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The Prevalence and Diversity of Enteric Parasitic Infections in Domestic Turkeys (Meleagris Gallopavo) in Egypt

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Abstract: The current study aimed to investigate the infection rate and diversity of enteric parasites in domestic turkeys (*Meleagris Gallopavo*) in different localities of Egypt. One hundred and thirty intestines were collected from slaughtered turkeys; 97 from Zagazig City in Sharkia Province and 33 from El-Salam Abattoir in Cairo Province. The total prevalence of parasitic infection reached 49.23%. The rates were 62.89% and 9.09% in examined samples from Zagazig City and El-Salam Abattoir. Nematoda infections included *Heterakis gallinarum* (34.6%), *Capillaria* species (13.08%), *Trichostrongylus tenuis* (5.38%) and *Strongyloides avium* (0.77%). Protozoan infections included *Eimeria* species (18.46%); *Balantidium* species (0.77%) and *Cryptosporidium* species (3.08%). In wet season, the infection rate (59.02%) was higher than in dry one (40.58%). In wet season, the percentages of single, double, triple and fifth infection reached 18.03%, 27.87%, 11.48% and 1.64%, respectively; but in dry season, the percentage of single, double and triple infection reached 30.43%, 5.8% and 4.35%, respectively. A significant increase of *H. gallinarum* was observed all over the year, while *Eimeria* species infection rate was significantly higher in the wet season. In relation to seasonal variations of co-infections, double infection type recorded significant higher values both in wet and dry seasons than the other infection types. The current study recommends the urgent need to use advanced and improved methods of animal care and management, as well as testing of new antiparasitic agents for control of such parasites, whether on farms or in home turkey housing system, to reduce the risks of increasing parasitic infection rates.

Keywords: *Capillaria, Eimeria, Oocyst, Season, Sedimentation, Trichostrongylus.*

Introduction

Poultry is an important income source where their meats considered a rich energy nutritional source for essential proteins. Poultry production increased significantly because of their short production cycle, low beginning costs as well as the wide acceptance of poultry meat and eggs as sources of animal protein [1]. Turkeys breeding was becoming more popular among the small farmers due to their quick replacement and feed transformation rates in dry environments.

The incidence of parasitic infections had been increased in poultry as a result of the recent shift toward application of extensive free range housing system to achieve animal welfare [2]. Presence of the enteric parasites had a negative impact on poultry industry by lowering the growth and gaining rates of birds resulting in malnourishment and death [3]. Parasites affect the intestinal tract of turkeys include protozoa, nematoda, cestoda and trematoda which affect the general health condition via appetite loss, and appear in the form of

general weakness, diarrhea, anemia, reduced egg production, and decreased growth rates [4]. Nematoda were considered one of the most common types of parasitic infections that affecting the intestinal tract of turkeys due to presence of varied species and their wide spread geographical distribution [5]. *Heterakis gallinarum* considered one of the most famous nematode infection types in galliform birds. They might induce diffuse chronic & nodular typhlitis and had the ability to transfer other protozoa like *Histomonas meleagridis* where the infection transmitted via their eggs inducing serious lesions in ceci and liver in infected turkeys [6]. *Capillaria species* affect the small intestine of domestic turkeys inducing weight loss, diarrhea and economic losses in severe infections [7]. *Trichostrongylus species* infection causes retarded growth rates in young turkeys, decreased productivity rates in adults for egg or meat, reduced bird immunity and natural reactivity and eventually death [8].

Protozoan infection like *Eimeria* species affecting turkeys were worldwide distributed and resulted in bloody diarrhea, poor growth rates and high mortalities especially in young ages [9]. Several species of *Eimeria* infect turkeys including *Eimeria meleagridis*, *E. meleagrimitis*, *E. dispersa*, *E. gallopavonis*, *E. adenoids*, *E. innocua,* and *E. subrotunda*. Infection with *E. adenoids* and *E. meleagrimitis* induce malabsorption, reduction in feed intake and growth rates, dehydration, poor feed conversion values, and high mortality [10].

Cryptosporidium species had reported in more than thirty avian species all over the world, including turkeys [11]. *C. parvum* and *C. meleagridis* in turkeys had a zoonotic importance to human [12]. *C. baileyi* infects respiratory and gastrointestinal (GIT) systems [13] whereas *C. meleagridis* infects small intestine causing mild to severe diarrhea [14].

