Original Article

The occurrence of gastrointestinal parasitic infections of goats in Ratchaburi, Thailand

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Abstract

Gastrointestinal (GI) parasitic diseases play an important role in the major constraints on goat production in Thailand and worldwide. The aim of this study was to assess the occurrence of GI parasitic infections among goats in Ratchaburi province of Thailand. In this study, fecal samples (394) were collected and tested by means of the floatation, sedimentation and direct smear methods to discriminate eggs or oocyst of the parasites. The overall occurrence of GI parasitic infections was 86.54%. The respective occurrences for the raising distance, farm system, water source nearby, type of feed and aquatic plants were found to vary significantly ($p < 0.01$), while a significant difference was not observed counting upon the goats' gender and age. The result disclosed that the highest occurrence of nematode, trematode, cestode and protozoa were *Strongyloides* sp. (57.77%), *Paramphistomum cervi* (33.43%), *Moniezia* sp. (29.91%) and *Eimeria* sp. (1.75%), respectively. Both single infection (18.78%) and mixed infection (67.67%) were evaluated in the examined goats. And so, on top of this, GIS results exhibited the movements or raising distance of goats indicating parasitic disease distribution. We intensively noted the need to find appropriate preventive control strategies against parasitic diseases in order to reduce or eliminate the harmful impact of parasitic infections on the goat industry.

Keywords: Gastrointestinal parasites, Goats, Occurrence, Thailand

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Introduction

Up to now, the worldwide goat population has shown a rather rapid growth of more than 800 million goats in developing countries including Thailand and the local demand for goat meat and milk products is still increasing. Parasitic infections in the gastrointestinal tract are one of the serious restraints on a beneficial goat industry in tropical and subtropical countries including Thailand. Gastrointestinal (GI) parasites are responsible for causing huge economic loss as a consequence of weight loss, digestive disorders, lowered production, a deteriorated reproductive system, condemnation of effected organs and death in infected animals (Gibbs, 1981; Raza *et al*., 2007; Panyarachun *et al*., 2010, 2013; Anuracpreeda *et al*., 2012, 2015, 2016a, b, 2017; Marskole *et al*., 2016; Sohail *et al*., 2019). In Thailand, parasitic infections in goats have been reported in some provinces such as Lumpang and Songkhla (Trongwongs *et al*., 1984; Suttiyotin, 1987; Suksaithaichana *et al*., 1993).

Geographic Information System (GIS) has been increased since the early 1990s and utilized for public health applications in veterinary medicine. It plays an important role in health care, surveillance of infectious diseases, as well as the mapping and understanding of parasitic diseases (Fletcher-Lartey and Caprarelli, 2016). In addition, GIS is an instrument which is defining the geographical field of populations at risk, identifying specific geographical clusters of vulnerable animals and determining good geographical areas for storage and vaccine management (Khan *et al*., 2010). Unfortunately, little is known about the details of GI parasitic infections in goats in Thailand. Hence, the aims of this work were to investigate the occurrence of GI parasitic infections in goats and provide information on the distribution of the infections using GIS.

Materials and Methods

Study areas and sample collection: The present work was carried out from 22 October 2018 to 27 September 2019 in nine districts [Suan Phueng (22 to 26 October 2018; 9 farms), Pak Tho (19 to 23 November 2018; 2 farms), Bang Phae (24 to 28 December 2018; 3 farms), Damnoen Saduak (21 to 25 February 2019; 2 farms), Chom Bueng (18 to 22 March 2019; 5 farms), Photharam (18 to 22 May 2019; 3 farms), Ban Pong (22 to 26 June 2019; 4 farms), Ban Kha (20 to 24 July 2019; 6 farms) and Mueng Ratchaburi (23 to 27 September 2019; 3 farms)] of Ratchaburi province, western Thailand (13° 34' 60" N latitude / 99° 31' 60" E longitude). Generally, goat herds are reared by the free-range system, where animals graze freely all over the area. None of the selected farms in this study was following a deworming program. Clinical examination was investigated for all animals under the experiments. A total of 394 fecal samples were obtained from 12 males and 382 females. Age groups were classified as < 1 year, 1-2 years, > 2 years old. Using a plastic glove, fresh fecal samples were collected from the rectum or during defecation and stored individually in sterile zip-lock bags, then placed in an icebox or at 4°C until use. All samples were collected with the respective GPS locations and other associated field information.

