PSM Veterinary Research ISSN: 2518-2714 (Online) – An International Peer-reviewed Journal

Research Article 2018 | Volume 3 | Issue 2 | 36-44

Article Info

Open Access
Citation: Fereig, R.M., Mohamed, A.E.A., Ismail, M.N.E., Ali, A.O., 2018. Occurrence, Risk Factors, and Health Hazards of *Dictyocaulus filaria* Infection in Goats in Qena, Egypt. PSM Vet. Res., 3(2): 36-44.

Received: October 8, 2018

Accepted: November 26, 2018

Online first: November 27, 2018

Published: December 16, 2018

***Corresponding author:**
Ragab M. Fereig;
Email:
ragabmakhlouf84@yahoo.com

Scan QR code to see this publication on your mobile device.

Occurrence, Risk Factors, and Health Hazards of *Dictyocaulus filaria* Infection in Goats in Qena, Egypt

Ragab M. Fereig*, Adel Elsayed Ahmed Mohamed, Mohammed Nour Eldin Ismail, Alsagher O. Ali

Department of Animal Medicine, Faculty of Veterinary Medicine, South Valley University, Qena City, Qena 83523, Egypt.

Abstract
The lungworm infection is considered one of the main causes of respiratory tract infections among goats in various regions of the globe. Herein, we provided the first evidence of occurrence of *Dictyocaulus filaria* among goats in Qena governorate, southern Egypt. Migratory larvae in fecal samples of tested goats (n=67) were detected using modified Baermann method; the standard method for diagnosis of lungworm infection. Among goats exhibiting chronic respiratory distress, high incidence of *D. filaria* was recorded (22/67: 32.84%). Higher infection rate was observed during the seasons of winter and autumn (50% and 44%, respectively) than the summer and spring (0%, 18.8%, respectively), assuming to the favorable environmental conditions for survival of the infective 3rd stage larvae. Concerning the age, the infection rate was apparently lower in group of mid-aged (25-48 month; 25%) than young (6-24 month; 37.5%), and old aged (49-84 month; 34.8%) animals. The infected goats revealed anemia-related findings such as marked decrease in red blood cells count, hemoglobin concentration and packed cell volume percentage. Immunopathology was evidenced in increase in the number of total leucocytes, and percentages of eosinophils, and neutrophils, associated with decrease in lymphocytes. Additionally, the infected goats revealed significant increase in serum total proteins and globulins, and significant decrease in albumin/globulins ratio. This study declares the lungworm *D. filaria* as an important cause of respiratory problems among goats in Egypt. In regard to its impact on production, emphasis should be given for the prevention and control of lungworm infection in Egypt.
Keywords: Lungworm, *Dictyocaulus filarial*, Pneumonia, Goat, Cough.

INTRODUCTION

Three species of lungworms are of primary importance in sheep and goats; they are *Dictyocaulus filaria* (*D. filaria*), *Protostrongylus rufescens* (*P. rufescens*), *and Muellerius capillaries* (*M. capillaries*). Lungworms are most often a problem in moist, warm areas and on irrigated pastures in hot areas (Smith, 1996). Previous studies have focused on survey of lungworm infections in goats revealed high incidence of infection in different countries. In Morocco, *M. capillaries*, *P. rufescens* and *Cystocaullus ocreatus* were detected among tested goats as 69-78%, 16-25%, and 5-6%, respectively (Berrag and Urquhart, 1996). In Ethiopia, which is considered an important region for importing small ruminants to Egypt, numerous studies have identified high prevalence of lungworms infection in goats; high incidence of various species of lungworms (50.7%) was recorded in several districts in northeastern region (Alemu *et al*., 2006); *M. capillaris* (31.7%) in northeastern area (Regassa *et al*., 2010); and *D. filaria* (19.2%) in southern region (Abebe *et al*., 2016). A prevalence rate (21.8%) of lungworm infection with mostly *D. filaria* has been reported in goats in the Himalayan region of India (Sharma, 1994). In Egypt, there is paucity on available data on lungworm infection among sheep. In Assiut governorate in the middle region of Egypt, a previous study revealed that *D. filaria* (33.3 %) was detected in a flock of balady sheep suffered from severe respiratory distress (Abd-El-Salam *et al*., 1992). Similarly, our previous study that conducted on sheep in Qena governorate, Egypt had revealed high incidence for two lungworm species; *D. filaria* (36%) *and P. rufescens* (6.7%) (Mohamed *et al*., 2008).

Respiratory signs were observed on sheep and goats infected with lungworms where the adult worms inhabit the lower respiratory tract especially lung bronchioles and alveoli resulting in severe tissues damage, induration, emphysema and area of consolidation (Ellis *et al*., 1993, Mansfield and Gamble, 1995). Sever persistent cough which occur in form of paroxysmal bouts was the most frequent and characteristic symptom of lungworm infections in sheep and goats of different ages and sexes. This symptom occurred due to irritations of the bronchial mucous membranes by the adult inhabitant worms and migrating larvae (Abd-El-Salam *et al*., 1992, Smith, 1996, Asrani *et al*., 1999).