Little data was known about enteric parasitic infection in turkeys (*Meleagris gallopavo*) in Egypt where Mervat et al. [15] reported *Ascaridia galli*, *Eimeria meleagrimitis* and *Tritrichomonas eberthi* in Sharkia Province; Nagwa et al. [16] reported *Railliatina tetragona* , *R. georgiensis* , *A. galli* , *Heterakis gallinae* , *H. dispar*, C*apillaria obsignata* in Gharbia Province; El-Dakhly et al. [17] reported *Ascaridia dissimilis* in Beni-Suef Province*;* Ammar [18] reported *Raillieatina echinobothriida* and *Spirora meleagaris* in Qena Province. Finally, El-sayed & Raef [19] reported *E. adenoeides*, *E. meleagrimitis*, *E. innocua*, *Cryptosporidium meleagridis*, *Tetratrichomonas gallinarum and Tritrichomonas eberthi* in Sharkia Province. Therefore, the current study aimed to determine the prevalence rate and diversity of enteric parasitic infection in turkeys (*Meleagris Gallopavo*) in different localities and seasons in Egypt.

Materials and Methods

Ethical approval

All instructions and requirements had been followed in this study for collection of intestinal samples were approved by the animal care and use committee (IACUC), Faculty of Veterinary Medicine, Zagazig University, Egypt under number of ZU_IACUC/2/F/205/2023.

Birds and sampling

One hundred and thirty intestines were collected from slaughtered turkeys (*Meleagris Gallopavo*) (White Dutchman and American Bronze, age of 5 – 7 months) from the slaughter house at El-Salam Abattoir, Cairo Province and slaughter shops at Zagazig city, Sharkia Province during the period from March, 2023 till July, 2024. The samples were placed in labeled clean, sterilized plastic bags and transported in an ice tank to Parasitology Laboratory, Department of Parasitology, Faculty of Veterinary Medicine, Zagazig University for further examination.

Processing and examination of intestinal samples

The obtained intestinal samples were divided into small intestine, cecum and rectum; each part was opened separately using scissor and forceps and the grossly observed adult worms were collected. The intestinal mucosa was scraped by clean and sharply edged glass slide into a large petri dish (15 Cm in diameter) containing a suitable amount of tap water. The scrapings were divided into small amounts in small petri dishes

(5 Cm in diameter) and examined visually and by using a stereomicroscope for presence of different parasitic stages. The gross adult worms were collected and prepared for morphological identification.

Preparation and identification of recovered nematodes

After several washing with distilled water, the worms were relaxed in refrigerator and transferred into lactophenol solution for at least 24 hours for clearance. For permanent preparations, mounting of worms were done with polyvol on clean glass slides and covered with cover slips; then slides left to dry in hot air oven at 40 ^{0}C for 24 – 48 hours [6]. They were identified microscopically according to descriptions of Yamaguti [20] and Belding [21].

Fecal examination

A small part of intestinal contents was taken, prepared by both direct and concentration sedimentation techniques and examined microscopically for parasites [22, 23].

Sporulation & identification of Eimeria species oocysts

A part of the intestinal contents was collected, mixed with distilled water, filtrated and centrifuged at 1500 rpm for 10 minutes. The sediment was kept in petri dishes containing 2.5% potassium dichromate solution at room temperature with daily shaking and aeration until sporulation occured. The sporulated *Eimeria* species oocysts were identified according to the descriptions of Soulsby [22] and El-Sherry et al. [24].

Ziehl neelsen (Zn) stain for Cryptosporidium species

Intestinal smears were dried, fixed with absolute methyl alcohol and stained by Ziehl neelsen (Zn) stain for detection of *Cryptosporidium* species oocysts [25, 26].

Statistical analysis

Chi-Square Test was run to test significant difference among the detected enteric parasites in turkeys and to determine the significant variance in between infection rates in different localities, different parasitic group (Nematoda/ Protozoa) and type of infection (single/mixed). Also, Z-test used to compare the proportions of infected individuals in each group (*Heterakis, Capillaria,* etc); $P < 0.05$ statistically considered significant. All analyses and charts were performed by Statistical Package for Social Sciences version 24.0 (SPSS, IBM Corp., Armonk, NY) and Graph Pad prism 8.0.2 (GraphPad Software, Inc) [27].

