



Clinical and Biochemical Assessment of *Eimeria* Infection in Goats at Sohag Governorate

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ABSTRACT

Eimeriosis is an important enteric disease caused by a protozoon named *Eimeria* that affects a wide range of animal species. Specifically in small ruminants, this parasite has global economic importance in young animals, particularly those reared in high densities. This study aimed to investigate *Eimeria* infection in goats. One hundred (100) goats of the local breed have been surveyed. Fecal and blood samples were collected from each animal. Fecal samples were examined microscopically after applying the standard fecal flotation technique. Herein, we detected about 63% *Eimeria* spp. infection among goats in Sohag governorate at Southern Egypt. In addition, the clinical manifestation of Eimeriosis in infected goats was recorded. Liver enzymes, blood proteins including total protein and albumin, and calcium levels were measured by spectrophotometer in sera of infected goats. Results indicated an elevation of ALT and AST enzymes in sera of infected male kids and pregnant goats. This study highlights the importance of the altered biochemical profile as an indicator of the possible liver dysfunction resulting from *Eimeria* infection in goats. The overall findings reflect significant environmental contamination that continues to pose hazards on animal health and represent a major challenge for small ruminant production under the current raising conditions in Sohag villages.

Keywords: Egypt, *Eimeria* infection, Goats, Liver enzymes, Sohag.

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INTRODUCTION

Goats are widely distributed small ruminants in Africa, because of their unique adaptation to survive in harsh conditions of hot and dry environments. In Egypt, goats are multipurpose animals that provide an important source of milk, meat, and hair (Aboul-Naga *et al.*, 2012). Gastrointestinal tract (GIT) parasites are considered major threats to the small ruminants industry because of the economic losses and mortalities in severe cases. A variety of GIT parasites can infect goats. Protozoal infections are frequently encountered problems in goats and represent one of the major challenges in raising cattle, sheep, and goats. Clinically, Eimeriosis is characterized by enteritis, anemia, emaciation, dehydration and even death in severe cases. Consequently, growth rate, body weight and reproductive performance of goats are greatly affected leading to huge economic losses for farmers

and breeders (Sharma *et al.*, 2014, Hassan *et al.*, 2019).

Eimeriosis produces both acute and chronic damage to GIT and increases the susceptibility to secondary infections. Infected young animals usually pass liquid feces containing mucus or blood, show marked emaciation, and sometimes death occurs in severe cases (Constable *et al.*, 2017). On the contrary, older animals are usually affected by the subclinical form of Eimeriosis, which is reflected by growth impairment as a main sign. In addition, subclinical cases act as carriers, passing the oocysts in their feces without demonstrating clinical manifestations and contaminating the environment (Chartier and Paraud, 2012). *Eimeria* species (spp.) can be transmitted orally via ingestion of contaminated water or feed (Constable *et al.*, 2017 and Bangoura and Bardsley 2020). Some studies had been previously

performed in Egypt to investigate the prevalences of *Eimeria* spp. infections among goats in several governorates as in Saint Katherine's Protectorate, Suez, Giza and Southern Egypt, respectively (Soliman and Zalal, 2003; Mohamaden *et al.*, 2018; Hassan *et al.*, 2019 and Abdelaziz *et al.*, 2021).

The present study aims to record the infection rate of *Eimeria* spp. in goats at Sohag governorate. Additionally, detailed clinical examination and fecal analyses were performed along with biochemical analyses of protein levels and liver enzymes in sera of the infected cases.

MATERIALS AND METHODS

1. Study area and sample collection:

Sohag governorate was the target for this survey. A collection of 100 samples from goats of local breeds, both sexes and of different ages, was performed. Detailed information of all diseased animals is mentioned in Table (1). Suspected cases were examined in the field or at Sohag Veterinary Hospital, Department of Animal Medicine, Faculty of Veterinary Medicine. Sample collection was carried out between Feb. 2018 and Oct. 2020. According to (Blagburn and Butler, 2006, Kaplan and Nielsen, 2010), complete clinical examinations and fecal analysis employing standard techniques such as direct, floatation, and sedimentation were performed. Moreover, all clinical manifestations exhibited by diseased goats were registered.