Floatation method: Floatation technique was used for demonstrating nematode and cestode eggs and oocyst of protozoa according to the method of Soulsby (1986). Briefly, 1-3 grams of each fecal sample were mixed with 50 ml of saturated salt solution (sodium chloride with 1.2 specific gravity) in a conical glass test tube. The presence of parasite stages (i.e., eggs or larvae of helminths, oocysts of coccidian) were observed by their morphological characteristics as described by Urquhart *et al*., (1996) using ×10 and ×40 magnifications.

Sedimentation method: As per the method of Soulsby (1986), sedimentation technique was used to detect the trematode eggs. Briefly, 3-5 grams of feces were mixed in 250 ml of water in a measuring cup and filtered through a sieve (50 meshes). The filtrates were allowed to stand for 1 h to precipitate the parasite eggs and then the supernatant was removed. Thereafter, identification of parasite stages was carried out on their morphological properties as per Urquhart *et al*., (1996) utilizing ×10 and ×40 magnifications.

Additional fecal examination: Direct fecal smears were used to examine the protozoan trophozoites. Some smears were stained using the modified Zieht-Neelsen method (Henriksen *et al*., 1981) and observed under a microscope with oil immersion at ×100 magnification to detect the oocysts of *Cryptosporidium* sp.

GIS database: The study area was observed in two districts (Ban Pong and Suan Phueng) of Ratchaburi province in Thailand, the locations of a free-range system for goat farms. Locations and subjects in this work were determined with global positioning system (GPS) technology using collar receivers suitable for monitoring animal position. The GIS data was imported into a GIS to evaluate animal behavior characteristics, survey locations and the number of positive samples using the software QGIS version 3.12, and verification identified errors in data entry.

Statistical analysis: The overall occurrence was calculated as a percentage of number of parasitic-infected animals in the total number of examined animals. Relative occurrence for different species of the parasites was calculated and proceeded by three age groups. For all analyses, confidence level was taken at 95% and the p - value of ≤ 0.05 was established as the level of significance. Statistical analysis was determined using SPSS software for Windows version 22.0 (SPSS Inc., Chicago, USA).

Ethics statement: Experiments on animals were approved by the Mahidol University - Institute Animal Care and Use Committee (MU-IACUC) (Protocol No. MU-IACUC2016/11), Mahidol University, Thailand.

Results

In this study, the clinical examination of 394 goats located at the study areas in Ratchaburi province (Fig.

1) showed that 53 (13.45%) goats were healthy, while 341 (86.54%) goats were unhealthy and showed clinical signs including depression, anorexia, diarrhea, weakness, weight loss, lethargy and emaciation.

A total of 341 goats from nine districts of Ratchaburi province were successfully examined. The fecal examination of the goats (Fig. 2) exhibited that the occurrence of GI parasitic infections ranged from 77.55% in Mueang Ratchaburi district to 96.96% in Suan Phueng district as illustrated in Table 1. The overall occurrence of GI parasitic infections in all three age groups was 86.54% (341/394), reaching 91.66% (11/12) of males and 86.38% (330/382) of females being infected with GI parasites. In addition, the overall occurrences of GI parasitic infections in goats aged < 1 year, 1-2 years and > 2 years old were 91.04% (61/67), 87.71% (200/228) and 88.88% (80/90), respectively (Table 2). The association between the occurrence of GI parasitic infections and raising distance, farm system, water source nearby, type of feed and aquatic plants was considered to be statistically significant ($p < 0.05$), while significant difference was not found counting upon the goats' gender and age (Table 2).