Results

Enteric parasitic infection rates in examined domestic turkeys (*Meleagris gallopavo*) in Zagazig city, Sharkia and in El-Salam Abattoir, Cairo Provinces were 62.89% and 9.09%, respectively. There was statistical significant difference in between them toward Sharkia Province where P value reached 0.0000001 (Table 1).

The infection included nematoda (53.85%) and protozoa (22.31%). Nematoda included *Heterakis gallinarum* (34.6%), *Capillaria* sp. (13.08%), *Trichostrongylus tenuis* (5.38%), and *Strongyloides avium* (0.77%). Protozoa included *Eimeria spp*. (18.46%), *Cryptosporidium sp.* (3.08%) and *Balantidium sp.* (0.77%). There was a significant difference in between nematoda and protozoa (P value < 0.05). The highest infection rates were recorded in *H. gallinarum* and *Eimeria sp.* infection (Table 2).

In relation to seasonal variation, the infection percentages reached (59.02%) and (40.58%) for wet (November to April) & dry seasons (May to October), respectively. In wet season, the infection included *Eimeria spp.* (37.7%), *H. gallinarum* (34.43%), *Capillaria species* (16.39%), *Trichostrongylus tenuis* (6.56%), *Cryptosporidium sp.* (4.92%) and *Balantidium sp*. (1.64%). While in dry season, the infection included *H. gallinarum* (34.78%), *Capillaria species* (10.14%), *Trichostrongylus tenuis* (4.35%), *Eimeria spp.* (1.45%), *Cryptosporidium sp.* (1.45%) and *strongyloides avium* (1.45%). There was significant variation in between the detected parasites in wet and dry seasons. *H. gallinarum* recorded a higher significant values in dry season (P value = 0.36) when compared with those in wet season (Table 3).

Regarding the infection type (single/mixed infections), *H. gallinarum* was highly detected among the examined turkeys (18.46%). *Eimeria meleagrimitis* was only found as single infection, while *E. meleagridis* and *E. innocua*

were found mixed with *Trichostrongylus tenuis.* Single infections included: *H. gallinarum* (18.46%), *E. meleagrimitis* (2.31%), *Capillaria sp.* (1.54%), *Cryptosporidium sp.* (1.54%) and finally *Strongyloides avium* reached (0.77%). Double mixed type reported as the following: (*H. gallinarum+ E. meleagrimitis* 5.38%), (*H. gallinarum+ Capillaria sp.* 4.62%), (*E. meleagrimitis + E. innocua* 3.08%), (*H. gallinarum+ E. meleagridis* 0.77%), (*Capillaria sp. + E. meleagrimitis* 0.77%), (*E. meleagrimitis+Balantidium sp*. 0.77%), (*E. adenoids + Cryptosporidium sp*. 0.77%). Triple type infection was as the following: (*H. gallinarum+ Capillaria sp. + Trichostrongylus tenuis* 3.85%), (*Trichostrongylus tenuis+ E. meleagridis + E. innocua* 0.77%), (*Capillaria sp. + E. meleagrimitis+ Cryptosporidium sp.* 0.77%), (*E. meleagrimitis + E. meleagridis + Capillaria sp.* 0.77%), (*E. meleagrimitis + E. meleagridis + E. innocua* 0.77%) and *E. meleagrimitis + E. meleagridis + H. gallinarum* 0.77%). Fifth mixed type included (*H. gallinarum+ Capillaria sp. + Trichostrongylus tenuis+ E. meleagrimitis + E. meleagridis*) and was found in one sample only (0.77%) (Table 4).

In wet season, the overall percentages of single, double, triple and fifth infection reached 18.03%, 27.87%, 11.48% and 1.64%, respectively. In dry season, the overall percentages of single, double and triple infections reached 30.43%, 5.8% and 4.35%. No fifth mixed infection could be detected in the dry season. Double type of infection recorded significant difference in between wet and dry seasons where P value = 0.0006. On the contrary, the single and triple types didn't record any differences in between wet and dry seasons (Table 5 & Fig. 1).