D. filaria in lambs causes alteration in values of various hematological parameters where there was decrease in hemoglobin and hematocrite value and increase in osmotic lysis of erythrocytes (Sharma and Bhat, 1997). There was an increase in the level of serum IgG in the lungworms infected animals (Ploeger *et al*., 2000). The infected sheep revealed decrease in hemoglobin, packed cell volume and lymphocytes, while there was an increase in the value of neutrophils, eosinophils, basophils, monocytes, and significant rise in level of gamma globulin (Dhanalakshmi *et al*., 2002). Another study had been conducted by our group, infections of sheep with *D. filaria* or *P. rufescens*, induced adverse effects on animal health indicated in the resultant microcytic hypochromic anemia as evidenced in low number of RBCs and hemoglobin levels. Moreover, immunopathology and altered serum protein levels were observed in infected animals indicated in remarkable increase in total leucocytic count, eosinophils and globulins levels and significant decrease in lymphocytes and albumin/globulins ratio (Mohamed *et al*., 2008).

To the best of our knowledge, no any previous report about lungworm infection in goats in southern Egypt, thus we conducted this study to recognize the incidence and analyze the risk factors associated with lungworm *D. filaria* infection in Qena governorate, Egypt. Larval migration technique, and more specifically the modified Baermann method (the gold standard method), (Rode and Jorgensen, 1989, Eysker, 1997, Traversa *et al*., 2008, Viña *et al*., 2013) was used for the diagnosis of lungworm infections.

MATERIALS AND METHODS

Ethical approval

All samples were collected after obtaining the consent of animal owner. All applicable international, national, and/or institutional guidelines for the care and use of animals were followed. All fecal and blood sample collections were performed by expert persons or veterinarians with minimal invasive method. The samples used in this study were collected specifically and solely for the purposes of this study.

Study region

This study was conducted at Qena governorate, located in the southern part of Egypt (Fig. 1). Although Qena is considered a semi arid hot and dry region, it has many agricultural fields especially those around the Nile River which are relatively humid and temperate. In the rural region, water resources and feedstuffs are available, thus, most of animal population are located. Samples were collected from different villages in Qena with similar weather and geographical conditions.

Animals of study

In the current study, goats (n=67) of different native breeds, ages, genders, geographical areas, seasons, and physiological states were involved. To find clinically infected cases, we investigated the goats admitted to veterinary clinics or convoys with a complaint of persistent paroxysmal cough particularly those have not recovered by antibiotic therapy as an indication for verminous bronchitis/pneumonia. These animals are mostly managed by individual owners or smallholder flocks. Animals of this study were including three categories; first (healthy; total number = 45), the control animals obtained from farms with

routinely applied control measures including the periodical anthelmintic drug administration. Second (non-infected; total number = 45), animals were exhibiting chronic respiratory distress but negative to lungworm infection via Baermann fecal analysis (Fraser, 1991). Third (infected; total number = 22), the animals were positive to diagnostic stage of *D. filaria*, in addition to showing characteristic clinical signs. Matching of age, gender, and physiological status was applied as much as possible between healthy animals and those infected with *D. filaria*. For epidemiological study, a total 67 samples only from animals showing respiratory distress was considered. Seasonal effects were investigated because of applying this study during one year period. On the other hand, for studying the effect of *D. filaria* on animal health, comparative analysis was conducted only between *D. filaria* infected animals and healthy animals as a control according the different age patterns (n =15 for each group of different age). The age classification for three groups was applied to represent the early puberty and breeding life (6-24 month), the mid breeding life (25-48 month) and the last breeding life (49-84 month). Starting by the age of 6 month because this is the actual age in goats which called finishing kids that the animal starts its actual grazing experience by high rate and hence its liability for infection increased tremendously. Similar patterns for seasonal and age animal grouping were conducted in our previous study applied on sheep (Mahmoud *et al*., 2008).

