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Prevalence of *Eimeria* species of the domestic goats *Capra hircus* Linnaeus, 1758 in Al-Baha area, Saudi Arabia

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ABSTRACT

This work aimed to identify *Eimeria* species of goats and to investigate the factors that might potentially influence their prevalence and parasite load. This study was conducted in Al-Baha area, south-west Saudi Arabia from September 2011 to June 2012. Out of 336 faecal samples examined, 180 (53.57%) were positive for *Eimeria* oocysts. The prevalence of *Eimeria* ranged from 39.64% to 61.40% in different localities. Nine different *Eimeria* species were identified from faecal samples of goats. *Eimeria* species were: *Eimeria arloingi* (35.71%), *E. alijevi* (26.19%), *E. hirci* (25.29%), *E. ninakohlyakimovae* (16.36%), *E. christenseni* (14.59%), *E. caprina* (11.31%), *E. jolchijevi* (9.52%), *E. caprovina* (5.59%) and *E. apsheronica* (3.27%). *E. arloingi* (35.71%), *E. alijevi* (26.19%) and *E. hirci* (25.29%) were the most prevalent species and *E. apsheronica* (3.27%) was the least prevalent one. The main factors affecting prevalence and parasite load of *Eimeria* species were host age, locality and season. Significant negative correlations were found between host age and both prevalence and OPG number. Multiple-species infections were detected in 89.44% of positive goats which carried two to five species. In conclusion, the prevalence of coccidiosis is relatively low compared to other studies. Moreover, no signs of clinical coccidiosis were found in this study. We need further research to study the interaction between multiple-species infections in coccidiosis and parasite load in natural host-parasite systems.

Keywords: *Eimeria*, oocysts, goats, host age, season, Saudi Arabia.

INTRODUCTION

Domesticated small ruminants, especially goats, constitute an important source of animal protein to most inhabitants in Saudi Arabia. A lot of socio-economic importance is therefore attached to ownership of these animals. However, the productivity of goats is constrained by parasitic infections (Dhar *et al*., 1982; Ibrahim *et al.,* 2008). Coccidiosis is a worldwide distributed disease and one of the most economically important infections that threatening goats production (Alyousif *et al.,* 1992; Gül, 2007; Wang *et al.,* 2010; Cavalcante *et al.,* 2012). Coccidiosis is a parasitic disease caused by intracellular protozoa called *Eimeria*. *Eimeria* can invade and destroy intestinal cells of the hosts, causing anaemia, electrolyte loss and poor absorption of nutrients. The most common sign of infection is diarrhoea, and affected goats can show a rough hair coat, poor weight gain and weakness (Wang *et al.*, 2010).

Thirteen *Eimeria* species have been reported from the goats (Pellérdy, 1974; Levine, 1985; Norton, 1986; Wang *et al.*, 2010). In Saudi Arabia, ten *Eimeria* species have been found in goats, namely *E. arloingi, E. alijevi, E. ninakohlyakimovae, E.*

hirei, E. christenseni, E. caprina, E. apsheronica, E. caprovina, *E. punctate* and *E. jolehijevi* (Alyousif *et al.*, 1992).

Alyousif *et al.* (1992) showed that infection of goats with *Eimeria* species is common in the central region of Saudi Arabia. There are no studies of prevalence of *Eimeria* infection in goats in Al-Baha area, which has unique climatic and geographic conditions different from other areas of Saudi Arabia. This area has very cold and dry winter season, but has a warm and rainy temperate climate during the spring and summer seasons in Al-Baha locality. Therefore, the objective of the present study was to investigate the factors affecting in prevalence and parasite load of *Eimeria* species of goats. The results obtained would be quite useful to devise appropriate and effective control strategies and prophylactic programs for coccidiosis of goat unique to this climatic zone and other parts of the world with similar climatic and husbandry production systems.

