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Intensity of Gastrointestinal Parasites and the Associated Risk Factors and Sero-Prevalence of Hemonchosis among Camels in Egypt

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ABSTRACT

The current study aims to determine the most dominant and zoonotic gastrointestinal parasites (GIPs) affecting camels in Giza Governorate in Egypt, and spotlight on hemonchosis among camels. A total of three hundred live camels at Elmoneib, and Kerdasa regions in Giza Governorate, Egypt were used for parasitological and sero-prevalence surveys, during the period extended from December 2022 to March 2023. Coprolological examination revealed that the overall prevalence of GIPs among camels was 80%. The animals harbored nine parasites including the zonotic ones *Fasciola* sp. (2%), *Schistosoma* sp. (1.7%), *Cryptosporidium* sp. (6.3%), and *Balantidium coli* (4%), furthermore *Strongylida* sp. (51.3%), *Strongyloides* sp. (8%), *Trichuris* sp. (8%), *Moniezia* sp. (2.7%) and *Eimeria* sp. (33.3%). The larvae of *Haemonhcus sp.* were observed in 89.6% (138/154) of the positive samples for strongyles; with 46% (138/300) of the total samples. Young and adult animals were significantly infected with *Eimeria* sp. (68%) and storngyles (54.4%), respectively. The age of the camel is considered a risk factor for *Eimeria* sp. (OR = 4.9157, 95 % CI: 2.041 - 11.8382), *Fasciola* sp. (OR =183.6667, 95 % CI: 9.9761 - 3381.4271) and *Schistosoma* sp. (OR =3.7664 (0.2058 - 68.9247). No significant difference associated with the GIP infection based on camels' sex has been recorded. The seroprevalence of hemonchosis was 93.3%. Moreover, there was a significant correlation between fecal egg count and total immunoglobulin G (IgG) level in the infected sera. The study elicited that GIPs are highly prevalent and *Haemonchus sp.* is the most common gastrointestinal nematode among camels. The IgG response might be used as marker for monitoring the intensity of gastrointestinal nematodes infection. The periodical evaluation of GIPs is of great significance for food security and preventing the transmission of parasitic and zoonotic diseases.

Key words: Camels, Prevalence, Gastrointestinal parasites, Hemonchosis, Seroprevalence, Immunoglobuline G

INTRODUCTION

The camel breeding industry has become a main sector in animal farming in arid and semiarid areas all over the world. With the worldwide camels' population of 40 Bactrian and dromedary million heads, they are deemed significant food animals particularly, in Asia and Africa (Faye 2020). They have been known as domesticated multi-purpose animals utilized for the transport and travel of Bedouins through the ages. Besides, the Camels are source of valuable meat, hair and highly nutritional and protective milk (Sazmand et al. 2019). *Camelus dromedarius* or the one-humped camels are the major common species that represent 95% of the whole population of Old World Camels (FAOSTAT 2019). Egypt has a somewhat limited camel population, approximately 66,228 in the countryside while the annually imported camels reached about 176,000 heads mainly from, East African countries, Ethiopia, and Sudan (Elfadaly 2016).

Gastrointestinal parasitic infection is one of the most common obstacles among the camel population worldwide (Guowu et al. 2020; El-Seify et al. 2021; Bouasla et al. 2023).

Besides, camels are notable sources of zoonotic diseases that are transmitted to human through contamination, especially in communities with inefficient sanitation and medical interferences (Sazmand et al. 2019; Maxamhud et al. 2023). Gastrointestinal parasites including protozoa and helminthes, can result in nutritional and immune impairment, poor growth, and adversely affect camels health and productivity (Ederli and de Oliveira 2015; Niaz et al. 2023; Hussein and Musse 2023).

Among gastrointestinal parasitic infections, hemonchosis caused by *Haemonchus* sp. is considered the most prevalent and pathogenic with a major economic loss

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among camels (Fadhil et al. 2018; Hassan et al. 2021). It is the blood-sucking abomasal nematode causing anemia, gastrointestinal disturbance, and mortalities in heavy infection of young animals (Soulsby 1968; Hassan et al. 2021; Arsenopoulos et al. 2021). The most widespread species detected in camels' abomasa are *Haemonchus longistipes* and *Haemonchus contortus* (Brasil et al. 2012; Hussain et al. 2014). *Haemonchus* sp. is a multidrug-resistant and the annual treatments of hamonchosis are causing severe financial losses all over the world (McRae et al. 2014).

Defining gastrointestinal parasites infecting animals depends mainly on observation of clinical signs, fecal examination, fecal culture, identification of infective larvae, and postmortem investigation. Coproculture has been the fundamental method to assign *Haemonchus* sp. in feces of infected animals due to the inability to morphologically differentiate between Trichostrongylid egg kinds, but this approach claims a skilled technician and takes several days (Soulsby 1986).

Indirect-ELISA is one of the beneficial serologic techniques that can be achieved for mass screening of parasitic infections among the population (Demeler et al. 2012; Gowda 2016; El-Shanawany 2021; El Shanawany et al. 2019; Hassan et al. 2022).