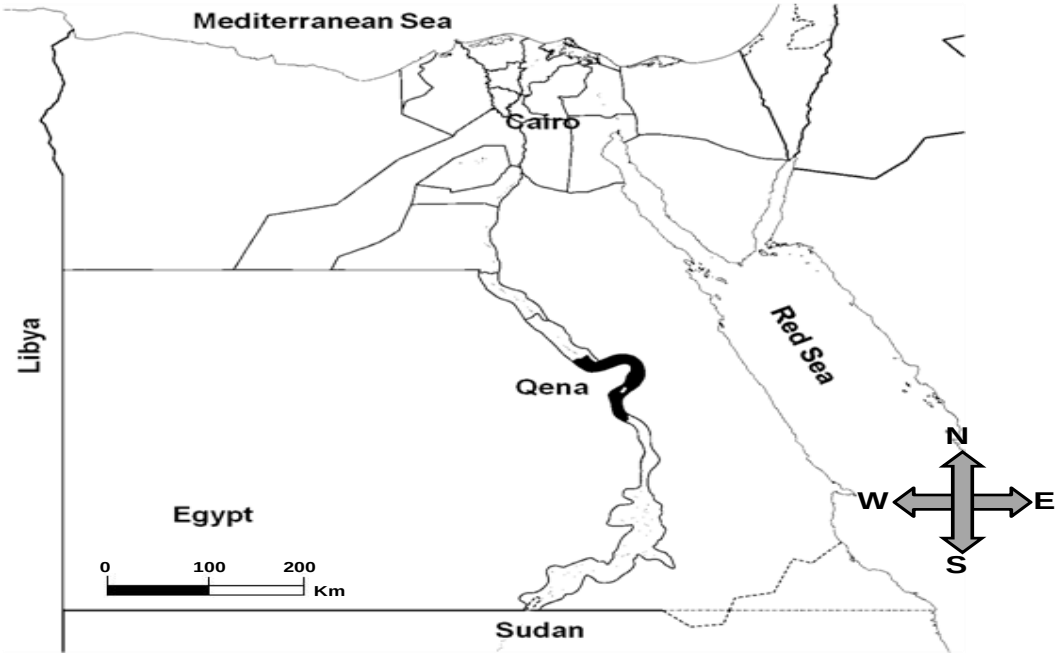

Fig. 1. Geographic location of the sampling site in Egypt used in this study. Dark-colored area indicates the site of Qena governorate; our investigated area.

Clinical inspection

In both clinically healthy and infected animals, a number of clinical parameters were investigated including; auscultation on chest, detection of pulse rate, and measurement of body temperature as described previously (Radostits *et al*., 2007).

Fecal sample collection and parasitological examination

Fecal samples were collected from all investigated animals directly from the rectum and put in plastic bag, and then kept in icebox until transportation to our laboratory in South Valley University, Egypt. Modified Baermann funnel technique was applied to identify the first stage larva (L_1 larvae: diagnostic stage for *D. filaria*) as reported previously (Fraser, 1991). In brief, fecal sample was wrapped in a piece of gauze and submerged in a clean funnel containing lukewarm water connected with closed plastic tube. After 6 hours of incubation, about 1 mL of the settled down solution was collected and checked under the microscope to find L_1 larvae. Direct fecal smear, sedimentation and flotation technique were additionally applied to exclude other types of parasitic infections such as gastro-intestinal parasites and liver flukes (Coles, 1986). The detection and identification of larvae of lungworms were identified based on the linear lengths and the morphology of the anterior

and posterior ends, according to morphological keys (Van Wyk *et al*., 2004).

Hematological and biochemical parameters analysis

Two blood samples were collected from each animal of control and infected groups through the jugular vein puncture. The first blood sample (5 mL) was collected in a glass tube with EDTA to obtain whole blood for assessment of hematological parameters and differential leucocytic count. The second blood sample (5 mL) was taken in a tube without EDTA for harvesting serum to detect total proteins, albumin, globulins, and A/G ratio. The procedures for sample preparation and analysis were performed as illustrated formerly (Coles, 1986).

Statistical analysis

Differences in the incidence of *D. filaria* infection in goats and risk factors for infection were detected using a chi-square test. A *P* value of < 0.05 was considered as a statistically significant value. The 95% confidence intervals of a proportion including continuity correction and odds ratios were calculated using www.vassarstats.net.

RESULTS

Seasonal and age risk factors associated with *D. filaria* infection in goat.

For epidemiological investigation, in total, 67 fecal samples from goats exhibiting chronic respiratory distress, and incurable for antibiotic therapy were investigated for presence of L_1 larvae of *D. filaria*. We could identify 22 (32.8%) of 67 animals as positive cases. The infection rate was significantly higher in winter season (50%), when compared with summer (no cases out of 11 investigated animals) or spring (18.8%) (*P* < 0.05). The infection rate was also high in autumn (44%) which was comparable to those of winter season (50%) (Table 1). On the contrary, no significant differences were observed among investigated animals of different age patterns (Table 1). These results revealed the occurrence of *D. filaria* in goat in Qena, Egypt, and necessitate the considering of such infection as an important cause of respiratory tract infections during cold seasons.

Table 1. Seasonal and age patterns of *D. filaria* infection in goat in Qena governorate, Egypt.

	Factor	No. of samples tested	No. of Positive (%)	95% CI	OR (95% CI)	P-value
Season	Summer	11	0	0-0.32	ND	ND
	Autumn	18	8 (44)	0.22-0.69	1.25 (0.36-4.36)	0.73
	Winter	22	11 (50)	0.29-0.71		Ref
	Spring	16	3 (18.8)	0.05-0.46	4.33 (0.96-19.58	0.04
Age	6-24 m	24	9 (37.5)	0.19-0.59		Ref
	25-48 m	20	5 (25)	0.10-0.50	1.8 (0.49-6.65)	0.37
	49-84 m	23	8 (34.8)	0.17-0.57	1.13 (0.34-3.71)	0.84
	Total	67	22 (32.8)	0.22-0.46		

CI = Confidence interval, OR = Odd ratio, ND = Non detectable, Ref = Reference group compared with other groups. 95% CI, OR (95% CI) and P-value were calculated according to method described by (http://vassarstats.net/)

Changes in clinical, hematological and biochemical variables of *D. filaria* infected- goats.