MATERIAL AND METHODS

The study area

The study was conducted in Al-Baha area, south-west Saudi Arabia (20°N, 41-42°E) from September 2011 to June 2012. The study area is mainly hilly, with small areas of either mountainous or flat land and extends from 500 to 2500 m a.s.l. The climate in Al-Baha has two extremes. Mild winters and hot summers, with an average annual rainfall between 100 and 250 mm, prevail in the lowlands; cold winters and mild summers, with an average annual rainfall between 229 and 581 mm, prevail in the highlands (Ibrahim *et al.,* 2008).

Sample collection

A total of 336 goats from three localities in Al-Baha area were randomly chosen from each sheepfold. Faecal samples of approximately 3-5 g were collected directly from the rectum using examination gloves. All samples were placed into plastic bags and were classified into three age categories: < 6-months old (90 goats), 6-12-months old (121 goats) and >12-months old (125 goats) and two seasons (dry: September 2011-January 2012 and wet season: February 2012-June 2012). The structure of the sampled host population of goats according to season, locality, sex and age categories was shown in Table (1). The collected samples were stored at 4°C until being examined.

Table 1: The structure of the sampled host population of goats.

Factors considered		No. of goats examined
Season	Dry season (September 2011-January 2012)	155
	Wet season (February 2012-June 2012)	181
Location	Al-Baha	111
	Al-Aqiq	111
	Al-Mikhwah	114
Sex	Male	183
	Female	153
Age categories	<6 months old	90
	6-12 months old	121
	>12 months old	125

Sample processing and recovery of Eimerian oocysts

Faecal samples was examined for the presence or absence of eimerian oocysts by a flotation technique using saturated saline. Oocysts per gram of faeces (OPG) were quantified using a modification of the McMaster technique (MAFF, 1986).

Oocysts in two chambers of the McMaster slide were counted and the sum number of oocysts in both chambers was multiplied by the dilution factor (100) to obtain an estimation of the number of OPG of each faecal sample. Each faecal sample was examined three times using the same method (Wang *et al.,* 2010, Cavalcante *et al.*, 2012). The results are expressed as the mean value of the three independent examinations.

Eimerian species identification

After examination, positive samples were filtered through sieves covered with folded gauze and centrifuged at 250 × g for 10 min. Filtered material was placed into Petri dishes with 2.5% potassium dichromate solution ($K_2Cr_2O_7$) for sporulation at laboratory temperature. After sporulation, sporulated oocysts were recovered by centrifugation in saturated saline solution at 250 × g for 5 min followed by washing with distilled water. Concentration of sporulated oocysts was performed by centrifugation at 250 × g for 10 min, stored in potassium dichromate solution at 4°C for subsequent study. The oocysts were identified based on their morphological characteristics (size, shape, colour, form index, presence or absence of micropyle and its cap, presence or absence of residual, polar and stieda bodies) of the oocysts and sporocysts (Pellérdy, 1974; Levine, 1985; Soulsby, 1986; Wang *et al*., 2010; Cavalcante *et al.*, 2012). To ensure that species identification is valid, when possible, at least 50 sporulated oocysts from each species were observed and measured (Wang *et al.,* 2010, Cavalcante *et al.,* 2012).

Data analysis

Prevalence was calculated according to Bush *et al.* (1997). Differences in prevalence of *Eimeria* among different age categories of goats, as well as among different localities were evaluated using a Chi square test. Comparisons of OPG numbers according to sex and season were tested using Mann-Whitney test (U-test) while according age categories and locality were tested by Kruskal Wallis. Correlations between host age and both prevalence and OPG number were examined by using the non-parametric, Spearman's rank correlation coefficients (r_s). All the statistical tests were performed by using the software packages SPSS 17.0 (USA) and a value of $P < 0.05$ was considered significant.