ELISA is more sensitive for the development of epidemiological surveys than coprological examination which is confined to patent infection so revealing of circulating antigens of the parasite in the blood of the host would be an ideal approach for accurate diagnosis. Various *Haemonchus* antigens showed variable degrees of sensitivity and specificity in monitoring the host anti-*Haemonchus* antibodies and could be used to detect hemonchosis (Arab et al. 2013; El Shanawany et al. 2019; Hassan et al. 2019). Immunoglobulin G (IgG) represents about 80% of the total immunoglobulins in serum. The IgG response is deemed one of the unique markers for *Haemonchus*- caused parasitism (Mcrae et al. 2015). Periodical study of gastrointestinal parasites infecting animals in different localities is essential for epidemiological baseline data and planning an efficient control strategy. Therefore, the present study aimed to determine the most dominant, and zoonotic gastrointestinal parasites affecting camels in Giza Governorate in Egypt, through parasitological approaches, and spotlight up on the most prevalent and pathogenic *Hemonchus* sp. through serological investigations' strateg.

MATERIALS AND METHODS

Ethical approval

Ethical permission for the use of animals was approved by institutional guidelines of the National Research Centre's Animal Research Committee (2474052023). All procedures involving animals were performed solely by licensed personnel.

The study locality and animals

The study was conducted at Elmoneib, and Kerdasa regions in Giza Governorate, Egypt (29° 16′ N 29° 40′E/29.26° N 29.67°E). A total of three hundred live camels were used during the period extended from December 2022 to March 2023 at Winter Season. The sampling of the used animals was handled during the quarantine period that is usually required before slaughtering. For each animal, the sampling date, age and sex were recorded. The study included 75 females and 225 males of age ranged about from 2 to 5 years old.

Clinical inspection

Clinical examination was carried out thoroughly for all the animals in this study.

Parasitological survey

Fecal samples

Fecal samples were collected from each camel and labeled for identification in the Laboratory of Parasitology and Animal Diseases Department, National Research Centre, Giza, Egypt. A fecal sample was obtained from each animal directly from the rectum using a sterile plastic glove; the sample was then placed in a plastic cup and transported to the laboratory into an icebox to be transferred within 2–3 h. The collected samples were prepared and examined on the day of collection.

Coprological examination

Each fecal sample was divided, labeled and kept at 4°C to be undergone different investigations. The fecal sample has been checked employing the concentration sedimentation technique (Zajac and Conboy 2012) and the concentration floatation technique utilized a saturated salt solution (Cebra and Stang 2008). The modified Ziehl–Neelsen staining technique was also utilized to detect *Cryptosporidia* sp. adopted by Garcia et al. (1983) and Current and Reese (1986). Identification of parasite stages has relied on their morphological characteristics as reported by Urquhart et al. (1996). Images of the detected ova/oocyst were taken directly by utilizing a digital camera (Leica microsystems, CH-9435 Heebrugg, Ec3, Singapore). Fecal culture was carried out for each positive strongyles fecal samples to detect *Haemonchus* sp. larvae as described by Hassan et al. (2021). Shortly, the fecal samples were used to make fecal culture by adding sand, saw wood, and a few drops of tap water then covered with perforated aluminum foils to maintain air entrance. The culture was kept for 7 days at 25-27ºC with daily mixing and adding of few drops of water to keep humidity. The larval collection was done using the Bearman technique. Larval suspension was added to 1-2% formalin and heat at 56°C for 1 min then, microscopic identification of larvae was performed according to van Wyk et al. (2004) and van Wyk and Mayhew (2013).

Hemonchosis sero-prevalence

Adult *Haemonchus* sp.

Abomsa of slaughtered naturally infected camels at the Elmonib abattoir, Giza Governorate were inspected. Adult worms of *Haemonchus* sp. were recovered according to Soulsby 1982. Worms thoroughly washed using PBS pH 7.2 and kept at -20°C till used in antigen prepration.

Blood samples

Blood samples were assembled from each animal in this study and labelled. The serum samples were separated by centrifugation, aliquoted, and stored in the deep freezer at −20°C. To assign the positive sera, blood samples

collected from camels whose abomasa had been exposed to postmortem investigation and found positive for *Haemonchus* sp. (gold standard) were considered the positive sera. Blood samples from one day old newly born camels were collected and used for the preparation of negative sera.

Antigen

The antigen was prepared by following the procedure of Prasad et al. (2007) with slight modification. The collected *Haemonchus* sp. worms were washed thoroughly in 0.15M phosphate-buffered saline PBs (pH 7.2). Then the worms were transferred to a screw-capped vial containing 0.15 M PBs (pH 7.2). The worms were sonicated three times for 20 s each time at 100 mAmp less than 4°C. The suspension was centrifuged at 12000rpm for 30 minutes in a cooling centrifuge (4°C). Supernatant soluble antigen extract was collected. The protein content of the prepared antigen was measured by Lowry et al. (1951). Antigen was aliquoted and stored at −20°C till further use.