TABLE 1. Total parasitic infection percentages in the examined domestic turkeys in Sharkia and Cairo Provinces.

Locality	Examined No.	Infected No.	Infection %
Sharkia Province	97	61*	62.89%*
Cairo Province	33	3	9.09%
Total	130	64	49.23%

* indicates significant variation.

TABLE 2. Enteric parasitic infections in the examined domestic turkeys (*Meleagris gallopavo*) (N=130).

Examined No. (N=130)	Infected No.	Infection %
Nematodes		
Heterakis gallinarum	45*	34.6%
Capillaria sp.	17	13.08%
Trichostrongylus tenuis	7	5.38%
Strongyloides avium	1	0.77%
Total	70#	53.85%
Protozoa		
Eimeria sp.		
- *E.meleagrimitis*	21	16.2%
- *E.meleagridis*	6	4.62%
- *E.innocua*	6	4.62%
- *E.adenoides*	1	0.77%
Balantidium sp.	1	0.77%
Cryptosporidium sp.	4	3.08%
Total	29	22.31%

* indicates significant variation P value < 0.05, # indicate significant variation between nematoda vs protozoa.

TABLE 3. Seasonal infection percentages of enteric parasites in the examined domestic turkeys (*Meleagris gallopavo*).

Season	Examined No.	Infected No.	Infection %	Parasite	Infected No.	Infection %
				Heterakis gallinarum	21*	34.43%
				Capillaria species	10	16.39%
				Trichostrongylus tenuis	4	6.56%
Wet season	61	36	59.02%	*Cryptosporidium sp.*	3	4.92%
				Eimeria sp.	23*	37.7%
				Balantidium sp.	1	1.64%
Dry season	69	28	40.58%	*Heterakis gallinarum*	24**	34.78%
				Capillaria species	7	10.14%
				Strongyloides avium	1	1.45%
				Trichostrongylus tenuis	3	4.35%
				Cryptosporidium sp.	1	1.45%
				Eimeria sp.	1	1.45%

* indicates significant variation, ** indicate higher values of significant variation.

TABLE 4. Total infection percentages of single and mixed parasitic infections in the examined turkeys (N=130).

Type of infection	Parasite species	No.	Infection %
Single	*Heterakis gallinarum*	24	18.46%
	Capillaria species	2	1.54%
	strongyloides avium	1	0.77%
	Cryptosporidium sp.	2	1.54%
	Eimeria meleagrimitis	3	2.31%
Mixed			
Double	*H. gallinarum+ Capillaria sp.*	6	4.62%
	H. gallinarum+ E. meleagrimitis	7	5.38%
	H. gallinarum+ E. meleagridis	1	0.77%
	Capillaria sp. + E. meleagrimitis	1	0.77%
	E. meleagrimitis + E. innocua	4	3.08%
	E. meleagrimitis+Balantidium sp.	1	0.77%
	E. adenoids + Cryptosporidium sp.	1	0.77%
Triple	*H. gallinarum+ Capillaria sp.+ Trichostrongylus tenuis*	5	3.85%
	Trichostrongylus tenuis+ E. meleagridis + E. innocua	1	0.77%
	Capillaria sp. + E. meleagrimitis+ Cryptosporidium sp.	1	0.77%
	E. meleagrimitis + E. meleagridis + Capillaria sp.	1	0.77%
	E. meleagrimitis + E. meleagridis + E. innocua	1	0.77%
	E. meleagrimitis + E. meleagridis + H. gallinarum	1	0.77%
Fifth	*H. gallinarum+ Capillaria sp.+ Trichostrongylus tenuis+ E. meleagrimitis + E. meleagridis*	1	0.77%

TABLE 5. The overall percentages of single and mixed infections in relation to seasons in the examined turkeys.

Wet season (N=61)			
Single infection (n=11)	**Mixed infection Double (n=17)**	**Triple (n=7)**	**Fifth (n=1)**
18.03%	27.87% *	11.48%	1.64%
Dry season (N=69)			
Single infection (n=21)	**Mixed infection Double (n=4)**	**Triple (n=3)**	**Fifth (n=zero)**
30.43% NS	5.8%*	4.35% NS	0%

NS indicates non significant variation;* indicate significant variation.