RESULTS

Out of 336 faecal samples examined, 180 (53.57%) were positive for *Eimeria* oocysts. The prevalence of *Eimeria* oocysts in the three localities of Al-Baha area ranged from 39.64% to 61.40%. Statistically significant differences were found in prevalence (X^2*=12.98, df=2, P=0.002*) and OPG (X^2*=10.69, df=2, P=0.005*) among different localities of Al-Baha area. The highest prevalence (61.40%) and OPG (182.56±35.96) were observed in goats in Al-Mikhwah locality. The lowest prevalence (39.64%) was observed in goats in Al-Baha locality (Table 2). Nine different *Eimeria* species were identified from faecal samples of goats collected from Al-Baha area.

Table 2: Prevalence and parasite load of *Eimeria* oocysts in goats in different localities of Al-Baha area.

Locality	Examined number	Infected number	Prevalence (%)	Significance among location	Mean no. of oocysts per gram of faeces (range)
Al-Baha	111	44	39.64	X^2*=12.98, df=2, P=0.002*	102.80±23.95 (0-1209)
Al-Aqiq	111	66	59.46		180±34.45 (0-1809)
Al-Mikhwah	114	70	61.40		182.56±35.96 (0-1875)

The prevalence of these *Eimeria* species was: *Eimeria arloingi* (Marotel, 1905) Martin, 1909 (35.71%), *E. alijevi* Musaev, 1970 (26.19%), *E. hirci* Chevalier, 1966 (25.29%), *E. ninakohlyakimovae* Yakimoff & Rastegaieff, 1930 (16.36%), *E. christenseni* Levine, Ivens & Fritz, 1962 (14.59%), *E. caprina* Lima, 1979 (11.31%), *E. jolchijevi* Musaev, 1970 (9.52%), *E. caprovina* Lima, 1980 (5.59%) and *E. apsheronica* Musaev, 1970 (3.27%). *E. arloingi* (35.71%), *E. alijevi* (26.19%) and *E. hirci* (25.29%) were the most prevalent species and *E. apsheronica* (3.27%) was the least prevalent one (Table 3).

Table 3: Prevalence of *Eimeria* species in goats.

***Eimeria* species**	**Number of infected goats**	**Prevalence (%)**
Eimeria arloingi	120	35.71
E. alijevi	88	26.19
E. hirci	85	25.29
E. ninakohlyakimovae	55	16.36
E. christenseni	49	14.59
E. caprina	38	11.31
E. jolchijevi	32	9.52
E. caprovina	20	5.59
E. apsheronica	11	3.27

The prevalence of *Eimeria* oocysts in male was higher (55.19%) than that in female (51.63%). Also, the OPG number was higher in male (157.66 ± 26.19) when compared to female (152.62 ± 26.04). However, there were no statistically significant difference in prevalence (X2=0.42, df=1, P=0.52) and OPG (*U=13653; P=0.68*) between male and female (Table 4).

Table 4: Prevalence and parasite load of *Eimeria* oocysts per host sex of goats.

Host sex	**Examined number**	**Infected number**	**Prevalence (%)**	**Significance between host sex prevalence**	**Mean no. of oocysts per gram of faeces (range)**
Male	183	101	55.19		157.66±26.16 (0-1875)
Female	153	79	51.63	X^2*=0.42, df=1, P=0.52*	152.62±26.04 (0-1709)
Total	336	180	53.57		155.37 ± 18.52 (0-1875)

The prevalences of *Eimeria* oocysts in age categories were 65.56 % (59/90), 54.45% (66/121), and 44% (55/125) in <6-months old, 6-12-months old and >12-months old respectively. The highest prevalence (65.56 %) was recorded in the youngest age category (<6-months old) and the lowest one (44%) was observed in the oldest age category (>12-months old). Moreover, OPG number was higher (351.13±57.54) in <6-months when compared to other age categories (Table 5).

Table 5: Prevalence and parasite load of *Eimeria* oocysts in different age categories of goats.