Enzyme-linked immunosorbent assay (ELISA)

Indirect-ELISA was used to detect antibodies against *Haemonchus* sp. infection in camel. The working dilutions of conjugate, antigen and test sera were determined before use by checkerboard titrations. ELISA was done as described by Oldham (1983) and Connick et al. (2023). Briefly, the ELISA plate was coated with 100ìl somatic antigen in a coating buffer with a concentration 30 ìg /ml. The plate was incubated at 4°C overnight and washed thrice with washing buffer. Then incubated at 37°C for 1 h after adding 100ìl of blocking buffer and washed thrice with PBS Tween-20. The serum sample was used in dilution 1:100, and then incubated for 1 h at 37°C. After washing, the conjugate was added to protein A horse raddish peroxidase (100 ìl/well) (Sigma Chem. Co. St. Louis) and incubate for 1 h at 37°C. Then, substrate (100 ìl/well) (Ortho-phenylenediamine) was added, and finally the absorbance values were read in ELISA reader (ELX 800TM microplate reader) at 450nm. The cutoff point of optical density values was determined as described by El Shanawany et al. (2019) and Hegazi et al. (2023).

Association of IgG response and fecal egg conut

Detection of a correlation between serum IgG level and the number of egg per gram was conducted using pearson correlation as a marker for gastrointestinal nematode infection intensity. Thirty fecal samples belonged to camels which revealed varies degree of IgG response via the pervious ELISA have been used. Fecal egg count was performed for the selected animals utilizing MacMaster technique according to Soulsby (1986). The correlation between OD value of camel sera and the number of egg per gram in feces has been demonstrated.

Statistical analyses

The prevalence was recorded as a percentage of a number of animals infected in the total number of animals examined. Data were summarized by descriptive statistics for the overall prevalence in camels. A Chi-square test was used to check the association of gastrointestinal parasitic infection with age and sex of tested camel group. Variables were significant at $p \leq 0.05$. ORs (odds ratios) were reported to compare risks. Pearson's correlation coefficient (r) was performed to evaluate the association between the number of egg per gram and IgG level. All statistics were analyzed and graphs were plotted using GraphPad Prism version 6.0 (GraphPad Software, La Jolla, CA, USA).

RESULTS

Clinical investigation

The animals in the experiment showed signs of illness like diarrhea, rough coats, soft feces, weakness, and in appetence. They were used as they were more likely to be infected with gastrointestinal parasitic infections.

Parasitological survey

Out of the 300 examined camels, 240(80%) were infected with one or more types of gastrointestinal parasites. Overall infection was 80.4% (181/225) and 78.7% (59/75) in males and females, respectively. Overall mixed infection was 44% (132/300)) whereas reached in males 41.8% (94/225) and in females 50.7% (38/75). Total nematodes infection was 67.3% (202/300), total trematodes infection 3.7% (11/300), cestodes infection 2.7% (8/300) whereas total protozoa infection reached 43.7% (131/300).

Different detected ova and oocysts of the parasitic infection were demonstrated in Fig. 1. The detected trematodes species were *Fasciola* sp. (2%) and *Schitosoma* sp. (1.7%). The nematodes-infected camels were species that belonged to *Strongyles* group (51.3%), *Strongyloida* sp. (8%) and *Trichuris* sp. (8%). It was recorded that *Moneizia* sp. (2.7%) was the only detected cestode. The protozoal infection was included *Eimeria* sp. 33.3%, *Cryptosporidium* sp. (6.3%), and *Blantidium coli* (4%). *Eimeria* species were continuously detected mixed with other infections.

Fecal examination revealed that *Strongylida* sp. was the highest prevalent ones infecting camels 51.3% (154/300). The examination of larvae from the fecal samples that were positive for strongyles revealed 89.6% (138/154) of them had *Haemonhcus* sp. larvae; with 46% (138/300) of the total samples.

It was found that camels less than three years old had the lowest nematode infectivity percentage where it is recorded 20% (5/25). Meanwhile, older camels harbor nematodes as 71.6% (197/275), besides they had the highest prevalence of strongyle 54.5% ($P<0.05$) as demonstrated in Table 1. There were no significant differences between different ages regarding infection with trematodes whereas reached 3.6 and 4% in young and adult camels, respectively. Whereas *Fasciola* sp. was found only in adult older camels, meanwhile *Schistosoma* sp. was detected in young 4% and adult 1.8%. Furthermore, calf camels had the highest protozoa infection 76% (19/25) contrary to 40.7% (112/275) in adults. The coprological examination exhibited a significant high prevalence of *Eimeria* sp. among young camels 68% and the infection rate of *Cryptosporidium* sp. was 4% while they were reported as 30.1% and 6.5% in adults, respectively.