Significant increase in respiratory rate but insignificant changes in pulse rate and body temperature (*P* < 0.05) between the lungworm infected and healthy goats at 6-24 months old were observed on the clinical investigation (Table 2). Added to marked increase in respiratory rate, pulse rate was also significantly increased (*P* < 0.05) in goat aged 25 to 84 month in infected rather than non-infected goats of the same age (Table 2). Regarding hemogram, significant decrease (*P* < 0.05) in values of red blood cell count (RBCs), hemoglobin (Hb) concentration, and packed cell volume in infected goats than healthy ones of various age patterns were reported (Table 3). On investigating leucogram and differential leucocytic count, significant increase (*P* < 0.05) in total leucocytic count, eosinophils %, neutrophils % and significant decrease in lymphocytes %, meanwhile there was insignificant changes in basophils % and monocytes % in infected than healthy animals were reported (Table 4). This effect was markedly noticed in goat aged 6-24 m and 49-84 m rather than 25-48 m. Similar results were obtained when analyzing biochemical parameters such as total proteins, albumin and globulins in the serum of tested goats. Significant increase (*P* < 0.05) in total proteins and globulins, and decrease in albumin/globulins ratio was noticed in infected animals than healthy ones in relatively young aged (6-24 m) and old aged (49-84 m) than those of mid aged animals (25-48 m) (Table 5). These results reveal the adverse effect of *D. filaria* infection on the health condition of infected goats as reported in induced anemia, and altered effector immune cells and serum proteins.

Table 2. Effect of *D. filaria* infection on some clinical parameters in goats.

	Goats aged 6-24 month			Goats aged 25-48 month			Goats aged 49-84 month		
Parameters	Healthy	Infected	Significance	Healthy	Infected	Significance	Healthy	Infected	Significance
	No.= 15	No.= 9		No.= 15	No.= 5		No.= 15	No.= 8	
	Mean ± SD	Mean ± SD		Mean ± SD	Mean ± SD		Mean ± SD	Mean ± SD	
Respiratory Rate	33.2 ± 5.	53.2 ± 4.3	**	31.27 ± 5.5	48 ± 6	**	30.6 ± 4.3	48.8 ± 9.7	**
Pulse Rate	102.2 ± 7.4	104.2 ± 6.4	ns	80.2 ± 5.5	93 ± 7.4	**	80 ± 5.9	91.5 ± 3.7	**
Temperature	39.6 ± 0.4	40 ± 0.6	ns	39.5 ± 0.5	40 ± 0.6	ns	39.7 ± 0.4	39.6 ± 0.2	ns

SD; standard deviation, ns; non-significant. *, statistically significant differences were observed between the healthy and infected goats with the Student's *t* test ($P < 0.05$).

Table 3. Effect of *D. filaria* infection on hemogram in goats.

	Goats aged 6-24 month			Goats aged 25-48 month			Goats aged 49-84 month		
Parameters	Healthy	Infected	Significance	Healthy	Infected	Significance	Healthy	Infected	Significance
	No.= 15	No.= 9		No.= 15	No.= 5		No.= 15	No.= 8	
	Mean ± SD	Mean ± SD		Mean ± SD	Mean ± SD		Mean ± SD	Mean ± SD	
RBCs, T/L	11.4 ± 1.2	9.2 ± 1.2	**	10.8 ± 1.1	8.8 ± 1.4	*	10.9 ± 2.6	8 ± 2.5	*
Hb, g/dl	8.8 ± 0.8	7.5 ± 0.9	**	9.7 ± 1.2	8.6 ± 1.4	**	8.7 ± 0.7	7 ± 1.6	*
PCV, %	27.2 ± 3.3	24.9 ± 1.1	**	25.1 ± 1	25 ± 3.2	ns	23.7 ± 2.6	21 ± 1.9	*
MCV, fl	24.1 ± 4.7	27.3 ± 3.8	ns	23.4 ± 25	28.7 ± 4.5	ns	22.7 ± 4.9	28.5 ± 8.8	ns
MCH, pg	7.7 ± 0.9	8.2 ± 1.3	ns	9 ± 1.4	10 ± 2.1	ns	8.4 ± 1.9	9.4 ± 3.2	ns
MCHC, g/dl	32.6 ± 4.3	30.2 ± 3.5	ns	38.6 ± 5.8	34.8 ± 4.4	ns	36.9 ± 3.7	34.2 ± 10	ns

T/L; Tera/litre, g/dl; grams/deciliter, fl; femotolitres/cell, pg; picograms/cells, SD; standard deviation, ns; non-significant.
*, statistically significant differences were observed between the healthy and infected goats with the Student's *t* test ($P < 0.05$).

Table 4. Effect of *D. filaria* infection on leucogram in goats.