Age categories	**Examined number**	**Infected number**	**Prevalence (%)**	**Significance among age categories prevalence**	**Mean no. of oocysts per gram of faeces (range)**
<6 months old	90	59	65.56		351.13±57.54 (0-1875)
6-12 months old	121	66	54.45	X^2*=9.81, df=2, P=0.007*	104.42±18.87 (0-1123)
>12 months old	125	55	44		63.72±11.89 (0-619)
Total	336	180	53.57		155.37 ± 18.52 (0-1875)

Significant difference was found in prevalence (X^2=*9.81, df=2, P=0.*007) and OPG number (X^2=*18.41, df=2, P<0.*001) among different age categories (Table 5). Significant negative correlation were found between host age and both prevalence (r_s=0.17, P=0.002) and OPG number (r_s=0.23, P<0.001).

There was seasonal difference in prevalence of *Eimeria* oocysts in goats. The prevalence of coccidial oocysts was significantly higher (60.22%) in wet season than that in dry season (45.81%) (X^2=*9.81, df=1, P=0.008*). OPG numbers were significantly higher (173.15±27.56) when compared to that in dry season (Table 6; *U=12366.5, P=0.049*).

Table 6: Prevalence and parasite load of *Eimeria* oocysts in different seasons in Al-Baha area, Saudi Arabia.

Season	Examined number	Infected number	Prevalence (%)	Significance among age categories prevalence	Mean no. of oocysts per gram of faeces (range)
Dry season	155	71	45.81		134.60±24.00 (0-1623)
Wet season	181	109	60.22	X^2=*6.95, df=1, P=0.008*	173.15±27.56 (0-1875)

Multiple-species infections (simultaneous infections with multiple parasite species in an individual host) of more than one *Eimeria* species were commonly present in all age categories. Multiple-species infections were detected in 89.44% (161/180) of positive goats which carried two to five species; 67.77% (122/180) of positive goats had two to three species. Infections with 4 and 5 species were less common (21.66%; 39/180) (Table 7).

Table 7: Percentage of single and multiple-species infections of different *Eimeria* species in goats in Al-Baha, Saudi Arabia.

The number of *Eimeria* species in examined samples	**0**	**1**	**2**	**3**	**4**	**5**
Infected goats	157	18	49	73	27	12
Percentage (%)	46.7%	5.4%	14.6%	21.7%	8.0%	3.6%

DISCUSSION

In the present study, the prevalence of *Eimeria* species infection was 53.57% in goats in Al-Baha area, south-west Saudi Arabia. This finding is lower than those reported in central region of Saudi Arabia (Alyousif *et al.,* 1992), Turkey (Gül, 2007), northeastern China (Wang *et al.,* 2010), Barazil (Cavalcante *et al.,* 2012), which revealed a prevalence of 90.3%, 82.55%, 90.9%, 91.2% in goats respectively. These differences in prevalence may be due to various sanitation efforts in the management programs attempted by goat producers to control coccidiosis or due to differences in ecological condition.

Thirteen *Eimeria* species known to infect goats (Pellérdy, 1974; Levine 1985; Norton, 1986; Wang *et al.,* 2010), ten of them were previously reported in Saudi Arabia, namely *E. arloingi, E. alijevi, E. ninakohlyakimovae, E. hirei, E. christenseni, E. caprina, E. apsheronica, E. caprovina*, *E. punctate* and *E. jolehijevi* (Alyousif *et al.,* 1992). But we found only nine species in goats including all species that found by Alyousif *et al.* (1992) except one species, namely *E. punctate*. The reported species in this study is similar to those recorded in Poland by Balicka-Ramisz (1999). *E. arloingi* (35.71%), *E. alijevi* (26.19%) and *E. hirci* (25.29%) were more frequent. This result is similar to those reported by Alyousif *et al.* (1992), Harper and Penzhorn (1999), Gül (2007), Wang *et al.* (2010) and *Cavalcante et al.* (2012). The present results

demonstrated that multiple-species infections with two or three *Eimeria* species were more commonly seen than infection with a single *Eimeria* species. This finding is consistent with findings of other researchers (Alyousif *et al*., 1992; Wang *et al*. 2010; Cavalcante *et al.* 2012).