Concerning sex, in she-camels, the infection rate of the trematodes was 1.3% where the characteristic eggs of *Fasciola* sp. were obviously observed. Meanwhile the prevalence of cestodal worm; *Monezia* sp. was 2.7% Moreover, nematodes infection reached 66% (50/75) and

Table 1: Intensity of gastrointestinal parasite infections among camels in Giza Governorate, Egypt stratified by age and sex between December 2022 to March 2023

PGI	Male		Female		$\chi 2$	P value	<3years		>3years		$\chi 2$	P value
	N= 225		N=75				N= 25		N= 275			
	n	%	n	%			n	%	n	%		
Fasciola sp.	5	2.2	1	1.3	0.333	0.564	---	---	6	2.2	---	----
Schistosoma sp.	5	2.2	---	---	---	----	1	4	4	1.8	0.667	0.414
Moniezia sp.	6	2.7	2	2.7	0.000	1.000	1	4	7	2.5	0.143	0.705
Strongylida sp.	115	51.1	39	52	0.010	0.922	4	16	150	54.5	21.423	<0.001*
Trichuris sp.	19	8.4	5	6.7	0.067	0.796	1	4	23	8.36	1.333	0.248
Strongyloides sp.	18	8	6	8	0.000	1.000	---	---	24	8.7	---	----
Balantidium coli	8	3.6	4	5.3	0.111	0.739	1	4	11	4	0.0	1.0
Eimeria sp.	75	33.3	25	33.3	0.000	1.000	17	68	83	30.1	14.735	<0.001*
Cryptosporidium sp.	14	6.2	5	6.7	0.077	0.782	1	4	18	6.5	0.818	0.366

*P<0.05; statistically significant. N= total number of cases: Write P value as shown in green font

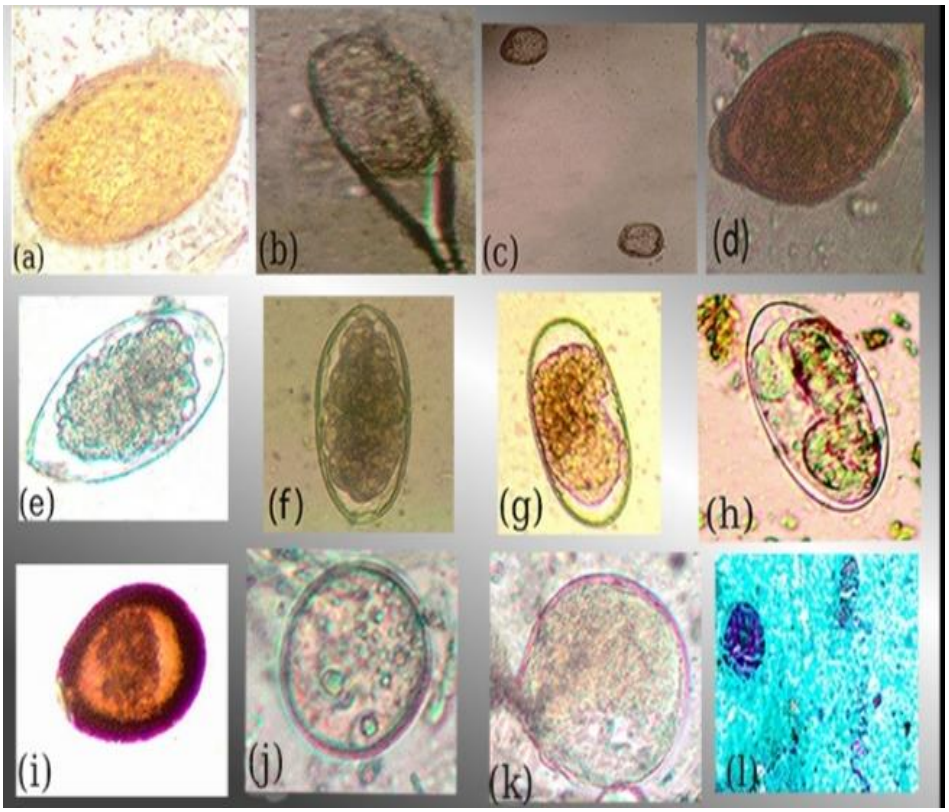

Fig. 1: Micrograph of the helminthes ova and protozoa oocysts detected in camels in Giza Governorate Egypt;
(a). *Fasciola sp*., (b). *Schistosoma sp*., (c). *Moniezia sp*., (d). *Trichuris sp*., (e-f-g). *Strongylida sp*, (h). *Strongyloides sp*., (i-j). *Eimeria sp*., (k). *Balantidium coli*, (l). *Cryptosporidium sp*..

they included *Strongylida* sp., *Trichuris* sp. and *Strongyloides* sp. with 52, %6.7% and 8%, respectively. Protozoal infection reached 45.3% (34/75) and involved *Balantidium coli* 5.3%, *Eimeria* sp. 33.3% and *Cryptosporidium* sp. 6.7%. The prevalence of trematodes in male camels reached 4.4% where *Fasciola* sp. 2.2% and *Shistosoma* sp. 2.2% were detected. Nematodiasis was recorded at 67.5% and include *Strongylida* sp. 51.1%, *Trichuris* sp. 8.4% and *Strongyloides* sp. 8%. The protozoa were recovered in 43.1%, separately; *Balantidium coli* 3.6%, *Eimeria* sp. 33.3%, and *Cryptosporidium* sp. 6.2%. Meanwhile prevalence of cestodes male camels was 2.7% and *Monezia* sp. was the only one found. No significant difference (p>0.05) has been recorded depending on the sex of the infected camels as presented in Table 1.

