3%) and brain toxoplasmosis (7%).

Keywords: Blood protozoa, Extra-intestinal protozoa, Intestinal protozoa, Parasitic infection in quail.

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Introduction

Quail (*Coturnix coturnix*) is one of the smallest poultry birds provide more advantages than chickens such as its resistance to many poultry diseases, its greater capacity to benefit from food, high production proportions, and low feed intake. Additionally, they characterized by primary low costs which do not require wide area for farming, lucrativeness, and entertainment so it represented a modern poultry industry trend (Bashtar et al., 2010; Bahar et al., 2014).

Parasitism is one of the major problems which can inflict heavy economic losses to poultry industry. There are variety of parasitic organisms that infect quail's vital systems; digestive, circulatory, respiratory, and integumentary systems. The common parasites that is infective to the digestive tract of quails are worms, and protozoa such as *Eimeria* spp., *Cryptosporidium* spp., *Isospora* spp., *Cyclospora* spp. and *Trichomonas* spp. *Plasmodium* spp., *Leucocytozoon* spp., *Haemoproteus* spp. and *Aegyptianella* spp. are infective to haemocytes, while *Toxoplasma gondii* can infect all cell types (Garcia, 2001; Peterson, 2007).

Moreover, quails are reservoirs for several emerging zoonotic parasites like the coccidian parasites, Cryptosporidium and Toxoplasma that transmitted to human either by ingesting the environmentally robust transmissive oocysts through contact with contaminated feces or ingestion of contaminated water and food or by eating in case of both parasites or undercooked meat containing infective tissue stages in case of Toxoplasma (Smith and Nichols, 2010; Shaapan et al., 2011).

Parasitism effects on quail include retarded growth, low productivity, increased susceptibility to other infection, and death. Some parasitic infections of quail are zoonotic and could be transmitted to human (Peterson, 2007).

Currently, there is limited information regarding the prevalence and identification of parasites in quails. Therefore, the present study was conducted to investigate the prevalence and identification of most common parasitic infections of quails and to determine their seasonal variation in Upper Egypt.

Materials and Methods

Sample collection:

A total 100 diseased quails obtained from quail farms in different localities of Assiut and El-menia Governorates. Sixty quails were examined in summer season, while 40 quails were examined in winter season. The age of quails was ranged from 7 days to 37 days old. Quails showed symptoms of depression, dullness, poor performance with or without diarrhea.

Ectoparasites examination

The birds were examined excessively for presence of any ectoparasites on their body surface.

Endoparasites examination

Birds were sacrificed for endoparasites examination and post-mortem examination.

Specimens processing

After decapitation, the birds were then necropsied and the ceci of each bird was dissected out, and then scribed into respectively labeled plastic cups, sieved and preserved using potassium dichromate 2.5 % in ratio of 1:3. Mucoid specimens were mixed with several drops of 1% of KOH to avoid trapping of protozoan oocysts during sieving (Gracia, 2001). Brain, trachea, lung and liver were collected separately.

Intestinal parasites examination
Gross examination:

Intestinal contents were examined grossly for presence of cestodes and nematodes.

Direct microscopic examination:
Unstained wet mount technique: it was done according to Garcia (2001) for detection of any helminth's eggs, motile protozoa, and or coccidian oocysts. On clean slide, a drop of the scribed intestines was mixed with a drop of 0.9% saline, thoroughly mixed till forming uniform smear. Examination was done systematically and thoroughly by 10x objective lens of the microscope and confirmation was made by switching to 40x objective lens.

Concentration technique: each intestinal specimen was concentrated using one-step ethyl ether sedimentation concentration technique according to Garcia (2001), the sediment was examined microscopically as direct smear. The remaining sediment was kept for further examination by staining techniques.

Permanent staining technique:

Using Modified Kinyoun's Acid fast stain (MKAF) according Gracia (2001); For detecting *Cryptosporidium* spp, *Isospora* spp., *Cycolspora* spp., and *Microspridium* spp. infections. The stained smears were examined with the light microscopy supplied with eye piece micrometer to detect the internal morphology and morphometric with an oil objective (100x).