	Goats aged 6-24 month			Goats aged 25-48 month			Goats aged 49-84 month		
Parameters	Healthy	Infected	Significance	Healthy	Infected	Significance	Healthy	Infected	Significance
	No.= 15	No.= 9		No.= 15	No.= 5		No.= 15	No.= 8	
	Mean ± SD	Mean ± SD		Mean ± SD	Mean ± SD		Mean ± SD	Mean ± SD	
WBCs, G/L#	10.6 ± 2.4	13.5 ± 1.7	**	7.9 ± 2.7	11.9 ± 2	**	8.8 ± 2.5	13.1 ± 2.3	**
Band cells, %	1.3 ± 0.8	3.7 ± 0.5	**	1.5 ± 1.1	1.8 ± 0.8	ns	1.2 ± 0.9	3.8 ± 0.7	**
Neutrophil. %	35.6 ± 4.4	39.2 ± 2.7	*	38.7 ± 3.3	39 ± 2.2	ns	34.4 ± 3.4	37.9 ± 3.6	*
Eosinophil, %	4 ± 1	10.1 ± 2.4	**	4.7 ± 1.7	11 ± 2.1	**	4.5 ± 1.6	10.3 ± 1.4	**
Basophil, %	1.3 ± 0.9	0.8 ± 0.8	ns	1.2 ± 0.9	1.6 ± 1.1	ns	1.5 ± 1.4	1.4 ± 0.9	ns
Lymphocyte, %	54.5 ± 5.5	43.4 ± 4.4	**	51.3 ± 4.1	44 ± 2.5	**	56.1 ± 3.1	44 ± 5.3	**
Monocyte, %	3.3 ± 1.2	2.8 ± 1.2	ns	2.7 ± 1	2.6 ± 0.5	ns	2.3 ± 1	2.8 ± 0.9	ns

G/L; giga/litre, SD; standard deviation, ns; non-significant.
*, statistically significant differences were observed between the healthy and infected goats with the Student's *t* test ($P < 0.05$).

Table 5. Effect of *D. filaria* infection on some biochemical parameters in goats.

Parameters	Goats aged 6-24 month			Goats aged 25-48 month			Goats aged 49-84 month		
	Healthy	Infected	Significance	Healthy	Infected	Significance	Healthy	Infected	Significance
	No.= 15	No.= 9		No.= 15	No.= 5		No.= 15	No.= 8	
	Mean ± SD	Mean ± SD		Mean ± SD	Mean ± SD		Mean ± SD	Mean ± SD	
Total protein, g/dl	6.8 ± 0.26	8.36 ± 0.26	**	8.1 ± 0.17	8.4 ± 0.15	*	7.8 ± 0.24	8.16 ± 0.34	*
Albumin, g/dl	3.3 ± 0.13	3.2 ± 0.32	ns	4.1 ± 0.14	4 ± 0.16	ns	4.4 ± 0.2	4.32 ± 0.2	ns
Globulins, g/dl	3.5 ± 0.24	5.16 ± 0.47	**	4 ± 0.25	4.4 ± 0.23	*	3.3 ± 0.34	3.84 ± 0.32	**
A/G ratio	0.95 ± 0.08	0.6 ± 0.11	**	1.05 ± 0.1	0.9 ± 0.08	*	1.34 ± 0.17	1.13 ± 0.12	**

g/dl; grams/deciliter, SD; standard deviation, ns; non-significant.
*, statistically significant differences were observed between the healthy and infected goats with the Student's *t* test ($P < 0.05$).

DISCUSSION

Goats are unique among the domestic animals in the sense that they can be maintained under diverse environments with a little expense on housing and feeding (Boyazoglu *et al.*, 2005). At the same time, this animal provides us with meat, milk, leather and manure. Small ruminants are indeed excellent alternatives to traditional large animals to meet at least a part of the requirement of animal protein (Boyazoglu *et al.*, 2005, Escareño *et al*., 2013). In the current study, we reported a high prevalence of *D. filaria* as a cause of verminous bronchitis/pneumonia in goat in Qena, Egypt. The high incidence of infection may be attributed to that the study focused on animals that exhibited the characteristic clinical sign of lungworm infection (paroxysmal cough). *D. filaria* has a direct life cycle so the infection may take place by ingestion of the 3rd stage larva contaminating the feedstuffs of animals, oppositely to other lungworm parasites. For instance, *P. rufescens* needs snails as an intermediate host for development the infective 3rd stage larva and completion of life cycle. These may explain why the large lungworm *D. filaria* was only recorded in the infected cases in this study; particularly in our investigated few sampled animals (Sharma, 1994, Mohamed *et al*., 2008, Borji *et al*., 2012, Abebe *et al*., 2016).

Higher incidence of lungworm *D. filaria* infection in goats in winter and autumn than those in summer and spring seasons may be attributed to the favorable environmental conditions for survival of the infective 3rd stage larvae of *D. filaria* such as temperature and humidity (Arnett *et al*., 1993, Berrag and Urquhart, 1996, Alemu *et al*., 2006, Mohamed *et al*., 2008, Borji *et al*., 2012). Regarding the effect of age, despite no significant differences in the infection rate between the different animal groups, the rate was apparently lower in group of mid-aged (25-48 m) than young (6-24 m) and old aged (49-84 m) animals. Interestingly, even the alteration in certain essential health parameters such as PCV, band cells, neutrophils, and globulins was relatively lower in mid-aged than young or old-aged animals. These results indicate the high resistance of animal group (25-48 m) against *D. filaria* infection, which may be related to the peak functionality of local and general immune system, fully developed architectures of vital organs and better nutritional status (Marchall-Clarke *et al*., 2000, Kramer *et al*., 2003, Borji *et al*., 2012).