2. Clinical examination of goat cases:

General observation and case history were performed for each case. Owner consents for questionnaire and examination of animal included the following information (age, general health status, current problem, disease history, rearing conditions, and presence of other animals). Body temperature measurement and physical examination were performed. Goats that showed one or more of these signs (emaciation, diarrhea, loss of hair, and inappetence) were included in this study.

3. Fecal analysis:

The fecal samples were collected directly from the rectum of each animal using a disposable glove and then placed into a sterile plastic cup. The date of sampling and goats information including sex, age, and identifying number for each case, were labeled on cups. The samples were transferred directly on the same collection day to the laboratory in an airtight box cooled with dry ice packs and then stored at 4 °C until analyses. A standard floatation test using saturated sucrose solution was used to detect *Eimeria* spp. by light microscope and (x 40) magnitude (Blagburn and Butler, 2006, Kaplan and Nielsen, 2010).

4. Biochemical analyses:

Five mL of blood was drained from the jugular vein of each animal and serum was extracted and stored at -20°C until use. Biochemical analysis of serum samples was performed to estimate levels of liver enzymes such as alkaline phosphate (ALP), aspartate aminotransferase (AST) and alanine aminotransferase (ALT). All enzymes were determined kinetically using Digital Ultraviolet Spectrophotometer (CE 790 KD NO 19 v4.74A. Shenzhen Kindle Medical Devices Co., Ltd, China) and according to manufacturer instructions of the specific kit of each enzyme (Wiesbaden, Germany). In addition, total protein, albumin, globulin and serum calcium level were determined calorimetrically using Digital Ultraviolet Spectrophotometer using the same apparatus and the specific kit (Hannover, Germany).

5. Statistical analysis:

The analysis of statistics was done using (SPSS) program. The student *t*-test (IBM Corp., 2012, Armonk, NY, USA, statistics version 21 for Windows.) was employed. Data will be presented as a mean ± standard error of the mean. *P*- values will be mentioned.

RESULTS

Clinical presentation of surveyed animals:

Results showed that the total number of infected goats with *Eimeria* spp. was 63/100 with an infection rate of (63%). All infected cases were determined to have unsporulated *Eimeria* spp. oocysts in fecal flotations (Fig. 1). Based on the ages of the infected goats, they were divided into two subgroups, less than 1 year and between 1-5 years of both sexes male (15/63) and female (48/63). Data of infected goats are shown in Table. 1. The most prominent clinical findings of infected goats with *Eimeria* spp. were diarrhea in 14/63 (22.2%), fever 7/63 (11.1%) and hair loss in 32/63 (50.8%). Emaciation and poor body conditions were noticeable in 29/63 (46.0%) (Fig. 2 a and b).

Table 1: Infection rate of Eimeriosis in goats according to animal's age and status.

Sex	Male		Female				
	15		48				
Age	< 1 year	1-5 years	< 1 year	1-5 year			
				36			
			Pregnant		Non pregnant		
			5		31		
		Lactating	Non lactating	Lactating	Non lactating		
Total. no (63)	9	6	12	-	5	14	17

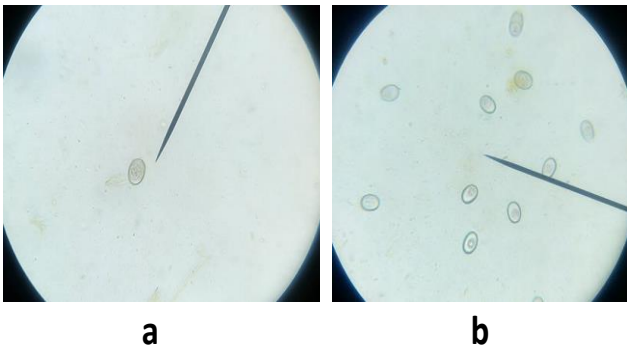


Fig.1: Microscopic examination of fecal flotates showing unsporulated *Eimeria* spp. oocysts (x 40) in mild (a) and heavy infected goat cases.