In this study, only 18.78% were positive for a single parasite (Table 2) and goats aged > 2 years old had more *Strongyloides* sp. infections mixed with other species of helminths or protozoa (Table 4). The significant difference of GI parasitic infection between districts and parasite group was determined. The association between the occurrence of nematode and cestode infections and various districts was considered to be statistically significant ($p < 0.05$), while significant difference was not observed in cestode and protozoa infections (Table 3). The highest occurrence of nematode (*Strongyloides* sp.), trematode (*Paramphistomum cervi*), cestode (*Moniezia* sp.) and protozoa (*Eimeria* sp.) was 57.77%, 33.43%, 29.91% and 1.75%, respectively (Table 4).

Moreover, GIS software showed the distribution of GI parasitic infections in goats in two districts, that is Suan Phueng and Ban Pong, of Ratchaburi province of Thailand as demonstrated in Figure 3. The distribution maps were conducted with 7 and 2 farms from Suan Phueng and Ban Pong, respectively. The raising distances were 8000 m of Suan Phueng and 3000 m of Ban Pong. However, the infection areas of the farms in Suan Phueng and Ban Pong were 375 m and 2000 m, respectively.

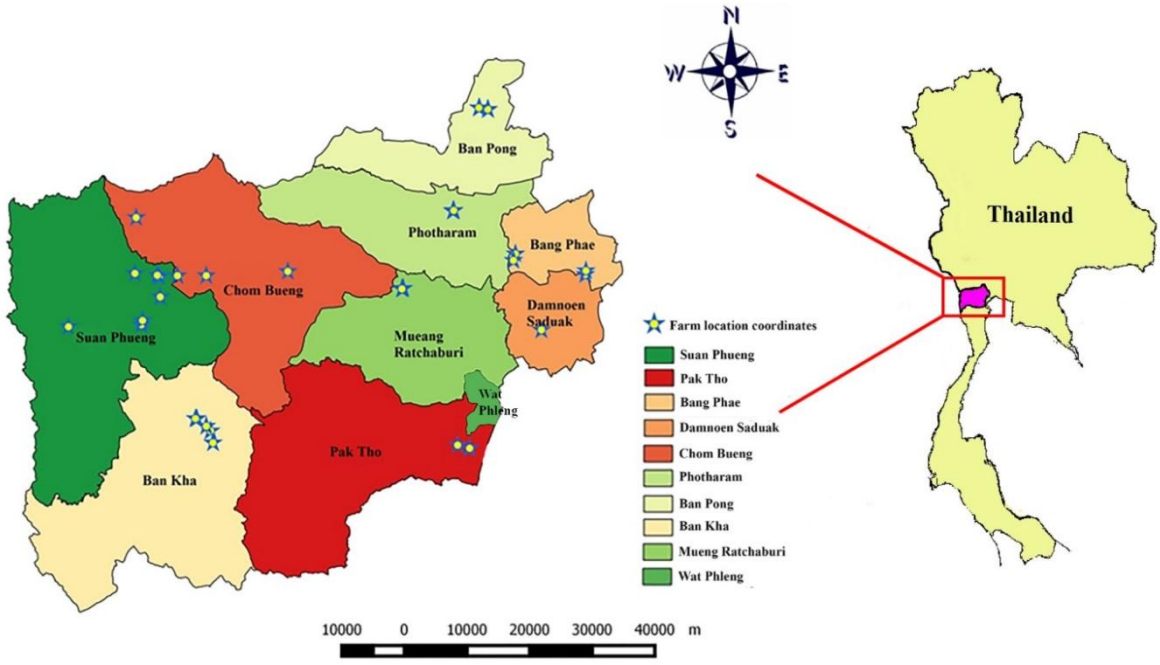

Figure 1 Location of nine studied areas in Ratchaburi province of Thailand, where samples were collected from 22 October 2018 to 27 September 2019.