Blood samples examination:

During bird's sacrificing, blood samples were collected immediately after decapitation to be saved into ethylene-diamine tetra acetic acid (EDTA) tubes. From each blood sample, three blood films were prepared within one hour. Blood films were stained by Giemsa staining and then microscopically examined at 40x and oil emulsion lens 100x objective for blood parasites (Farah et al., 2002).

Extra-intestinal (Pulmonary, Hepatic, Cephalic/Brain) parasites examination

Brain, trachea, lung, and liver were collected separately, washed in saline, dried with filter paper and then lightly impressed on clean slide (2 films for each organ), stained by Giemsa staining microscopically and examined at 40x and oil emulsion lens 100x objective for tissue protozoa (Farah et al., 2002). Identification of different protozoan parasites was based on the morphological characters as described by (Solusby, 1982; Levine, 1985).

Results

Out of the whole 100 examined diseased quails, 55 were infected with at least single protozoon with 55% an overall prevalence rate. Neither ectoparasites nor macroscopic parasites were observed in the examined quails. Mainly, the encountered parasites in this study were protozoa that represented 44% (44 infected quails) for intestinal protozoal infections, 25% (25 infected bird) for blood protozoal infections and 28% (28 infected bird) for other organs parasites (respiratory tract, brain, and liver) were detected. The overall parasitic infection rate in the examined quails was higher in cold season (57%) than warm season (53%). Results were summarized in Table (1).

Table 1: Number of different protozoal infections in the examined quails (n=100).

	No. of infections
Intestinal protozoa infection	**44**
Eimeria spp.	30
Cryptosporidium spp.	19
Isospora spp.	3
Cyclospora spp.	4
Tetratrichomonas gallinarum	15
Microsporidia spp.	3
Blood protozoal infection	**25**
Aegyptianella spp.	7
Plasmodium spp.	4
Haemoproteus spp.	4
Atoxoplasma spp.	1
Babesiosoma spp.	8
Leucocytozoon spp.	9
Ehrlichia spp.	1
Other organs	**28**
Brain toxoplasmosis	7
Respiratory cryptosporidiosis	24
Hepatic Histomoniasis	3
Total No. of infections	**100**

Intestinal protozoal infection

The most common intestinal protozoon was identified in the examined quails was *Eimeria* spp. with a prevalence rate of 30%, followed by *Cryptosporidium* spp., *Tetratrichomonas galinarum*, *Cyclospora* spp., *Isospora* spp., and *Microsporidia* spp. with prevalence of 19%, 15%, 4%, 3%, and 3%, respectively, as shown in (Table 1). The prevalence rate of intestinal protozoal infection was higher in warm seasons 46.6% (28 out of 60 examined birds) than cold seasons 40% (16 out of 40 examined birds). The single intestinal protozoal infection occurrence was 19% (19 out of 100 examined birds) and the mixed intestinal infection was 25% (25 out of 100 examined birds). The most common protozoal combination was between *Eimeria* spp. and *Tetratrichomonas* spp. 10%. The combination between *Eimeria* spp. and *Cryptosporidium* spp. infections were 8%, while the *Cryptosporidium* spp. and *Tetratrichomonas* spp. infection combination was 5% and only 2 birds were co-infected with *Cryptosporidium* spp. and *Isopsora* spp. (2%). In cold season, the incidence rate of the mixed infection (25%; 10 birds out of 40) was higher than the single infection rate (15%; 6 birds out of 40), while, in warm season the incidence of single was 21.6% (13 birds out of 60) that is lower than the mixed infection incidence rate (25%; 15 birds out of 60).

Prevalence of each intestinal protozoal infection

***Eimeria* spp.:** *Eimeria* spp. was detected in the intestinal tract of 30 birds out of the

100 examined quails (30%); with the high prevalence in cold season than warm season (37.5% and 24.6 %, respectively). The main post-mortem lesion in *Eimeria* spp. infected quails was thickened intestinal wall. The most encountered types of *Eimeria* spp. in the present work were *Eimeria tsunodai*, *Eimeria uzura*, and *Eimeria bateri* according to their morphological differentiation (Fig. 1.A).