The risk factor associated with gastrointestinal parasitic infection in relation to the age and sex of studied camel groups was analyzed using odds ratio calculation (Table 2, Fig. 2). The age is considered a risk factor for camel's infection with *Eimeria* sp. (OR = 4.9157, 95 % CI: 2.041 - 11.8382) and *Fasciola* sp. (OR=183.6667, 95 % CI: 9.9761 - 3381.4271). Moreover, infection of young camel with *Schistosoma* sp. shows the highest risk factor in comparison with infection with other gastrointestinal parasites (OR =3.7664 (0.2058-68.9247). However, sex of infected camels shows no risk of being infected with *Emeria* sp. (OR=1, 95 % CI: 0.5744-1.7408).

Sero-prevalence of *Haemonchus* sp. infection in camel by ELISA

The seroprevalence of *Haemonchus* sp. infection by detecting circulating IgG antibodies in tested camel sera was demonstrated in Fig. 3. Out of a total of 300 serum samples, 93.3% (280) were seropositive by Indirect-ELISA using somatic antigen in Giza Governorate, Egypt. There was a complete agreement 100% between the results of positive samples for *Haemonchus* sp. (138/154) through larval examination, with the results that were obtained by indirect ELISA. The study detected that there were sixteen animals (16/154) found to be negative for *Haemonchus* sp. larvae, while they were being positive using ELSA. This indicated occurrence of false negative results using fecal culture.

Table 2: Association between gastrointestinal parasitic infection and risk factors related to age and sex of studied camels group in Giza Governorate, Egypt between December 2022 to March 2023

Parasitic infection/risk factors	Age		Sex	
	< 3 year	> 3 years	Male	Female
Emeria sp.				
Positive N=100 n (%)	17(17)	83(83)	75 (75)	25 (25)
Negative N=200 n (%)	8(4)	192(96)	150 (50)	75 (25)
P value ($\chi 2$)	0.0012 (14.7)		1.00 (0000)	
OR (95 % CI)	4.9157 (2.041 - 11.8382)		1.000 (0.5744 - 1.7408)	
Strongylida sp.				
Positive N=154 n (%)	4 (2.6)	150 (92.4)	115 (74.7)	25.3 (36%)
Negative N=146 n (%)	21 (14.4)	125 (85.6)	110(75.3)	24.7(16.9)
P value ($\chi 2$)	0.00		0.9	
OR (95 % CI)	0.1587 (0.0531 - 0.4746)		0.9650 (0.5720 -1.6281)	
Cryptosporidium sp.				
Positive N=19 n (%)	1 (5.2)	18 (94.7)	14 (73.6)	5 (26.3)
Negative N=281 n (%)	24(8.5)	257 (91.4)	211 (75)	70 (24.9)
P value ($\chi 2$)	0.61686 (0.2503)		0.89114 (0.0187)	
OR (95 % CI)	0.5949(0.0761 - 4.6523)		0.9289 (0.3230 - 2.6713)	
Balantidium coli				
Positive N=12 n (%)	1 (8.3)	11 (91.6)	8 (66.6)	4 (33.3)
Negative N=288 n (%)	24(8.3)	264(91.6)	217(75.3)	71(24.6)
P value ($\chi 2$)	1.0 (000)		0.496(0.463)	
OR (95 % CI)	1.0000 (0.1238 - 8.0798)		0.6544 (0.1913- 2.2383)	
Strongyloides sp.				
Positive N=24 n (%)	0	24 (100)	18 (75)	6(25)
Negative N=276 n (%)	25(9)	251(91.2)	207 (75)	69 (25)
P value ($\chi 2$)	0.2668(--)		1.00 (0.00)	
OR (95 % CI)	0.2013 (0.0119 - 3.4090)		1.0000 (0.3816 - 2.6203)	
Trichuris sp.				
Positive N=24 n (%)	1(4.1)	23(95.8)	19 (79.1)	5(20.8)
Negative N=276 n (%)	24 (8.6)	252 (91.3)	206 (74.6)	70 (25.3)
P value ($\chi 2$)	0.4413(0.59)		0.623 (0.24)	
OR (95 % CI)	0.4565(0.0590 - 3.5302)		1.2913 (0.4648 - 3.5873)	
Schistosoma sp.				
Positive N=5 n (%)	1 (20)	4(80)	5(100)	0 (0)
Negative N=295 n (%)	24 (8.1)	271(91.8)	220 (74.5)	75 (25.4)
P value ($\chi 2$)	0.3619 (0.906)		0.3712 (--)	
OR (95 % CI)	2.8229 (0.3033 - 26.2724)		3.7664 (0.2058 - 68.9247)	
Fasciola sp.				
Positive N=6 n (%)	6 (100)	19 (6.4)	5 (83.3)	1 (16.6)
Negative N=294 n (%)	0 (0)	275 (93.5)	220 (74.8)	74 (25.1)
P value ($\chi 2$)	0.0005 (--)		183.6667 (0.2268)	
OR (95 % CI)	0.6376 (0.2268)		1.6818 (0.1933 - 14.6295)	