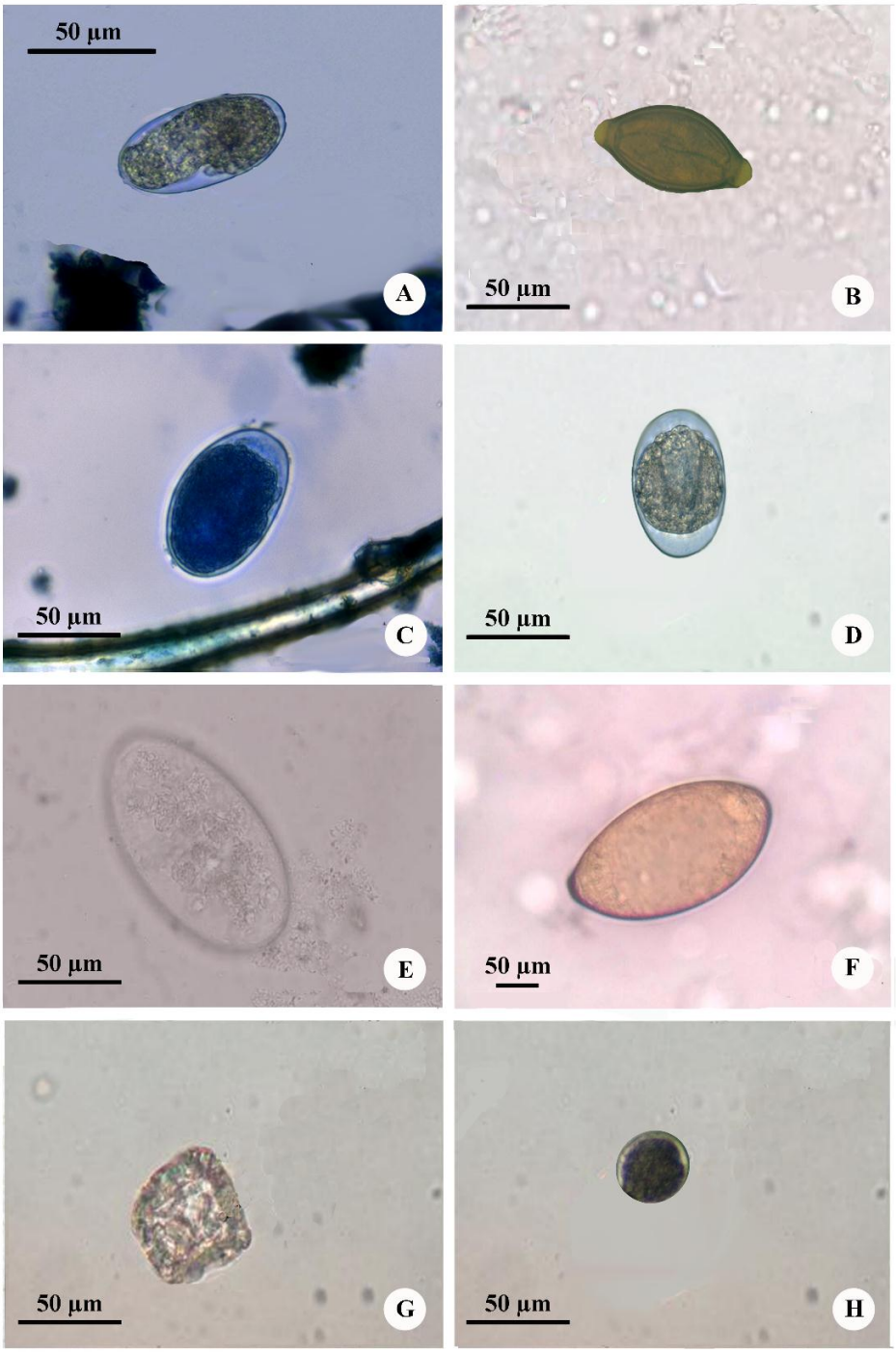

Figure 2 The egg representatives of GI nematode, trematode and cestode in goats are one of the important parasitic diseases reducing the livestock productivity (×40 magnifications). Egg of *Strongyloides* sp. (A), *Trichuris* sp. (B), *Haemonchus contortus* (C), Strongyle-type egg (D), *Paramphistomum cervi* (E), *Fasciola gigantica* (F), and *Moniezia* sp. (G) as well as unsporulated oocyst of *Eimeria* sp. (H).