Cryptosporidium* spp.:** *Cryptosporidium* spp. oocysts were encountered in the intestinal tract of 19 birds out of the 100 examined birds (19%), as shown in (Table 1). It appeared as red to purple stained spherical to ovoid shapes with MKAF stain (Fig. 1.B). Depending on shape with modified Kinyoun's acid fast stain and site of infection; 2 different *Cryptosporidium* spp. were observed in the examined quails. A spherical species measured 4.1x4.2 µm in diameter was seen mainly in the small intestine (*Cryptosporidium meleagridis*), and an ovoid species measured 6.5x5.3 µm was found mainly in the large intestine and identified as *Cryptosporidium baileyi.** Cryptosporidiosis prevalence was higher in cold season 20% (8 out of 40 birds) than warm season 18.3% (11 out of 60 examined birds).

***Tetratrichomonas* spp.:** *Tetratrichomonas* spp. was observed in the wet mount as motile pyriform protozoa with 4 anterior flagella and a posterior flagellum that runs along the undulating membrane and extends beyond it (Fig. 1.C). It was found in the large intestine of 15 quails out of the 100 examined quails (15%), as shown in (Table 1). Four birds out of 40 examined in the cold season were infected (10%) and 11 birds out of 60 examined were detected in warm season (18.3%).

***Isospora* spp.:** the oocysts of *Isospora* spp. were spindle measuring 20 µm in diameter and stained red to pink with Kinyoun's acid fast stain (Fig. 1.D). 3% of *Isospora* spp. infection rate was noticed (3 birds were infected), as shown in (Table 1). It was found as a single infection in 1 bird and in combination with *Cryptosporidium* spp. in 2 quails.

***Cyclospora* spp.:** *Cyclospora* spp. characteristic oocysts were spherical stained light pink to deep red with modified Kinyoun's acid fast stain and measured 8-10 µm (Fig. 1.E). It was observed in 4 quails (4%), as shown in (Table 1), in combination with *Eimeria* spp. and *Cryptosporidium* spp. It was also found in combination with other protozoa.

***Microsporidia* spp.:** *Microsporidia* spp. spores were observed in 3 birds (Table 1) as spherical shapes measuring 1.5-2 µm in diameter and stained red with modified Kinyoun's acid fast stain (Fig. 1.F). It was found in combination with other protozoa.

Blood Protozoal infections

Many protozoa were detected in the Giemsa stained thin blood films from the examined quails with a total prevalence of 25%. *Leucocytozoon* spp. is the most observed blood protozoon followed by *Babesiosoma* spp, *Aegyptianella* spp., *Plasmodium gallinaceum*, *Haemoproteus* spp., *Atoxoplasma* spp., and *Ehrlichia* spp. infection with a prevalence of 9%, 8%, 7%, 4%, 4%, and 1%, respectively (Table 1).

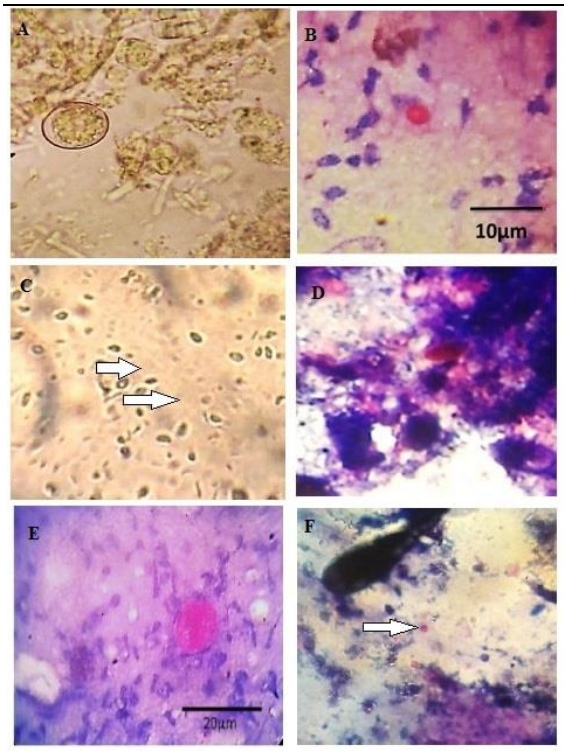

Fig. 1. showing intestinal protozoa detected in examined quails: **A:** *Eimeria* spp. non-sporulated oocyst, 100X; **B:** *Cryptosporidium* spp. oocyst stained with MKAF, 100X; **C:** unstained *Tetratrichomonas* spp. trophozoite (arrow), 100X; **D:** spindle shaped *Isospora* spp. oocyst stained with MKAF, 100X; **E:** *Cyclospora* spp. oocyst stained with MKAF, 100X; **F:** *Microsporidia* spp. spores stained with MKAF (arrow), 100X.