N= total number of cases. n = Number of cases found positive or negative for the parasites found in feces sample of examined camels. OR, odd ratios. *p<0.05 statistically significant factors.

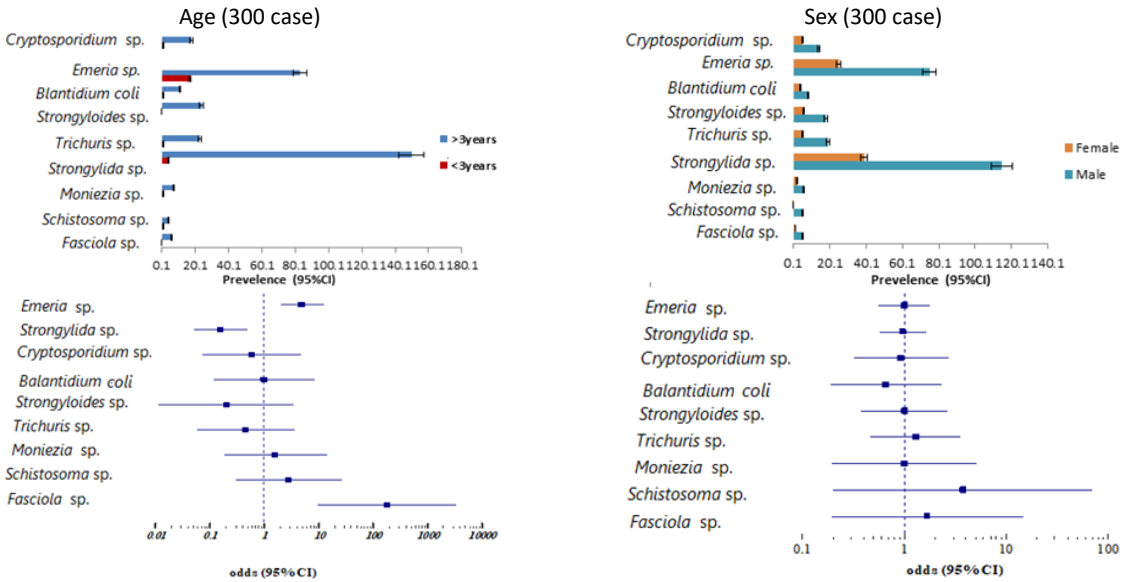

Fig. 2: Prevalence rates and adjusted odds ratios (OR) with 95 % confidence intervals (CIs) for infection with gastrointestinal parasites in camels in Giza Governorate, Egypt.

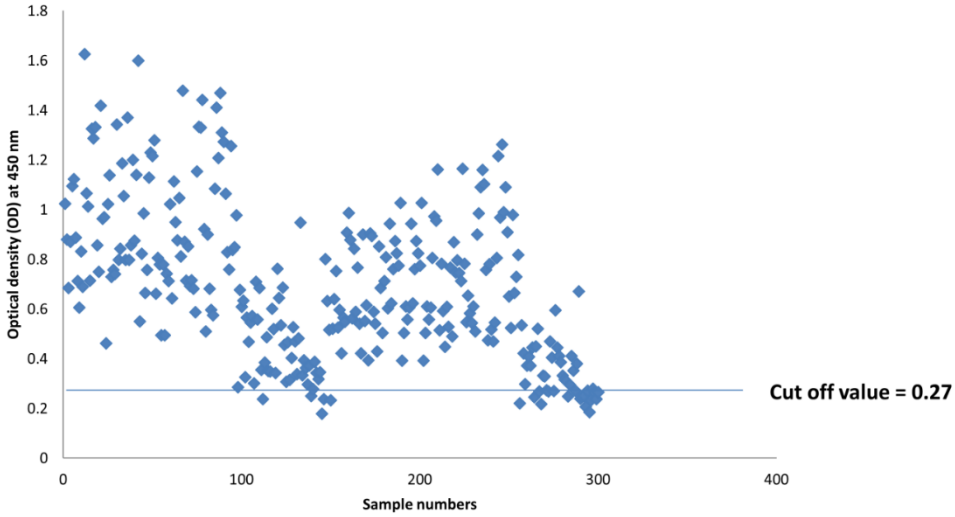

Fig 3: Sero-prevalence of *Haemonchus* sp infection by detecting circulating IgG antibodies in camel using indirect ELISA in Giza Governorate, Egypt. The cut off value for seropositivity was 0.27.