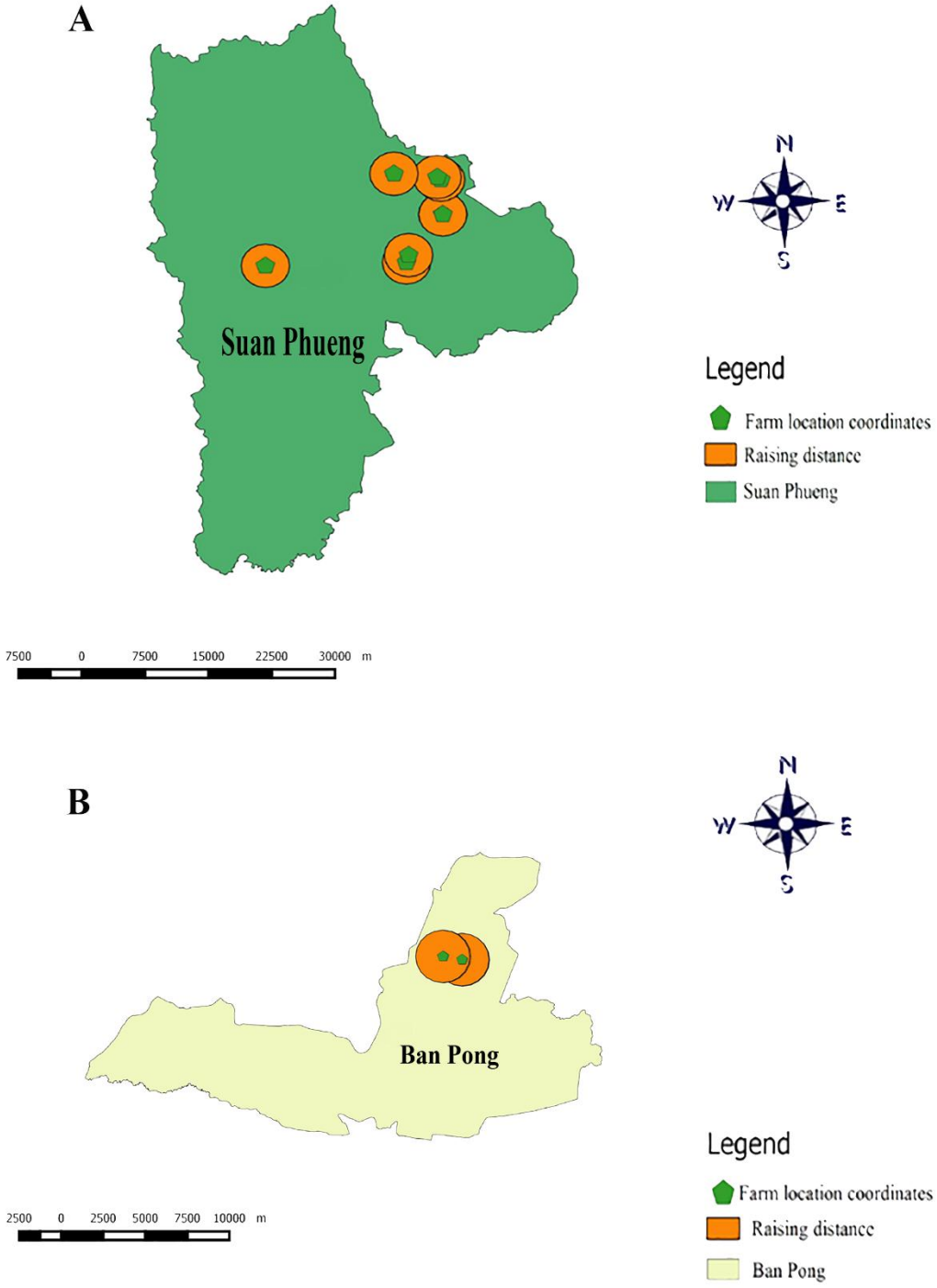

Figure 3 GIS map showing the distribution of GI parasitic infections in goats in Suan Phueng (A) and Ban Pong (B) districts of Ratchaburi province, Thailand.