***Leucocytozoon* spp.:** it is the most encountered blood protozoon in the examined quails (9%; 9 birds) which showed enlarged congested liver and spleen, and congested lungs in the post-mortem examination. Its characteristic developmental stage was encountered in the leukocytes circulating in the blood, and impression smears of livers and lungs. The infected host cells appeared spindle-shaped with the nuclei appearing as thin bands beside the parasite, where the protozoon's gametocytes appeared ovoid and elongated occupying the host cell cytoplasm. Another species deformed the leucocyte's nucleus into crescent shape, where the parasite organism lies next to the host cell nucleus and has a round form (Table 1) and (Fig. 2).

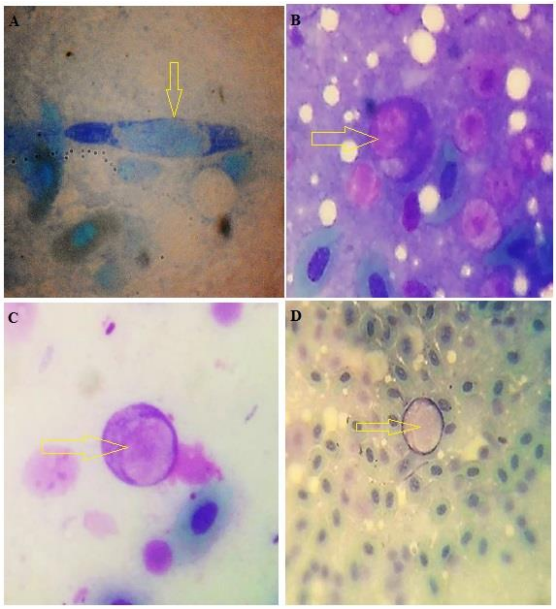

Fig. 2. *Leucocytozoon* spp. stained with Giemsa stain in: **A:** blood film (leukocytes) (arrow); **B:** liver impression smear (arrow); **C:** lung impression smear (arrow); **D:** liver impression smear (arrow), 100X.

***Babesiosoma gallinarum*:** it is the second most encountered blood protozoon in this study with a prevalence rate of (8%; 8 birds) (Table 1). It is observed as a single infection or in combination with *Leucocytozoon* spp. or *Haemoproteus* spp. The protozoon inhabited the bird erythrocytes and appeared as stained deep purple to red ring (Fig. 3).

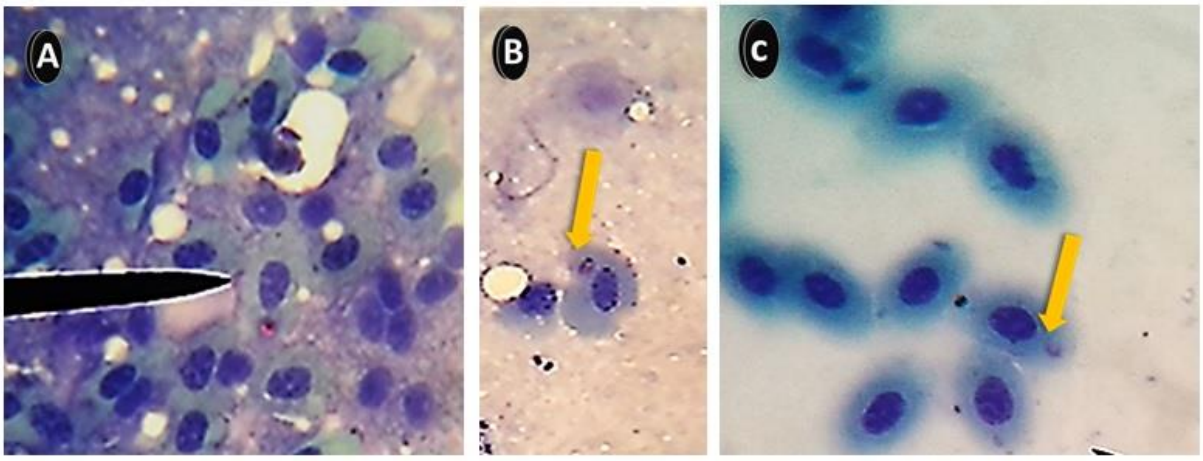

Fig. 3. showing *Babesiosoma* spp. stained with Giemsa stain in: **A:** lung impression smear; **B:** liver impression smear (arrow); **C:** blood film (arrow), 100x.