Correlation of serum IgG level and the number of egg per gram

The Pearson correlation results show that there was a strong significant ($p<0.001$) positive association $r = 0.9486$ between fecal egg count per gram which varied from (2500 to 9500) and optical density of total IgG measured by indirect- ELISA. The results are presented in Fig. 4.

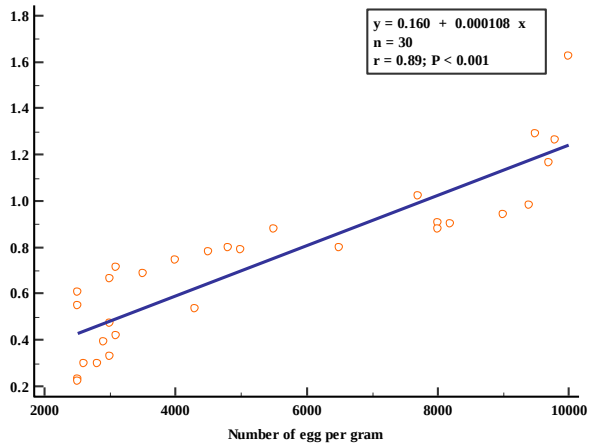

Fig. 4: Correlation analysis association between intensity of egg count per gram and OD values at 450 nm of Camels'sera.

DISCUSSION

Infection with gastrointestinal parasites seriously threatens the growth and development of camels and causes great economic losses. In the current study, the parasitological examination showed that camels harbored 9 parasites including *Fasciola* sp., *Schistosoma* sp., *Strongylida* sp., *Strongyloides* sp., *Trichuris* sp., *Moniezia* sp,, *Cryptosporidium* sp., *Eimeria* sp. and *Balantidium coli.* The overall prevalence of gastrointestinal parasitic infection reached 80% among dromedary camels in Giza Governorate, Egypt. This result might be in accordance with those obtained by Mahmuda et al. (2014) in Nigeria (78%); Hamed (2018) in Assiut Governorate Egypt (77.5%); Bekele et al. (2022) in Ethiopia (76%); Djerbouh et al. (2018) in Ethiopia (73.8%); El-Khabaz et al. (2019) in Egypt (60%). Meanwhile, relatively low incidence of infection was recorded by Ahmed et al. (2013) Qaluobia Governorate in Egypt (51.02%); Bouasla et al. (2023) in Algeria (32.6%) and Azhar et al. (2013) in Pakistan (37.33%). The differences in the prevalence of gastrointestinal parasitic infection between studies might be due to differences in the age, species, climatic conditions, and management and husbandry methods of camels. Thus, gastrointestinal parasitic infection is considered a worldwide obstacle among camels.

This study disclosed that protozoa infections contributed heavily to the parasitic load among the examined camels. It was found that overall protozoa infection rate was 43.7%, for young was 76% meanwhile it reached 40.7% in adults. Among protozoa infection, *Eimeria* sp. was dominant (33.3%). This result might be more or less similar to those obtained by Utebaeva et al. (2021) who reported *Eimeria* sp. as one of the most enteric infections with an overall prevalence of 42.5% among camels in the Turkestan region of the Republic of Kazakhstan. Moreover, Metwally et al. (2020) studied eimeriosis among camels in Saudi Arabia and found that the prevalence of oocysts in Riyadh 33.89% and Al-Qassim 38.46%. Meanwhile, El-Khabaz et al. (2019) stated that 28.3% of imported camels to Egypt from Sudan in Abu-Simbel quarantine station, Aswan governorate were positive for eimeriosis. Meanwhile these results revealed that eimeriosis was found significantly among young camels 68% while in adults recorded 30.1%. These might be go parallel with the results obtained by Abou El-Naga and Barghash (2016); Narnaware et al. (2017); Utebaeva et al. (2021) reported that young camels were more susceptible for *Eimeria* sp. than adults and caused enteritis with higher morbidity and mortality.

Zoonotic parasites of camels are able to contaminate milk and meat, which represent threats to food safety and the health of herders (Sazmand et al. 2019). The coprolgical examination proved that camels under the experiment were infected with parasites of zoonotic concerns which could transmit to humans causing severe and various pathological manifestations including *Balantidium coli* (Khodakaram-Tafti et al. 2001; Tajik et al. 2013), *Cryptosporidium* sp. (Wernery et al. 2014; Sazmand and Joachim 2017; Cao et al. 2020), *Fasciola* sp. (El-Khabaz et al. 2019) and *Schistosoma* sp. (Islam et al. 2019). Therefore, the periodical assessment of the

prevalence of gastrointestinal parasites in camels is of great significance for food security and preventing the transmission of parasitic zoonotic diseases.