Because of limited available data on lungworm infection in goat and high similarity between goat and sheep in phenotypic and genetic traits in addition to physiological and behavioral patterns (Alberto *et al*., 2018), we have compared our results with other studies either conducted on goats or sheep. Alterations in the clinical parameters in goats were evidenced in significant increase in respiratory rate in all infected groups, and increase in pulse rate in mid and old-aged infected groups, may be assumed to the difficult in respiration as a result of destructions in the pulmonary tissues and obstructions of some bronchioles by impacted adult worms. Previous reports had revealed that pulmonary necrosis usually results in impaired gas exchanges, and rise in blood carbon dioxide (CO_2) and bicarbonates (HCO_3) with decrease in oxygen (O_2) and blood pH. Exact reasons for insignificant elevation in pulse rate in young aged-group is unknown. However, it might be related to the normal high value in healthy kids and the marked increase during several physiological conditions as fear and recent weaning (Radostits *et al*., 2007). More researches are required to understand deeply the pathogenesis and consequences of lungworm infections are required. Altogether, these systemic changes will adversely affect the function of vital organs especially lung, heart and brain (Berrag and Cabaret, 1996, Berrag and Cabaret, 1997, Mohamed *et al*., 2008).

The obtained results of hematological investigation of *D. filaria* infected goats showed significant decrease in RBCs count, Hb concentration and PCV. These results were coincide with those explained by Bhat *et al*. (1989), Sharma and Bhat, (1990), Mansfield and Gamble, (1995), Sharma and Bhat, (1997), and Mohamed *et al*. (2008), but disagreed with the results obtained by Abd-El-Salam *et al*. (1992) who reported that in the lungworm infected sheep there was insignificant changes in red blood cell count, hemoglobin concentration and packed cell volume between the infected and healthy animals. Such discrepancy might be attributed to the difference in timing and location of sampling, severity of infection, and animal species. *D. filaria*-induced anemia is related to increased osmotic fragility of red blood cells due to alterations in constituents of cell membrane as cholesterol, lipoprotein, phospholipids, actyle choline estrases activity and cholesterol/phospholipids ratio were fell significantly when compared with the uninfected animals (Bhat and Sharma, 1989, Sharma *et al*., 1989, Sharma and Bhat, 1997, Dhanalakshmi *et al*., 2002). Another cause of anemia in the lungworm infected animals is the direct blood loss through the sucking habits of adult worms inhabiting the respiratory system (Jubbs *et al*., 1993, Dhanalakshmi *et al*., 2002).

The significant leucocytosis in infected goat might be related to significant eosinophilia and some other types of leucocytes. These findings agreed with Bhat *et al*. (1989), Berrag *et al*. (1997), and Dhanalakshmi *et al*. (2002), Mohamed *et al*. (2008), but conflicted with Abd-El-Salam *et al*. (1992), who recorded that no significant changes in total leucocytes between healthy and lungworm infected sheep. The obtained marked eosinophilia in all the infected animals indicates sever animal parasitism by *D. filaria*, these coincide with Abd-El-Salam *et al*. (1992), Jubbs *et al*. (1993), Mansfield and Gamble, (1995), Berrag *et al*. (1997), and Dhanalakshmi *et al*. (2002). Eosinophils are responsible for killing of parasite by degranulating into its surface through deposition of major basic proteins into the parasite cuticle and contain specific receptors of complement and immunoglobulins that help in killing of parasite by secreting peroxidases (Jubbs *et al*., 1993, Strandmark *et al*., 2016). The recorded neutrophilia in some infected goats might be attributable to sever pulmonary tissues damages and inflammation which give chance for secondary bacterial infections complicating the condition (Krishna *et al*., 1987, Jenkins *et al*., 2007). The alteration in number of circulating neutrophils can occur via three pathways, 1) movement between the circulating and marginal blood pools, 2) changes in the movement of cells from the storage pool into the blood pool, and 3) alteration in the rate of movements of the cells out of the blood pool. Moreover, lymphopenia which was observed in our study, suggesting the suffering of infected animals from long-term stress which usually associated with decrease in number of lymphocytes triggered by the action of glucocorticoids (Coles, 1986).

Regarding the effect of *D. filaria* infection on biochemical profile, we recorded significant increase in total protein and globulins, insignificant changes in albumin and significant decrease in A/G ratio in the infected cases than the healthy ones. This might be occurred due to alteration in rate of synthesis of globulins and antibodies response against worms and their metabolites and also as a compensatory reaction to restore the reduced serum osmotic pressure because of low albumin concentration. These results coincided with those obtained by Abd-El-Salam *et al*. (1992), Dhanalakshmi *et al*. (2002), Mohamed *et al*. (2008). Globulins represent a group of proteins; identified as alpha, beta, and gamma globulins according to their mobility in an electrical field, the alpha and beta globulins are carrier molecules and vary in concentration depending up on the species of animal. Meanwhile gamma globulins are primary associated with antibodies and combating the parasitic infections via antibody-mediated immunity, thus they may be the major protein contributing to the elevation of globulins and total proteins levels (Meeusen *et al*., 1999).