The prevalence and OPG of *Eimeria* oocysts in lower age category (kids) (89.5%) were significantly higher than that in adult goats (87.5%). Moreover, the number of *Eimeria* oocysts excreted in the group less than 1-year-old group was higher than older (>1-year-old) animals investigated. These findings are in agreement with previous observations (Alyousif *et al.,* 1992; Wang *et al*., 2010). This has been attributed to lower resistance or less immunity to *Eimeria* species in young animals compared to the older animals (Gregory *et al.,* 1980; Kanyari, 1988; Maingi and Munyua, 1994).

In the present study, the prevalence and OPG of *Eimeria* species in wet season (60.22% and 173.15±27.56 OPG respectively) were significantly higher than that in dry season (45.81% and 134.60±24.00 OPG respectively). Similarly, Bakunzi *et al.* (2010), El-Bahy *et al.* (2008) and Majaro and Dipeolu (1981) found higher *Eimeria* oocyst counts during the hot, rainy season than those during the cold, dry season. El-Bahy *et al.* (2008) reported that *Coccidia* sp. are abundant during April to June and their incubation period is about 1-2 week, so new infection could be occurs in the same period as end of March till end of June. On the contrast, other researchers observed that the overall OPG counts of goats were significantly higher during the dry season than those during the wet season (Harper and Penzhorn, 1999; Soliman and Zalat, 2003).

In conclusion, the prevalence of coccidiosis is relatively low compared to other studies. Moreover, no signs of clinical coccidiosis were found in this study. We need further research to study the interaction between multiple-species infections in coccidiosis and parasite load in natural host-parasite systems. These results also provide relevant base-line data for assessing the effectiveness of future control strategies against coccidiosis in goats.

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ARABIC SUMMARY

نسبة انتشار الإصابة بأنواع الأيمريا في ماعز منطقة الباحة ، المملكة العربية السعودية

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يهدف هذا العمل إلى تعريف أنواع الأيمريا في الماعز وفحص العوامل المحتملة التي تؤثر في نسبة الانتشار والحمل الطفيلي. تم عمل هذه الدراسة بمنطقة الباحة بالمملكة العربية السعودية من شهر سبتمبر 2011 إلى شهر يونيه 2012. تم فحص 336 عينة براز ووجد أن 180 (53.57%) عينة منها مصابة بحويصلات الأيمريا. تراوحت نسبة انتشار الأيمريا من 39.64 % إلى 61.40 % في الأماكن المختلفة بمنطقة الباحة. وأوضحت النتائج أنه يوجد تسعة أنواع من الأيمريا وهي *Eimeria arloingi* ، *E. alijevi* ، *E. hirci* ، *E. ninakohlyakimovae* ، *E. christenseni* ، *E. caprina* ، *E. jolchijevi* ، *E. caprovina* و *E. apsheronica*. كانت الأنواع *Eimeria arloingi* (35.71%) و *E. alijevi* (26.19%) و *E. hirci* هي الأكثر انتشاراً بينما كانت *E. apsheronica* (3.27%) هي الأقل انتشاراً. بينت النتائج أن أهم العوامل التي تؤثر في نسبة الانتشار والحمل الطفيلي كانت عمر العائل والمكان والموسم. كما أوضحت النتائج أنه يوجد ارتباط سالب معنوي بين العمر وكل من نسبة الانتشار وعدد حويصلات الأيمريا في البراز. كما كانت نسبة العدوي بأكثر من نوع من الأيمريا (العدوى المتعددة) 89.44% والتي كانت فيها الاصابة بعدد من 2 إلى 5 أنواع. نستخلص من نتائج هذا البحث أن نسبة الانتشار للكوكسديا منخفضة إذا ما قورنت بنتائج الدراسات الأخرى علاوة أنه لا يوجد علامات للإصابة بالأيمريا. نحتاج إلى إجراء مزيد من الدراسات الأخرى لدراسة التفاعل بن الاصابة بعدد من أنواع الأيمريا وعلاقته بالحمل الطفيلي.