***Aegyptianella pullorum*:** seven birds (7%) were found to be infected with *Aegyptianella pullorum* (Table 1). The protozoon inhabited the erythrocytes and appeared as 1.5µm red to deep purple spheres (Fig. 4.A).

Plasmodium gallinaceum: its various developmental stages (ring stage, schizonts, and gametocytes) were observed in the erythrocytes (Fig. 4.B) of 4 examined quails (4%), as appeared in (Table 1).

***Haemoproteus* spp.:** its infection rate was 4% in this study (4 quails were infected), as shown in (Table 1). The protozoon's characteristic sausage shape was encountered in the bird erythrocytes surrounding its nucleus (Fig. 4.C).

***Atoxoplasma* spp.:** its infection was noticed in 1 bird in this study (1%) (Table 1). The protozoon appeared as purple ovoid body in the cytoplasm of the lymphocyte (Fig. 4.D).

***Ehrlichia* spp.:** One bird (1%) had *Ehrlichia* spp. protozoon in its leukocytes and platelets (Table 1). The protozoon appeared as blue inclusions inside the cell cytoplasm (Fig. 4.E).

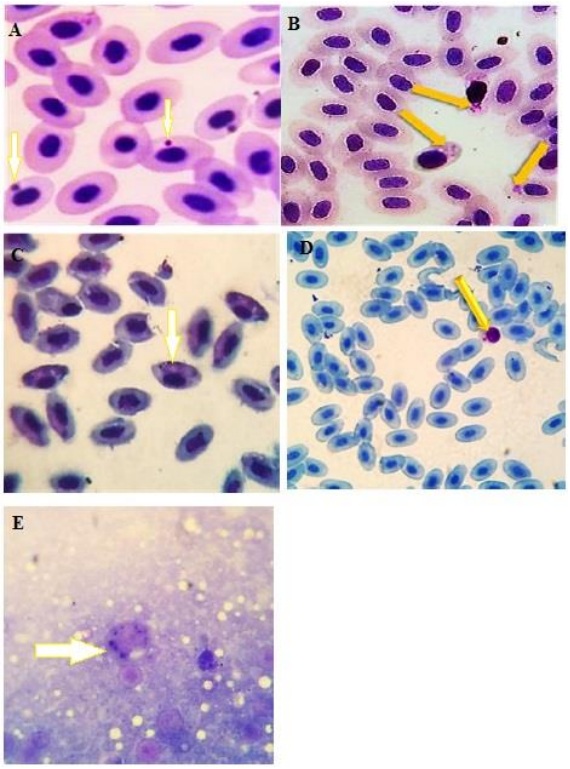

Fig. 4. showing other blood protozoa in Giemsa stained blood films: **A:** *Aegyptianella* spp. (arrows); **B:** *Plasmodium gallinaceum* (arrows); **C:** *Heamoproteus* spp. (arrow); **D:** *Atoxoplasma* spp. (arrow); **E:** *Ehrlichia* spp. (arrow), 100X.

Protozoal infections of other organs

Twenty-eight birds (28%) had extra-intestinal protozoal infection with infection most frequent in the respiratory tract (trachea and lung) with *Cryptosporidium* spp. (24%; 24 birds) and few birds had hepatic histomoniasis (3%; 3birds) and others had brain toxoplasmosis (7%; 7birds), (Table 1, Fig. 5).

Respiratory cryptosporidiosis: *Cryptosporidium* spp. oocysts appeared as red ovoid shapes against blue background in the lung tissue and the tracheal mucosa with the MKAF stain (Fig. 5.A). The infected birds had tracheitis and pneumonia.

Hepatic histomoniasis: *Histomonas meleagridis*'s tissue phase was encountered in the hepatic tissue as purple pleomorphic shapes (3-16 μm) (Fig. 5.B).

Brain toxoplasmosis: *Toxoplasma gondii* tachyzoite appeared as crescentic or banana shapes with a nucleus towards the broad end in the brain tissue (Fig. 5.C).