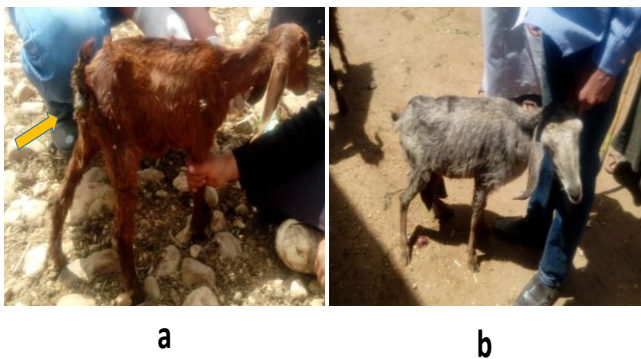


Fig. 2: Clinical signs observed in infected goats with *Eimeria* spp. Severe diarrhea, dullness and depression signs in a goat kid (a) and loss of hair, rough coat, severe emaciation and poor body condition in an adult goat (b).

The oocysts of *Eimeria* spp. could not be detected in the fecal examination of the remaining goats, 37/100 (37%) and so they were considered negative for *Eimeria* spp. infection. Based on physical examination, these goats were probably suffered from variable disease conditions and were not apparently healthy. Therefore, they could not be considered as a control group.

In this study, biochemical analyses as blood proteins including (total protein, albumin, globulin) and total calcium. In addition to these, some liver enzymes such as ALT, AST and ALP were investigated. The results demonstrated that age, sex, pregnancy and lactation affect these parameters in infected goats. A comparison between young and adult male goats revealed significant increases in ALT and AST and a non-significant increase in ALP in young males compared with adult ones. No differences were observed in other serum proteins and calcium levels (Table 2).

Table 2: Effect of *Eimeria* spp. infection on biochemical parameters in young and adult male goats.

Parameter	Groups		P-Value
	Young male (n=9)	Adult male (n=6)	
Total protein (g/dl)	5.76±0.48	6.68±0.54	0.230
Albumin (g/dl)	2.56±0.06	2.58±0.07	0.788
Globulin (g/dl)	3.21±0.45	3.80±0.41	0.382
ALT (IU/L)	39.29±5.90	19.17±1.57	0.009*
AST (IU/L)	144.99±22.83	83.20±10.02	0.031*
ALP (IU/L)	380.76±14.31	344.82±29.19	0.303
Total calcium (mg/dl)	9.47±0.53	8.43±0.86	0.297

Effect of Eimeriosis on serum biochemistry:

Pregnant goats had a significant increase in ALT and AST than non-pregnant female goats. While ALP level was statistically higher in non-pregnant than pregnant ones (Table 3). The level of ALP was also extremely elevated in lactating goats (Table 4). A comparison between young and adult males and female goats showed non-significant variations in levels of all of the aforementioned parameters (Table 5 and 6). The P-values were mentioned in tables.

Table 3: Effect of *Eimeria* spp. infection on biochemical parameters of pregnant and non-pregnant female goats.

Parameter	Groups		P-Value
	Pregnant female (n=5)	Non-pregnant female (n=16)	
Total protein (g/dl)	6.72±0.62	6.59±0.28	0.824
Albumin (g/dl)	2.54±0.20	3.09±0.21	0.182
Globulin (g/dl)	4.18±0.66	3.51±0.26	0.264
ALT (IU/L)	34.75±5.84	21.01±1.98	0.009 *
AST (IU/L)	120.34±3.82	91.11±5.19	0.007 *
ALP (IU/L)	194.74±10.41	300.75±16.71	0.003 *
Total calcium (mg/dl)	8.06±0.69	9.27±0.39	0.141

DISCUSSION

Table 4: Effect of *Eimeria* spp. infection on biochemical parameters of lactating and non-lactating female goats.

Parameter	Lactation status		
	Lactating female (n=14)	Non lactating female (n=16)	P-Value
Total protein (g/dl)	6.48±0.29	6.59±0.28	0.799
Albumin (g/dl)	2.83±0.12	3.09±0.21	0.316
Globulin (g/dl)	3.65±0.22	3.51±0.26	0.679
ALT (IU/L)	23.23±1.49	21.01±1.98	0.388
AST (IU/L)	85.61±6.24	91.11±5.19	0.500
ALP (IU/L)	578.98±22.42	300.75±16.71	<0.0001 *
Total calcium (mg/dl)	9.55±0.42	9.27±0.39	0.635

Table 5: Effect of *Eimeria* spp. infection on biochemical parameters in young male and female goats.