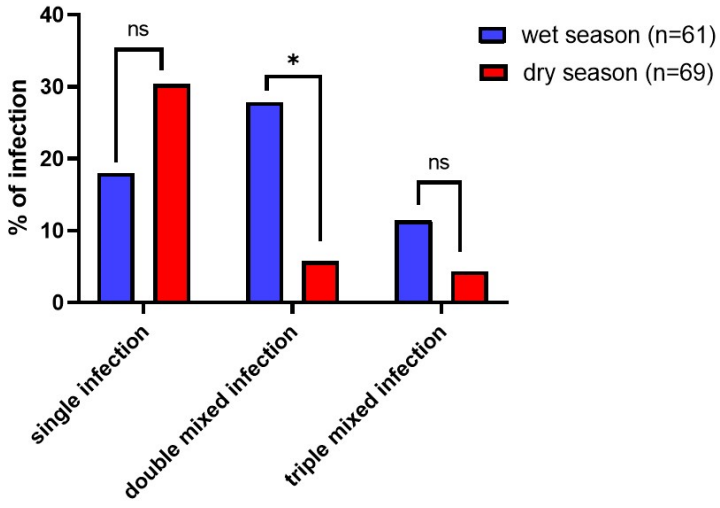

Fig. 1. Showing statistical significant variation in between different infections (single/mixed) in wet & dry seasons; ns: indicate non-significant variation and *: indicate significant variation.

Discussion

Higher prevalence rates of enteric parasites were detected in Zagazig City, Sharkia Province (62.89%) than that of El-Salam Abattoir, Cairo Province (9.09%). The few number of samples examined at El-Salam Abattoir, Cairo Province might be a cause; but also, this might be attributed to the difference in management systems, breeds of turkeys and feeding habits (ration/grasses) as the samples were taken from domestic turkey in Zagazig City, reared on the floor and fed on green grasses, which might be contaminated with the different infective stages of detected parasites. While in El-Salam Abattoir, the samples were collected from farms where they exposed to anthelmintic medication as a preventive measure against parasitic infections.

The current study investigated the parasitic infection in domestic turkeys (*Meleagris Gallopavo*) at two localities in Egypt, namely Sharkia and Cairo Provinces. Few studies were performed on the prevalence of enteric parasites of domestic turkeys in this country. However, the total infection rate with enteric parasites in our study (49.23%) was higher than those recorded previously by Nagwa et al. [16] in Gharbia Governorate,

El-sayed and Raef [19] in Sharkia Province and El-Dakhly et al. [17] in Beni-Suef Province which reached (42.9%), (22%) and (6%), respectively.

Away from Egypt, previous studies of Bahadory et al. [28] and Udoh et al. [29] in Iran and Nigeria, respectively showed higher infection percentages of 75% and 57.7%, respectively. On the other hand, lower percentages were reported by Khalaf [30] in Erbil city, Iraq and Mohammed et al. [31] in Abuja city, Nigeria which was 35.21% and 40% respectively. This variance in infection rates might be due to the differences in environmental, climatic and seasonal conditions, different breeds of turkey and their rearing systems [32]. Also age and sex of infected birds affected occurrence of gastrointestinal parasites in infected birds [33].

Among the found parasites, nematoda had the highest prevalence (53.85%) followed by protozoa (22.31%). This was compatible with Udoh et al. [29] who reported that nematoda had the highest prevalence (31.1%), followed by protozoa (22.4%). Nearly similar rates of nematodes, 46% and 68.25% were reported by Almayali and Al shabani [34] in Diwaniyah Province and Dauda et al. [35] in Nigeria, respectively. Also, Ohaeri & Okwum [36] found that nematoda was the most common parasitic infection in turkeys in Ikwuano, Abia State Nigeria. This might be due to long survival time of eggs and their soil borne transmission pattern of infection [36].