CONCLUSION

This study showed the first demonstration of *D. filaria* in goats in southern Egypt, and revealed the high occurrence of such parasite among animals suffering from chronic respiratory distress. Furthermore, we revealed that this helminth is capable of inducing adverse effect on animal health indicated in the resultant anemia because of estimation of the low number of RBCs and hemoglobin levels. Moreover, immunopathology and altered plasma protein levels were observed in infected animals. Eventually, this study provided an important recommendation about considering the lungworm as an important cause of respiratory infections in goat in the investigated area, and thus using appropriate preventive and control strategy based on anthelmintic drug administration.

CONFLICT OF INTEREST

The authors declare that no competing interests exist.

REFERENCES

Abd-El-Salam, M.N., Ali, H.S., Mourad, I.M., Dakka, A.A., Zaitoun, A.M., 1992. Effect of *Dictyocaulus filaria* and some parasitic infestation in sheep on clinical, hematological and serological findings. Assiut Vet. Med. J., 27, 168-173.

Abebe, R., Melesse, M., Mekuria, S., 2016. Lungworm infection in small ruminants in and around Wolaita Soddo town, southern Ethiopia. J. Veterinar. Sci. Technol., 7:2.

Alberto, F.J., Boyer, F., Orozco-terWengel, P., Streeter, I., Servin, B., de Villemereuil, P., et al., 2018. Convergent genomic signatures of domestication in sheep and goats. Nat. Commun., 9, 813.

Alemu, S., Leykun, E.G., Ayelet, G., Zeleke, A., 2006. Study on small ruminant lungworms in northeastern Ethiopia. Vet. Parasitol., 142 (3-4), 330-335.

Arnett, E.B., Irby, L.R., Cook, J.G., 1993. Sex- and age-specific lungworm infection in Rocky Mountain bighorn sheep during winter. J. Wildl. Dis., 29 (1), 93-96.

Asrani, R.K., Batta, M.K., Katoch, R.C., Jithendran, K.B., Sharma, M., Singh, S.P., et al., 1999. Outbreaks of verminous bronchopulmonitis among sheep and goats in Himachal Pradesh. Ind. J. Anim. Sci. 69 (4), 207-210.

Berrag, B. Rhalem, A., Sahibi, H., Dorchies, P., Cabaret, J., 1997. Bronchoalveolar cellular responces of goats following infections with *Muellerius capillaries* (Protostrongylidae, Nematoda). Vet. Immunol. Immunopathol. 58, 77-88.

Berrag, B., Cabaret, J., 1996. Impaired pulmonary gas exchange in ewes naturally infected by small lungworms. Int. J. Parasitol. 26 (12), 1397-1400.

Berrag, B., Cabaret, J., 1997. Assessment of the severity of natural infections of kids and adult goats by small lungworms (Protostrongylidae, Nematoda) using macroscopic lesion scores. Vet. Res. 28 (2), 143-148.

Berrag, B., Urquhart, G.M., 1996. Epidemiological aspects of lungworm infections of goats in Morocco. Vet. Parasitol. 61 (1-2), 81-95.

Bhat, T.K., Sharma, R.L., Jithendran, K.P., 1989. Experimental studies on anaemia in Sheep infected with *Dictyocaulus filaria.* Int. J. Parasitol. 19 (3), 349-351.

Borji, H., Azizzadeh, M., Ebrahimi, M., Asadpour, M., 2012. Study on small ruminant lungworms and associated risk factors in northeastern Iran. Asian. Pac. J. Trop. Med. 5 (11), 853-856.

Coles, E.H., 1986. A text book of veterinary clinical pathology. 4th ed., W.B. Sounder company, Philadelphia, London, Toronto, 331-333.

Dhanalakshmi, H., Jagannaath, M.S., Sousa, P.E., 2002. Haematological and gamma globulin changes in sheep naturally infected with strongyles. Ind. J. Anim. Sci. 72 (12), 1094-1095.

Ellis, J.A., Chavera, A.E.V., De Martini, J.C., 1993. Disease conditions in slaughtered sheep from small holder flock in Peru. Small Rumin. Res. 10 (3), 243-250.

Escareño, L., Salinas-Gonzalez, H., Wurzinger, M., Iñiguez, L., Sölkner, J., Meza-Herrera, C., 2013. Dairy goat production systems: status quo, perspectives and challenges. Trop. Anim. Health Prod. 45 (1), 17-34.

Eysker, M., 1997. Baermann method for the diagnosis of primary *Dictyocaulus viviparous* infections in calves. Vet. Parasitol. 69 (1-2), 89-93.

Fraser, C.M., 1991. The Merk veterinary manual. A handbook of diagnosis therapy and disease prevention and control for the veterinarians. 7th ed. Merk and Co., Inc. Rahway, Nit, USA, 714-717.