Parameter	Groups		
	Young male (n=9)	Young female (n=12)	P-Value
Total protein (g/dl)	5.76±0.48	6.33±0.36	0.345
Albumin (g/dl)	2.56±0.06	2.67±0.15	0.550
Globulin (g/dl)	3.21±0.45	3.67±0.35	0.426
ALT (IU/L)	39.29±5.90	38.77±6.12	0.953
AST (IU/L)	144.99±22.83	128.85±9.19	0.526
ALP (IU/L)	380.76±14.31	448.38±22.08	0.019
Total calcium (mg/dl)	9.47±0.53	10.80±0.87	0.243

Table 6: Effect of *Eimeria* spp. infection on biochemical parameters in adult male and female goats.

Parameter	Groups		
	Adult male (n=6)	Adult female (n=16)	P-Value
Total protein (g/dl)	6.68±0.54	6.59±0.28	0.864
Albumin (g/dl)	2.58±0.07	3.09±0.21	0.159
Globulin (g/dl)	3.80±0.41	3.51±0.26	0.557
ALT (IU/L)	19.17±1.57	21.01±1.98	0.477
AST (IU/L)	83.20±10.02	91.11±5.19	0.457
ALP (IU/L)	344.82±29.19	300.75±16.71	0.191
Total calcium (mg/dl)	8.43±0.86	9.27±0.39	0.313

Sohag governorate is one of the main Egyptian areas of animal production in Southern Egypt. Farmer's economics are greatly based on raising animals as sources for meat and milk production. Small ruminants, particularly, goats are convenient to live in variable weather conditions and can tolerate the hot and arid atmosphere in Southern Egypt (El-Manyawe *et al.*, 2010 and Aboul Naga *et al.*, 2021). This study was performed on goats that live in villages and small towns where the animals are suffering from poor hygiene and variable stress factors such as overcrowded stocking areas and environmental contamination. These predisposing factors, either high physiological demands and contamination by oocysts secreted in the feces of infected and carrier animals or malnutrition, were believed to increase the risk of Eimeriosis (Chartier and Paraud, 2012 Abdelaziz *et al.*, 2021). Previous studies had referred to the presence of several alterations in hematological and biochemical parameters of infected animals (El-Manyawe *et al.*, 2010). In this study, the clinical health status of *Eimeria*-infected goats in Sohag governorate was described focusing on its pathogenic effects on some serum biochemistry parameters.

Eimeriosis in ruminants is caused by *Eimeria* spp., which is a significant widely distributed enteric disease in young animals. Every year it causes high morbidities and sometimes death in severe cases (Jolley and Bardsley, 2006, Bangoura and Bardsley, 2020). In Egypt, many studies estimated the prevalence of *Eimeria* spp. in small ruminants. In Suez governorate, Eimeriosis among goats was 60% (Mohamaden *et al.*, 2018). Whereas, in Giza governorate, a high infection rate was detected as 76.89% (Hassan *et al.*, 2019). Also, at New Valley governorate, a relatively higher incidence of *Eimeria* spp. infection was detected as 78.02% in native goats reared in the desert (Osman, 2009). Recently, Abdelaziz *et al.*, (2021) reported an overall prevalence of *Eimeria* infection in goats as 40.63% in a study involving some governorates in Northern and Southern Egypt (Behera, Menofia, Assiut, Sohag).

In this study, the infection rate of *Eimeria* spp. infection in goats reared in Sohag governorate was 63%, which is also considered relatively high among goats. In addition, other studies also mentioned the *Eimeria* spp. infection in sheep that also had comparable prevalences to those of goats. This is likely to be due to keeping both animal species under the same farming conditions and similar environments in Egyptian villages. El-Alfy *et al.*, (2020) reported a prevalence of 68.4% in Dakahlia governorate. In Kafrelsheikh governorate, *Eimeria* spp. infection was

one of the most encountered protozoal infections in sheep. This because the Nile Delta is an agricultural area characterized by the high density of livestock that subsequently increase the contamination of pastures and water sources and increase the risk of exposure to variable GIT parasite (Sultan et al., 2016).