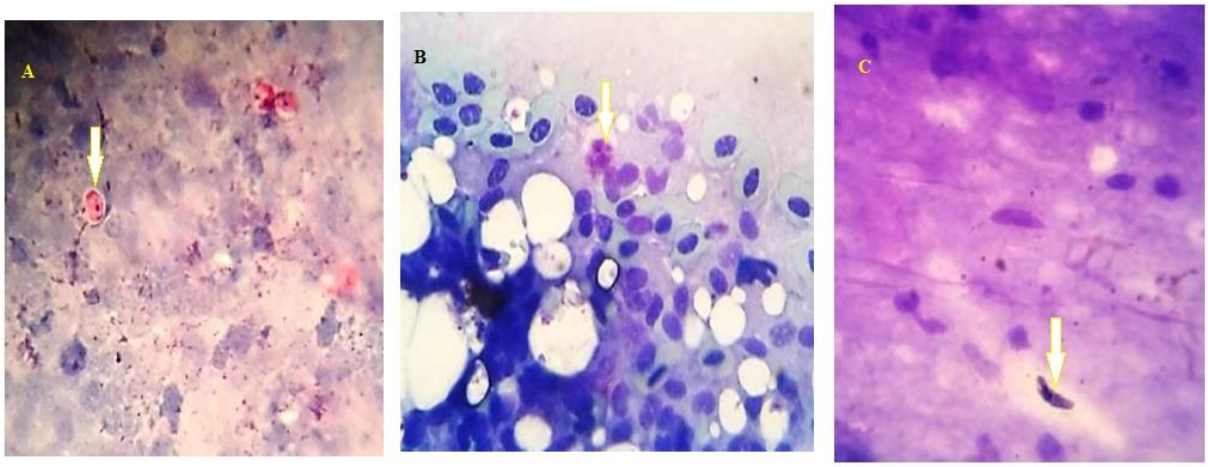

Fig. 5. showing protozoa of other organs: **A:** lung impression smear stained with MKAF showing *Cryptosporidium* spp. (arrow); **B:** liver impression smear stained with Giemsa showing *Histomonas* spp. (arrow); **C:** brain impression smear stained with Giemsa showing *Toxoplasma's* tachyzoite (arrow), 100X.

Discussion

Quail production is a part of the poultry industries that deserve care where quail is resistant to various diseases, not need big distance to farm, and is a good source of animal protein (Mohammad, 2012). Like the majority of animal production systems, it demands constant improvements on the application of new technologies and sanitary control (Teixeira et al., 2004; Mohammad, 2012). Parasitic diseases can affect development and production of this bird either directly or indirectly through induction of other pathogens. Studies deal with this aspect among quails in Egypt is still limited. Thus, this study presents an evaluation of parasitic infections in naturally infected clinically diseased quails from commercial rearing farms in Assiut and El-menia Governorates.

In the current study, the extent of parasitological invasion in the examined quails was 55% (55 birds out of 100 examined one). The encountered parasites in this study were only protozoa. The infected birds had one or more health problem included uneven growth, dullness, huddling, ruffling and mortality. The

intestinal protozoa occupied large sector among the detected protozoa (44%) while the extra-intestinal protozoa prevalence rates were lower in blood (25%) than other organs (28%). This high prevalence may be a warning sign of probable endemicity of depleting protozoa among quails and need to be ascertained in large-scale studies with more care. It was noted that all examined quails were floor reared in farms with low hygienic measures this may explain the high parasitological prevalence rate.

No ectoparasites observed during external examination of quails, which is similar to the results of Bahar et al., (2014). Also, no helminths were reported in the examined quails, these results disagreed with Bahar et al., (2014) and Otify, (1989), who recorded that 5% of the quails examined in Garmsar, Iran harbored one or more species of helminths. Alan kocan et al., (1979) recovered 27% and 6% nematodes and cestodes prevalence rates, respectively from quails in Oklahoma. No knowledge was available to us about the farming condition in which quails were reared to explain this high prevalence percent. The difference in results may be attributed to the different diagnostic methods, the different geoclimatic condition and the health status of the examined birds.