Table 1 The occurrence of GI parasitic infections in Ratchaburi province, Thailand.

Factor	Category	Number examined	Number positive (%)
Province	Ratchaburi		
District	Suan Phueng	33	32 (96.96)
	Pak Tho	18	17 (94.44)
	Bang Phae	26	24 (92.30)
	Damnoen Saduak	20	18 (90.0)
	Chom Bueng	126	112 (88.88)
	Photharam	25	22 (88.0)
	Ban Pong	36	30 (83.33)
	Ban Kha	61	48 (78.68)
	Mueang Ratchaburi	49	38 (77.55)
	Total	394	341 (86.54)

Table 2 Factors associated with GI parasitic infections of goats in Ratchaburi province, Thailand.

Factor	Category	Number examined	Number positive (%)	χ^2 (df)	*p* - value
Gender	Male	12	11 (91.66)	0.2785 (1)	0.597675
	Female	382	330 (86.38)		
	Total	394	341 (86.54)		
Age	< 1 year	67	61 (91.04)	4.234 (2)	0.120393
	1-2 years	228	200 (87.71)		
	> 2 years	99	80 (88.88)		
	Total	394	341(86.54)		
Raising distance	< 5 km	265	216 (86.58)	17.6509 (1)	0.000027
	> 5 km	129	125 (86.21)		
	Total	394	341 (86.54)		
Farm System	Extensive	208	198 (95.19)	28.2779 (1)	< 0.00001
	Intensive	186	143 (76.88)		
	Total	394	341 (86.54)		
Water source nearby	Yes	190	182 (95.79)	26.918 (1)	< 0.00001
	No	204	159 (77.94)		
	Total	394	341 (86.54)		
Type of Feed	Concentrate	112	81 (85.38)	27.528 (2)	< 0.00001
	Roughage	55	52 (94.55)		
	Mixed	227	208 (85.04)		
	Total	394	341 (86.54)		
Aquatic plants	Yes	142	135 (83.33)	13.85 (1)	0.000198
	No	252	206 (86.93)		
	Total	394	341 (86.54)		
Infection	Single	394	74 (18.78)	192.5657 (1)	< .00001
	Mixed	394	267 (67.77)		
	Total	394	341 (86.54)		

χ^2 = Chi-square; df = degree of freedom

Table 3 GI parasites of goats in nine districts in Ratchaburi province, Thailand.

Factor	Category	Nematodes			Trematodes			Cestode			Protozoa		
		Number positive (%)	χ^2 (df)	*p* - value	Number positive (%)	χ^2 (df)	*p* - value	Number positive (%)	χ^2 (df)	*p* - value	Number positive (%)	χ^2 (df)	*p* - value
Province	Ratchaburi	623 (92.02)			222 (65.10)			102 (29.91)			6 (1.75)		
Districts	Suan Phueng	99 (77.22)	27.069 (8)	0.000688	27 (19.42)	20.509 (8)	0.008574	10 (7.19)	8.3811 (8)	0.3972	2 (1.43)	16.8102 (8)	0.03215
	Pak Tho	18 (40.90)			21 (47.72)			4 (9.09)			0		
	Bang Phae	67 (69.79)			22 (22.91)			5 (5.20)			0		
	Damnoen Saduak	25 (51.02)			16 (32.65)			6 (12.24)			0		
	Chom Bueng	195 (73.86)			25 (9.46)			30 (11.36)			0		
	Photharam	29 (53.70)			11 (20.37)			10 (18.51)			1 (1.85)		
	Ban Pong	47 (55.95)			22 (26.19)			9 (10.71)			0		
	Ban Kha	105 (63.63)			30 (18.18)			14 (8.48)			3 (1.81)		
	Mueang Ratchaburi	38 (33.63)			48 (43.63)			14 (12.72)			0		

χ^2 = Chi-square; df = degree of freedom

Table 4 GI helminths and protozoa and their stages identified in goats in Ratchaburi province, Thailand.