Heterakis gallinarum was the most prevalent nematode type reported in the current study with an infection rate of 34.6%. Higher rates were recorded in Colombia (68.6%) by Montes-Vergara et al. [37], 64% in Pakistan by Ullah et al. [38] and 62% Dhaka city, Bangladesh by Nipu [39]. Lower rates were reported (28.3%) in Punjab, Pakistan by Sadaf et al. [9], (28%) in Erbil city, Iraq by Khalaf [30], (25%) in Nigeria by Jegede et al. [40], (17.39%) in Nigeria by Ola-Fadunsin et al. [33], (16.5%) in Kathmandu, Nepal by Kunwar [41] and 1% in Kaduna State, Nigeria by Udoh et al. [29]. In relation to different Provinces in Egypt, the current study reported higher rate than the previously recorded in Gharbia Governorate (7.1%) [16]. This might be due to difference in foraging habits of domestic turkeys, different management system, low sanitary system, varied environmental conditions, physiological stress, and the age of domestic turkeys [42].

The infection rate with *Trichostrongylus* spp. in the current study reached 5.38%. This finding was lower than that recorded by Khalaf [30] and Hon et al. [43], who reported 16% and 33% infection rates, respectively. The low prevalence of infection recorded in the current study might be due to changes of topography and environmental conditions.

The study showed infection of turkeys with *Capillaria* sp. (13.08%). Higher rates recorded by Montes-Vergara et al. [37] in Colombia (68.2%), 26% by Jegede et al. [40] in Nigeria, 24% by Khalaf [30] in Erbil city, 20.50% by Dauda et al. [35] in Nigeria and 17.5% by Kunwar [41] in Nepal. Lower rates recorded by Singh et al. [44] in India (5%) and Udoh et al. [29] in Nigeria (0.5%). Such variations might be attributed to the low quality of used management systems and control measures in either birds or the surrounding environment [45]. From our opinion, abundance of required intermediate hosts for completion of the life cycle of different *Capillaria* species with indirect life cycles may be a cause for these variations in infection rates in different localities.

In our study, *Strongyloides avium* infection rate reached (0.77%). Higher rates were recorded by Hon et al. [43] in Florida (48%), Jegede et al. [40] in Nigeria (32%), Khalaf [30] in Erbil city, Iraq (12%) and Dauda et al. [35] in Nigeria (2.5%). Variations might be referred to locality, poor hygienic measures and immunological status of birds that affect their susceptibility to infection.

Also, the current study recorded *Eimeria* sp. with infection rate of 18.46%. Higher rates of *Eimeria* sp. recorded by Montes-Vergara et al. [37] in Colombia (90.2%), Trujillo-Peralta et al. [46] in the United States (78.3%), Ola-Fadunsin et al. [33] in Nigeria (78.26%) and Udoh et al. [29] in Nigeria (22.45%). Lower rates recorded by Dezfoulian et al. [47] in Iran (10%).

In our study, *E. meleagrimitis* the total infection rate reached 16.2%. Lower infection rate was reported by El-sayed and Raef [19] in Zagazig city, Sharkia Province (10%). Higher rates recorded by Duff et al. [48] in United States (97.50%), Safiullin et al. [49] in Russia (80%) and Jatau et al. [50] in Nigeria (23.1%). In our study, *E. meleagrimitis* as a single infection rate reached 9.38%. Higher rate of such type of infection was recorded by

Mervat et al. [15] in Sharkia Province (40.91%) in the diseased and (40%) in the apparently healthy turkeys. Concerning with *E. innocua,* total infection rate in this study reached 4.62%. Higher infection rate was recorded by El-sayed & Raef [19] in Zagazig city, Sharkia Province (8%). Lower rate recorded by Jatau et al. [50] in Nigeria (3.8%). *E. adenoeides* total infection rate reached (0.77%) in our study. Higher rates recorded by Duff et al*.* [48] in United States (95%), El-sayed & Raef [20] in Zagazig city, Sharkia Province (14%), Jatau et al. [50] in Nigeria (7.7%) and Safiullin et al. [49] in Russia (5%). *Regarding E. meleagridis* infection rate reached 4.62% in our study. Higher rates were recorded by Jatau et al. [50] in Nigeria (30.8%) and Safiullin et al. [49] in Russia (15%). Such variance in infection rates of turkeys with *Eimeria* sp. might be attributed to the weather conditions including ambient temperature and moisture, the production system and management practices used by the farmers, the functional level of bird protective immunity, presence of a concurrent microbial infection, season of examination of birds for infection rates, and the different prophylactic control measures used against *Eimeria* sp. in the different localities.