In the current study, the total protozoa prevalence rate was relatively higher in the cold season (57%) than warm season (53%) this can be attributed to the bad management during cold seasons, high ambient humidity, and litter moisture. Conversely, the intestinal protozoal infection rate was higher in warm seasons (46.6%) than cold seasons (40%) that can be conferred to seasonality of different detected parasites.

Mixed infection is a common phenomenon in areas where various types of intestinal parasites are encountered (Habtamu and Kloos, 2006). The present study showed that all the recognized intestinal protozoa of the examined quails occurred as single or mixed infections, being the incidence rate of mixed infection was higher (24.8%) than the single infection (18.8%). This can be explained by that some protozoa like *Eimeria* spp. and *Cryptosporidium* spp. provides suitable conditions for other protozoal infections as *Tetratrichomonas* spp., *Cyclospora* spp., *Isosproa* spp., and *Microsporidia* spp. Another explanation is that *Eimeria* and *Cryptosporidium* spp. infections suppress bird's immunity hence attraction and flourishment of other low pathogenic protozoa. Moreover, these protozoa may share the same source of infection, like *Cryptosporidium* spp., and *Tetratrichomonas* spp. are water transmitted parasites and the similarity of favorable climatic condition, *Eimeria* spp. and *Cryptosporidium* spp.

The high frequency of infection with *Eimeria* spp. and *Cryptosporidium* spp. especially with other protozoa may call for concern of infections with these protozoa in quails especially subclinical infection that leads to immune suppression either through impaired feed conversion and loss of vital elements, or injury of intestinal, respiratory, and bursal mucosa initiating other infections (protozoal as in the present study, bacterial, and viral). Thus, the negative economic impact is considerable. More studies should be done for explanation of

the co-infection with more than parasite affect the pathological effect of each parasite within their habitat.

It was noted that in this study *Eimeria* spp. occupied the highest percent among the encountered intestinal protozoa (30%). *Eimeria tsunodai*, *Eimeria uzura*, and *Eimeria bateri* were the most encountered *Eimeria* spp. The examined infected birds had non-specific mild clinical signs. Alan kocan et al., (1979) reported that a 27% prevalence rate of *Eimeria* spp. in quails in Oklahoma. Teixeira et al., (2004) concluded that the natural quail coccidia infection is characterized as subclinical infection. The *Eimeria* infection rate was higher in cold seasons (37.5%) than warm season (24.6%). This can be conferred to that the cold and moist environment in addition to bad quail farm management favors greater protozoal flourishment, and transmission, and bad birds' health allowing the bird more prone to infection than warm seasons.

In this investigation, 19% intestinal cryptosporidiosis was obtained that approached rate of 20% recorded by Bahar et al., (2014). As well the obtained results in the present study approached the results of Musaev et al., (1998), (21.7%) in different localities in Azerbaijan**;** and Duszynski and Gutierrez, 1981, (14.9%) in USA but they depended in their investigation on the fecal examination. In 2011, Shaapan et al., recorded higher fecal cryptosporidial infection rate in Giza, Egypt (31.9%). In contrast to the current study, they depended in their study on the fecal examination of apparently healthy birds and did not differentiate intestinal cryptosporidiosis from the respiratory, while the current study depended on organ tissue from apparent clinically ill birds as a sample. Considering the seasonal prevalence of intestinal cryptosporidiosis in the current findings, it was noticed that the relatively high occurrence of infection was recorded in cold seasons (20%) and low in warm (18%). It could be attributed to the exposure of cryptosporidial oocysts to increasing temperatures increases its metabolic activity leading to shortage of its life span and adversely affecting its viability and infectivity (King et al., 2005). Moreover, high humidity and low temperature harmfully affect the bird health condition. Consequently, bird susceptibility to infection is increasing. *Cryptosporidium baileyi* and *Cryptosporidium meleagridis* could be recovered from the examined quails of the current study. The measurements of the detected cryptosporidial oocysts in the examined quails of this study revealed two *Cryptosporidium* spp. of rounded or slight ovoid shape. They were 4.1x4.2µm (*Cryptosporidium meleagridis*) and 6.5x5.3 µm (*Cryptosporidium baileyi*). That partially differed from Ryan et al., (2003) and Shaapan et al., *(*2011) results who recorded a third *Crytptosporidium* spp. which was *Cryptosporidium galli*, 8.2x 6.3 µm. Both *Cryptosporidium baileyi* and *Cryptosporidium meleagridis* have a public health aspect. They have been detected in both immune-competent and immune-compromised human (Gatei et al., 2003). It sounds that more studies are necessary to comprehend the competence of avian derived Cryptosporidia as a notable risk for public health.