Jenkins, E.J., Veitch, A.M., Kutz, S.J., Bollinger, T.K., Chirino-Trejo, J.M., Elkin, B.T., et al., 2007. Protostrongylid parasites and pneumonia in captive and wild thinhorn sheep (*Ovis dalli*). J. Wildl. Dis. 43 (2), 189-205.

Jubbs, K.V.F., Kennedy, P.C., Palmer, N., 1993. Pathology of domestic animals. 4th ed, 3, 102-104.

Kramer, B.W., Jobe, A.H., Ikegami, M., 2003. Monocyte function in preterm, term, and adult sheep. Pediatr. Res. 54 (1), 52-57.

Krishna, L., Gupta, V.K., Katoch, R.C., 1987. Studies on the outbreaks of verminous pneumonia in Gaddi sheep and goats in Himachal Pradesh. Ind. J. Comp. Microbiol., Immunol. Infect. Dis. 8 (4), 170-173.

Mansfield, L.S., Gamble, H.R., 1995. Alveolar mastocytosis and eosinophilia in lambs with naturally acquired nematode infections of *Protostrongylus rufescens* and *Haemonchus contortus*. Vet. Immunol. Immunopathol. 49 (3), 251-262.

Marshall-Clarke, S., Reen, D., Tasker, L., Hassan, J., 2000. Neonatal immunity: how well has it grown up? Immunol. Today. 21 (1), 35-41.

Meeusen, E.N., 1999. Immunology of helminth infections, with special reference to immunopathology. Vet. Parasitol. 84 (3-4), 259-573.

Mohamed, A.E.A., Fereig, R.M.M., Abdel-Mottelib, A., Ismail, M.N., 2008. The effect of *Dictyocaulus filaria* and *Protostrongylus rufescens* on some clinical findings, hematological picture and protein in sheep at Qena governorate. Kafr El-sheikh Vet. Med. J. 1, 200-216.

Ploeger, H.W., Borgsteede, F.H.M., Sol, J., Mirck, M.H., Huyben, M.W.C., et al., 2000. Cross-sectional serological survey on gastro-intestinal and lung nematodes infections in first and second year replacement stock in the Netherlands: relation with management practice and use of anthelmintics. Vet. Parasitol. 90 (4), 285-304.

Radostits, O.M., Gay, C., Hinchcliff, K., Constable, P., 2007. Veterinary medicine. A textbook of the diseases of cattle, horses, sheep, pigs and goats. 10th ed. Saunders Ltd, USA.

Regassa, A., Toyeb, M., Abebe, R., Megersa, B., Mekibib, B., Mekuria, S., et al., 2010. Lungworm infection in small ruminants: Prevalence and associated risk

factors in Dessie and Kombolcha districts, northeastern Ethiopia. Vet. Parasitol. 169 (1-2), 144–148.
Rode, B., Jorgensen, R.J., 1989. Baermannization of *Dictyocaulus sp*. from feces of cattle, sheep and donkeys. Vet. Parasitol. 30 (3), 205-211.
Boyazoglu, J., Hatziminaoglou, I., Morand-Fehr, P., 2005. The role of the goat in society: Past, present and perspectives for the future. Small Rumin. Res. 60 (1-2), 13-23.
Sharma, R.L., 1994. Parasitic bronchitis in goats and the possible use of *Dictyocaulus filaria* vaccine for its control. Vet. Parasitol. 51 (3-4), 255-562.
Sharma, R.L., Bhat, T.K., 1990. Effect of bronchodilator and intravascular oxygen releaser on the course of *Dictyocaulus filaria* in lambs. Vet. Parasitol. 35 (1-2), 147-155.
Sharma, R.L., Bhat, T.K., 1997. Effect of sodium acid phosphate and inosine on the course of *Dictyocaulus filaria* infection in sheep. Ind. J. Anim. Sci. 68, 17-20.
Sharma, R.L., Bhat, T.K., Dhar, D.N., 1989. Effect of *Dictyocaulus filaria* infection on osmotic fragility of sheep erythrocytes. Vet. Parasitol. 30 (3), 253-258.
Smith, B.P., 1996. Large animal internal medicine. 2nd ed, Mosby- Year Book, Inc. USA. Pp. 666-667.
Strandmark, J., Rausch, S., Hartmann, S., 2016. Eosinophils in homeostasis and their contrasting roles during inflammation and helminth infections. Crit. Rev. Immunol. 36 (3), 193-238.
Traversa, D., Di Cesare, A., Milillo, P., Iorio, R., Otranto, D., 2008. *Aelurostrongylus abstrusus* in a feline colony from central Italy: clinical features, diagnostic procedures and molecular characterization. Parasitol. Res. 103 (5), 1191-1196.
Van Wyk, J.A., Cabaret, J., Michael, L.M., 2004. Morphological identification of nematode larvae of small ruminants and cattle simplified. Vet. Parasitol. 119 (4), 277-306.
Viña, M., Panadero, R., Díaz, P., Fernández, G., Pérez, A., Díez-Baños, P., et al., 2013. Evaluation of the use of pooled fecal samples for the diagnosis of protostrongylid infections in sheep. Vet. Parasitol. 197 (1-2), 231-234.