The parasitological study showed that nematodes were the most prevalent gastrointestinal parasites infecting camels (67.3%). Of them the overall strongyles group infection was 51.3%. These results go parallel with that reported by Radfar and Gowhari (2013) who detected nematodes prevalence among camels as 64 % in Kerman and Yazd provinces of Iran, and El-Dakhly et al. (2020) who reported rate of gastrointestinal nematodes of 45.96% in El-Warrak abattoir, Giza Governorate. Regarding the age, in the current study older camels had the highest prevalence of strongyles group 54.5% ($p< 0.05$). That might go parallel with previous reports (Ahmed et al. 2020; Hasan et al. 2021; Bekele et al. 2022) who declared that older camels were more likely to possess GIPs. It might be due to that by increasing the age of camels, there would be more exposure to the infection.

This study revealed that the age of the camel was found to be a risk factor for camel's infection with gastrointestinal parasites particularly *Eimeria* sp. and *Fasciola* sp. in older camels and *Schistosoma* sp. in young camels. Similarly, Ararsa et al. (2014) and Guowu et al. (2020) reported that age might be a risk factor for the high prevalent gastrointestinal parasites infectivity among camels. Other reports observed no association between age of the host and the prevalence of the parasites (Parmar et al. 2019; Bouragba et al. 2020). Concerning sex of animals, there was no statistically significant difference in gastrointestinal parasitic infection ($p>0.05$) between males and females, that was similar to the results obtained by Ahmed et al. (2020); Parmar et al. (21019) and Bouragba et al. (2020). Meanwhile, Wakil et al. (2017) detected a significant association between sex and prevalence of parasites.

Hemonchosis is one of the major diseases among animals that leads to anemia, due to the blood-sucking activity of *Haemonchus* sp. and consequently, death of the infected animals especially young ones (Hassan and Ghazy 2022). The examination of larvae from the fecal samples that were positive for strongyles revealed 89.6% (138/154) of them had *Haemonhcus* sp. larvae; with (138/300) 46% of the total sample. Therefore, this study disclosed that *Haemonchus* sp. is the most common gastrointestinal nematode infecting camels. These results might go parallel with Guowu et al. (2020) who studied the incidence of gastrointestinal infection in camels in the Tianshan Mountains pastoral region in China and found that 88.1% of animals were infected with hemonchosis. While Radfar and Gowhari (2013) in Kerman and Yazd provinces of Iran found that 38% of camels were infected with *Haemonchus* sp. Besides, Sazmand and Joachim (2017) who mentioned that *Trichostrongylus* sp. and *Haemonchus contortus* are the most common species infecting camels.

The present study declared that the seroprevalence of *Haemonchus* sp. infection among camels reached 280/300 (93.3%). There were 16 out of 154 fecal samples; that were positive for strongyles, gave negative results for *Haemonchus sp.* using larval examination, while they were positive through ELISA. This pointed to presence of false negative results through the coprological examination. The absence of helminths egg in feces while animals are being positive through ELISA might be owing to the presence of arrested larvae in the tissue of the intestine (Jacquiet et al. 1995) and/or a previous infection then after, animals had undergone self-cure phenomenon (Soulsby 1986). Moreover, when animals are being at the pre-patent period of infection; before egg shedding, both 4th stage larvae and immature worms have the capability of sucking blood therefore antigens will be circulating in the host's blood (Soulsby 1986; Armour et al. 1996).

Besides, Cuquerella et al. (1994) reported the major spread of cross-reactivity among various gastrointestinal nematodes and animals in pasture mostly had mixed infection. The phenotypic association might act on the correlation between two traits and is relied both on genetic and of environmental impacts (Searle 1961; Aboshady et al. 2020).

The present study showed strong significant ($p<0.0001$) positive association $r = 0.9486$ between fecal egg count per gram and optical density of total IgG measured by indirect- ELISA. That was coincided with Stear et al. (1995) who mentioned a strong correlation between immunoglobulins and worm burden in an experiment conducted on sheep. Moreover, Amarante et al. (2009) noticed an elevation in the IgG level in the infection of hemonchosis and it paralleled with the mean FEC. This elevation of IgG level might be related to the increase worm burden, the resulted inflammatory conditions in the infected abomasa and the repeated or long term infection, chronic natural infection in pasture.

Conclusion

It is concluded that the examined camels were heavily infected with GIPs. This study disclosed that *Eimeria* sp. and strongyles infections contributed seriously in the parasitic load among the examined camels particularly young and adult ones, respectively. *Haemonchus* sp. is the most prevalent gastrointestinal nematode. IgG response against gastrointestinal nematodes infection might play a major role in resistance to nematodes besides, being a biomarker for assessing the intensity of infection. The periodical evaluation of the prevalence of GIPs is of great significance for food security and preventing the transmission of parasitic zoonotic diseases.

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Conflict of interest

According to the researcher, no conflicts of interest are associated with the publication of this article.

Authors' contribution

NMFH and EEE designed the experiment and the plan of work. NMFH, NMTA, AMA, collected the required samples. EEE, NMFH and AE performed the laboratory experimental procedures. NMFH and EEE edited and reviewed the manuscript. All authors read and approved the final manuscript.

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