In this study, *Tetratrichomonas gallinarum* infection rate was 15% that was lower than rate recorded by Alan Kocan et

al., (1979) 25% in Oklahoma. Concerning to *Tetratrichomonas* seasonal occurrence in the present study, the highest prevalence was in warm season (18%) while lower rate observed in cold (10%). This is not compatible with the other studies where it is known that trichomonads have no intermediate host and require moist conditions for environmental persistence (Stabler, 1954; Clark, 2012); in hot weather drier environmental conditions limit their survival, decreasing opportunities for parasite transmission. Additionally, *Trichomonas* trophozoites are extremely fragile, hence unable to survive outside the host for more than the briefest periods (Stabler, 1954). The cause of this high *Tetratrichomonas* spp. infection prevalence in warm season in the present study can be explained by occurrence of the infection secondary to coccidiosis or cryptosporidiosis.

To the less frequent protozoa in this study, 3%, 4%, and 3% prevalence rates were observed for *Isospora* spp., *Cyclospora* spp., and *Microsporidia* spp., respectively. The clinicopathological importance of these protozoa in quails is advised to be further studied. As well, the exact role of domestic quails as reservoir hosts for human cyclosporiosis, isosporiosis, and microsporidiosis need to be studied.

Concerning to haemosporidian parasitic infections that is one of the disease problems endangers quails. It is associated with a broad spectrum of clinical disease manifestations, from asymptomatic to acutely fatal and can be a contributing factor in the failure of quail industry (Pacheco et al., 2011). In the current work, many variable blood protozoa were observed in different tissues of the examined quails with a total of 25% infection rate. The most encountered blood protozoon in this study was *Leuckocytozoon* spp. (9%) followed by *Babesiosoma* spp. (8 %), and *Aegyptianella* spp. with 7% infection rate, then *Plasmodium* spp. and *Haemoproteus* spp. that had equal infection rate (4%), and *Atoxoplasma* spp. and *Ehrlichia* spp. had the least infection rate (1%).

Babesiosoma spp. prevalence rate was 8%, this result was higher than the result recorded by Esmaeil, (2004) in pigeons (1.03%) and lower than the ratio they recorded in fowls and ducks (23.3%, 21.66%, respectively) of Assiut Governorate, Egypt. Concerning to *Aegyptenella* spp., prevalence rate (7%), this result agreed with Mohammad, (2012) who recorded 7.7% *Aegyptianella* spp. in Nineveh governorate, Iraq. For *Plasmodium* spp. prevalence rate (4 %); this result agreed with Mohammad, (2012) who recorded 4.4% *Plasmodium* spp. in quails of Nineveh governorate, Iraq.

Protozoal infections of organs other than intestine in avian species and their adverse effect on poultry production in Egypt have few studies. In this study 28% prevalence of extra-intestinal protozoal infection in quails was detected. The respiratory organs were found to have the highest parasitic infection with *Cryptosporidium* spp. (24%) followed by brain with 7% toxoplasmosis incidence rate and the liver with 3% histomoniasis incidence rate. Concerning to respiratory cryptosporidial infection, most of the infected birds had excess tracheal mucous, pneumonia, and or bursitis. This coincided

with the first record for quail respiratory cryptosporidiosis (Tham et al., 1982). The current result is relatively lower than that recorded by Bahar et al., 2014, (32.5%). Based on microscopical examination, the toxoplasmosis occurrence rate (7%) that observed only in the brain in this study varied greatly from that recorded by Shaapan et al., (2011) recorded toxoplasmosis occurrence rate of 29.8% depending on the serological investigation by modified agglutination test (MAT). Hepatic histomoniasis infection rate was (3%), it was relatively lower than the rate recorded by Alan Kocan et al., (1979) 7% in Oklahoma.

Conclusion

In the present study, it was concluded that quail parasitic infections are not something that can be safely ignored and can participate largely in quail diseases and production. Therefore, more clinical and pathological studies are necessary to be carried out on quails.

Conflict of interest statement

The authors declare that they have no conflict of interest.

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