In the present study, *Cryptosporidium sp.* infection rate reached 3.08%. Higher rates of *Cryptosporidium sp.* recorded by Siham et al. [51] (41%) in north central Algeria, Jegede et al. [40] in Nigeria (34%), Abdullah [52] in Sulaymaniyah Province, Iraq (22.86%) and Rana et al. [53] in Pakistan (10%). This might be attributed to the difference in the examined localities and environmental factors, as well as the bird susceptibility to infection and resistance of oocysts against the used treatment [54].

Balantidium sp. had been reported in the current study and reached 0.77%. Higher rate was recorded by Hasan et al. [55] who examined faecal samples of 8 turkeys in Bangladesh and found 25% infection rate with *Balantidium coli*. Transmission of infection to turkeys might be resulted from lack of personal hygiene in people or from other infected animals or birds in contact with reared turkeys where the contaminated food and water played a key role as source of infection (fecal–oral route).

In the current study, seasonal variations of infection with enteric parasites showed that *H. gallinarum* showed significant variation in both wet and dry season with a higher value of significant variation in dry season. In agreement with our results, El-Dakhly et al. [17] detected *H. gallinarum* in pigeon in both wet and dry seasons like our finding in domestic turkey; Ara, et al. [56] reported that summer was the peak season for parasitic load in *H. gallinarum*. This might be attributed to that high temperature and relative humidity which were favorable for the development and survival of immature stages of *H. gallinarum*. On the other hand, *H. gallinarum* eggs can remain viable & infective in soil for up to three to four years [57], [58]. *Eimeria sp.* showed significant variation in wet season only. Also, Ola-Fadunsin, et al. [33] reported that the infection rate of coccidiosis was 1.7 times more during the wet season compared to the dry season. While Safiullin et al. [49] stated that seasonality did not affect the invasion of turkeys by *Eimeria* sp. The high infection rate of *Eimeria* during the wet season in our study might be due to climatic conditions which were more suitable for sporulation and survival of coccidian oocysts. In wet season, the total infection rate with double mixed infection with enteric parasites (27.87%) in turkeys was higher than single type (18.03%), followed by triple mixed type (11.48%) and fifth mixed type (1.64%). In dry season single infection rate (30.43%) was higher than double mixed type (5.8%) and triple mixed type (4.35%).

Concerning with co-infections, the present study showed that the number of infected cases with a single parasite generally was more than the mixed infections; also the double type of infection was the only type that showed a statistic difference when compared between wet & dry seasons. Similar results detected higher single infections were previously reported by Khalaf [30] who reported that the single infection (76%) was statistically higher than mixed infection (8%) in turkeys in Erbil city, Iraq; Ola-Fadunsin et al. [33] who reported that single infection rate (47.83%) was higher than double (30.43%), triple (13.04%) and quadruple (4.35%) and Dauda et al. [35] who reported that single infection rate (47.50%) was significantly higher than mixed infection (20.75%). On the other hand, Udoh et al. [29]reported that double infection (32.1%) was higher than single infection (22.9%), followed by triple (26.02%), then by quadruple (13.1%) and finally by pentaple

infection (5.1%) and Mervat et al. [15] who reported that in the diseased turkeys, single infection type (68.75%) was higher than mixed type (31.25%), while in the apparently healthy turkeys the mixed type (54.55%) was higher than single type (45.45%). Differences in Single or mixed infections might be attributed to the different feeding (ration or grasses), different parasitic strains, bird susceptibility, different environmental conditions and sources of contamination [29].

Conclusion

Enteric parasites were found among the domestic turkeys in Egypt and *Eimeria* sp. and *H. gallinarum* recorded the highest rates among the different detected parasites. These enteric parasitic infections of turkeys represent hazardous due to economic losses which results in deficiency of proteins and other nutritional requirements of human. It is necessary to improve the veterinary medical attention and education of turkey farmers on the need to regularly and periodically treat their flocks against enteric parasites using novel and effective medications to improve the economic value of the domestic turkeys industry in Egypt.

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Declaration of Conflict of Interest

The authors declare that there is no conflict of interest.

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