In this study, goats infected with *Eimeria* spp. were classified into subgroups according to their age and sex to study the effect of Eimeriosis in each category. Among 63 infected cases, the number of kids less than 1 year was 21 (about one-third) and the remaining 42 (two-thirds) were adult goats between 1 and 5 years old (Table 1). Although previous reports mentioned that small young ruminants have a higher susceptibility to Eimeriosis than adult ones (El-Alfy et al., 2020 and Abdelaziz et al., 2021). Therefore, based on our findings, both adult and young goats may have an equal chance of acquiring infection because of their exposure to similar stress factors as intensive rearing at small-scale yards that hold different ages and grazing as one flock at the same places.

Diagnosis of intestinal Eimeriosis is usually based on the laboratory detection of oocysts in diarrheal feces and observation of clinical findings such as mucoid to hemorrhagic diarrhea and tenesmus (Aitken, 2007 and Constable et al., 2017). Most previous studies reported clinical and pathological lesions of Eimeriosis only in the intestinal mucosa of ruminants; however, information about biochemical analysis was comparatively scarce (Jolley and Bardsley, 2006 and Keeton and Navarre, 2018). *Eimeria* spp. infected goats in this study showed notable clinical signs that included diarrhea with or without mucus, severe dehydration, emaciation, illthriftiness, weakness, anorexia, and fever associated with acute cases.

The purpose of biochemical analyses in this study was to determine the effect of Eimeriosis on blood proteins, including (total protein, albumin, globulin) and total calcium levels. In addition to some liver enzymes such as ALT, AST and ALP. Results demonstrated the effect of variables such as age, sex, pregnancy and lactation on these parameters in infected goats. The results obtained in this study were compared with previous reports that indicated reference values of apparently healthy local goat breeds reared in Egypt (El-Manyawe et al., 2010). In addition to the normal parameters of Maraz adult goats, a native breed raised in Iraq (Khan et al., 2016).

The degree of liver damage of infected animals was evaluated after estimating liver enzymes such as ALT, AST and ALP. In young male goats, we detected substantial increases in ALT and AST levels and a non-significant increase in ALP compared with adult ones (Table 2). On the other hand, protein levels and total

calcium concentration showed no differences. Pregnant goats had significant increases in ALT and AST. Non-pregnant and lactating female goats demonstrated elevated ALP levels (Table 3 and 4). No significant differences in levels of all measured parameters were found in young and adult goats of the same gender (Table 5 and 6). Based on these findings, we assumed that livers of *Eimeria*-infected goats might also be involved in the pathogenesis of Eimeriosis and may have a degree of damage.

An important point in the pathogenesis of Eimeriosis in domestic animals is that *Eimeria* spp. are mainly host and site-specific (Jolley and Bardsley, 2006); thus, developmental stages of *Eimeria* spp. is limited to the intestinal mucosa. However, a study performed by Mahmoud et al., (1994) described the hepato-biliary Eimeriosis in a dairy goat that succumbed due to liver failure. In addition, Oruc. (2007) had described the histopathological findings of a biliary Eimeriosis in a naturally infected goat kid. The author described two types of lesions occurring in a goat. The first is biliary, in which *Eimeria* was seen in the bile duct lumen, epithelium and wall. The second type affects liver parenchyma by *Eimeria* granulomas. Hepatic Eimeriosis is well recognized in rabbits in which the biliary epithelium is affected in a similar way to *Eimeria* spp. lesions at intestinal epithelium in other animal species (Al-Rukibat et al., 2001).

The remarkable elevation of some liver enzymes that were detected in young male kids and in pregnant and lactating does can be attributed to the physiological demands during these life stages, which may affect the liver function. However, the pathogenesis of Eimeriosis in goats is still not clear and such findings need to be confirmed in future studies. Further research with extensive nature is required to determine the species of *Eimeria* that possibly localize in the intestines and liver of infected goats.

CONCLUSION

Eimeriosis is a parasitic disease affecting small ruminants, can greatly affect the general health status, and therefore, reduce animal productivity. Biochemical measurements of liver enzymes could be important to assess the severity of infection as well as the possible host tissues damage.

Declaration of Conflicting Interests

The authors revealed that there are no potential conflicts of interest.

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