Parasite	Stage of identification	Number positive (%)
Nematodes		
Strongyloides sp.	egg	197/341 (57.77)
Trichuris sp.	egg	76/341 (22.28)
Ostertagia sp.	egg	69/341 (20.23)
Haemonchus contortus	egg	62/341 (18.18)
Strongyle-type egg	egg	60/341 (17.59)
Capillaria sp.	egg	41/341 (12.02)
Trichostrongylus sp.	egg	40/341 (11.73)
Oesophagostomum sp.	egg	32/341 (9.38)
Cooperia sp.	egg	15/341 (4.39)
Bunostomum sp.	egg	13/341 (3.81)
Marshallagia marshalli	egg	9/341 (2.63)
Toxocara sp.	egg	9/341 (2.63)
Trematodes		
Paramphistomum cervi	egg	177/341 (51.9)
Fasciola gigantica	egg	45/341 (13.19)
Cestodes		
Moniezia sp.	egg	102/341 (29.91)
Protozoa		
Eimeria sp.	oocyst	6/341 (1.75)

Discussion

Up to now, the detection of GI parasitic infections in goats has only been reported in some areas of Thailand (Trongwongs *et al*., 1984; Suttiyotin, 1987; Suksaithaichana *et al*., 1993). Likewise, there is an obvious lack of relevant information on GI parasitic diseases isolated in goats in Thailand. Our study is the first investigation on the helminths and protozoa infections in goats throughout Ratchaburi province, western Thailand.

In the present study, our findings showed that high overall occurrence of GI parasitic infections received from fecal examination (86.54%) were manifested in the infection intensity among goats in nine districts of Ratchaburi, Thailand. This is in accordance with those reported by Singh *et al*., (2015), Hao *et al*., (2018), Jena *et al*., (2018) and Hassan *et al*., (2019) who revealed that the occurrence of GI parasitic infections was 94.48%, 88.1%, 86.13% and 89.33%, respectively, while Raza *et al*., (2007), Negasi *et al*., (2012) and Das *et al*., (2017) showed that relatively lower occurrence of the infections was 52%, 35.33% and 28.65%, respectively. It is possible that the climate conditions, such as rainfall, are often involved with difference in the occurrence of GI parasitic infections due to the longer survival of the free-living infective stages, i.e., eggs, larvae, cysts and oocysts (Kumar *et al*., 2013). In addition, western Thailand has a long rainy season (about 3-4 months); this tropical area is a significant influence on the risk of GI parasitic infections and also seems to be a predisposing factor for the development of various species of the parasites which can survive in a humid environment (Yadav, 2000; Prentice *et al*., 2017). Thus, GI parasitic infection is likely considered to be a worldwide hindrance among goats.

Our findings exhibited that goats were positive with GI nematodes, predominated by *Strongyloides* sp. (57.77%) and the least dominant GI nematodes were *Toxocara* sp. (2.63%) and *Trichostrongylus* sp. (2.63%). This result is consistent with other reports; for example, Hassan *et al*., (2011) who showed that 51.74% of goats were infected with *Strongyloides* sp. Similarly, it has been reported that *Strongyloides* sp. infection was found in goats at a percentage of 45.6% (Yusof and Isa, 2016). Nevertheless, some works have differently reported from our study. The greatest occurrence of nematode species infected goats was *Haemonchus* sp. with a percentage of 45.7% - 90% (Wahab and Adanan, 1992; Dorny *et al*., 1995; Faizal and Rajapakse, 2001; Gwaze *et al*., 2009; Nwigwe *et al*., 2013). On the other hand, the low occurrence of *Toxocara* sp. and *Trichostrongylus* sp. in our work was consistent with the investigations of goats as described by Yusof and Isa (2016). The high infection rate of GI nematodes may be due to the raising distance of goat grazing on pastures contaminated with third stage infective larvae of nematodes. And so, on top of this, the examination of GI trematodes of goats exhibited that the occurrence of *Paramphistomum cervi* (51.9%) and *Fasciola gigantica* (13.19%) was similar to those of Negasi *et al*., (2012). By contrast, our findings differed from other reports as revealed by Sultan *et al*., (2010) and Hassan *et al*., (2019). It is likely that these infections were due to non-control of freshwater snails, such as *Lymnaea* sp., which are the first intermediate host for development of the free-living infective stages (Ukong *et al*., 2007; Dung *et al*., 2013).

In this work, the result showed that the cestodes detected through fecal examination were *Moniezia* sp. with an occurrence of 29.91%. In addition, similar results displayed that the occurrence of *Moniezia* sp. infection among goats was 19.04% (Sultan *et al*., 2010), 15.09% (Negasi *et al*., 2012), 18.74% (Verma *et al*., 2018) and 18.22% (Hassan *et al*., 2019). The emergence of this cestode parasite in the tropical area is related to the ingestion of oribatid mites as an intermediate host which is infected with larvocysts of *Moniezia* sp. Furthermore, the occurrence of metacestode infection among goats because of the high population of stray dogs around the grazing space of goats and thus feeding offal of goats to dogs makes for completion of the parasite's life cycle (Radostits *et al*., 2000). In our current study, the occurrence of coccidian oocysts (*Eimeria* sp.) in goats was 1.75%. This finding was a lower incidence and contrary to Obijiaku and Agbede (2007), Singh *et al*., (2015), Verma *et al*., (2018) and Hassan *et al*., (2019) who mentioned a high incidence of coccidian infection. This study supposes that goats may be infected with *Eimeria* sp. via infected animals reared in the same flock. Likewise, the infection occurrence is a result of exposure to contaminated water and pasture lands by human or animal excretions in the free-range rearing system (Kumar *et al*., 2013).

The occurrence of GI parasitic infections was highest in goats aged < 1 year old (91.04%) compared to goats aged 1-2 years (87.71%) and > 2 years old (80.80%), which is in line with the previous studies (Emiru *et al*., 2013; El-Shahawy, 2016; Verma *et al*., 2018; Hassan *et al*., 2019). This might be owing to underdeveloped and lower immunological resistance towards parasitic infections among young ages compared to adults with low occurrence rates due to well-developed resistance. It is interesting to note that the occurrence of parasitic infections was not incorporated with gender and age group ($p > 0.05$). This finding is in agreement with reports obtained by Verma *et al*., (2018) and Hassan *et al*., (2019). Hence, there is no possible evidence for host-gender differences among different ruminants except for variation in the stages of pregnancy. However, a significant difference was detected from comparison among the positive sample with raising distance, farm system, water source nearby, type of feeds and aquatic plants ($p < 0.05$).

Bearing in mind, the data of GIS in this study, high and moderate parasitic infections of goats were found in Suan Phueng and Ban Pong districts of Ratchaburi province, western Thailand. The distribution maps indicated that raising distances were involved with the GI parasitic infection rate of goats under free-range farming system. The factor associated with high infection rates is frequently related to the movement or raising distance of animals. In addition, most Thai farmers did not quarantine and pre-or post-movement investigation, such as deworming (Prentice *et al*., 2017). In this study; therefore, the application of GIS technology in the investigation of parasitic diseases was conducted significantly on the understanding of

parasitic ecology and their association with disease distribution, empowering the development of efficient control and prevention strategies, particularly in developing areas. Control is based on periodic deworming to get rid of infecting parasites, health education to prevent re-infection and improved sanitation to mitigate soil and water contaminations with infective eggs. Also, safe and effective medicines should be available to control the infection.

In conclusion, this study has updated and shown information on GI parasitic infections among goats in nine districts of Ratchaburi province, western Thailand. The overall occurrence of GI parasitic infections was 86.54% including nematode, trematode, cestode and protozoa. Single and mixed GI parasitic infections were assessed in the examined goats. In addition, the GIS database can be used to evaluate raising distances or movements of goats involved with the infection.

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