Living Location nears Dam andGastrointestinal Helminth Infections in Rural Communities, Thailand: A Cross-sectional Study

Thongroo Kophachon[1], Oranard Wattanawong[1], Phornphitcha Pechdee[2], Alisa Boonsuya[2], Nathkapach Kaewpitoon Rattanapitoon[2], Schawanya Kaewpitoon Rattanapitoon[2], Tiwakorn Prachaiboon[3]

[1]Personnel, Personnel, Division of General CommunicableDiseases, Department of Disease Control, Ministry of Public Health, Nonthaburi 11000, Thailand, [2]Researcher, Parasitic Disease Research Center, Suranaree University of Technology, Nakhon Ratchasima, 30000, Thailand, [3]Lecturer, Faculty of Public Health, Valaya Alongkorn Rajabhat University, Prathum Thani, 13180, Thailand

Abstract

Background: Gastrointestinal helminth infections (GHIs) are health problems worldwide. People with GHIs can develop gastrointestinal symptoms, general malaise and weakness, malnutrition, and impaired growth and physical development.This study was performed to determine the current prevalence of GHIs in epidemic areas in northeast Thailand.

Methodology: A cross-sectional survey was conducted between June 2020 and January 2021 in two districts (HuaiMek and Som Det) in Kalasin Province, Thailand. Stool samples were collected and processed using the formalin ethyl-acetate concentration technique to determine the presence of helminthic parasites. The odds ratio (OR) for GHIs was calculated according to the general characteristics.

Results: In total, 404 individuals were enrolled, and the overall prevalence of GHI was 8.91%. The species distribution included a majority of *Opisthorchis viverrini*infections (5.94%), followed by infections with *Strongyloidesstercoralis*(1.98%), *Taenia* spp. (0.50%), *Trichuris trichiura* (0.25%) and *Ascaris lumbricoides* (0.25%). Coinfections were identified in 4 cases with *O. viverrini* and *S. stercoralis* and 1 case with *O. viverrini* and *Taenia* spp. All infected participants had mild GHIs. The prevalence of helminthic infection was significantly higher in males ($P = 0.002$), in those aged >60 years old ($P = 0.025$), in those who were employed ($P = 0.004$) and in those who lived in the Som Det district ($P = 0.001$)than in their counterparts. Multivariable logistic regression analysis revealed that being male (adjusted odds ratio [aOR] 2.73, $P = 0.002$) and living in the Som Det district where nears dam(aOR1.73, $P<0.001$) were significantly associated with an increased likelihood of having aGHI.

Conclusion: This study demonstrated that GHIs, particularly in*O. viverrini*infections, are still prevalent in rural communities near large dams. The data from this study will be useful for guiding and improvingprevention and control strategies targeting*O. viverrini*and other helminths in this province.

Keywords: *Living Location. Dam. Gastrointestinal Helminth Infections. Thailand.*

Corresponding author:
NathkapachKaewpitoonRattanapitoon,
Researcher, Parasitic Disease Research Center, Suranaree University of Technology, Nakhon Ratchasima, 30000, Thailand,
E-mail: nathkapach.ratt@sut.ac.th

Introduction

Gastrointestinal helminth infections (GHIs) are health problems worldwide, and more than 1.7 billion people have GHIs, particularly in at least one of the five neglected tropical diseases[1]. It is estimated that 300 million people are infected with GHIs in ASEAN countries[2]. In Thailand, the national prevalence rate of GHIs was 18.1%, with a high prevalence rate of liver fluke infections[3].Furthermore, data collected on the incidence of liver fluke infections in Thailand by the Ministry of Public Health showed that the percentage of Thai people infected with liver flukes was 8.7%. InKalasinProvince, in northeastern Thailand, 27.4% of the people were infected with liver flukes[4]. One type ofliver fluke, *Opisthorchis viverrini*, is associated with hepatobiliary tract diseases, including cholangiocarcinoma, which is a serious health problem in Thailand, especially in KalasinProvince[5, 6]. In addition, a total of 22,338 patientsin a hospital-based study in northeast Thailand were tested for*Strongyloidesstercoralis,* and 17.4% tested positive for this helminth. In KalasinProvince, 21.1% had stool samples that tested positive for strongyloidiasis[7]. Meanwhile, 104 inhabitants of KalasinProvince were tested for GHIs, and the overall prevalence was 33.65%. The most common parasite was*S. stercoralis*(19.22%), followed by *O. viverrini*(5.76%) and *Taenia* spp. (0.96%)[8]. The data above indicate that KalasinProvince is an endemic area for GHIs, and more information is needed to definitely assess the current status of parasitic infections. People with GHIs can develop gastrointestinal symptoms, general malaise and weakness, malnutrition, and impaired growth and physical development[1]. Therefore, the current prevalence and burden of GHIs among residents at the district level need to be determined. These data may be useful for further prevention and control campaigns in the community.

Methodology

Study design and population: A cross-sectional survey was carried out from June 2020 to January 2021 and included people living in 12 rural villages located in the Sai Thong (5 villages)and Phi Moon (3 villages) subdistricts,HuaiMek district, and 4 rural villages located in the Som Det subdistrict, Som Det district, KalasinProvince, northeastern Thailand. The study area is located 517.4 km northeast of Bangkok and covers an area of 93 km^2 (Figure 1). Som Det and HuaiMekdistrictsare located near the Lam Pao dam (Som Det is closer than HuaiMek), the largest earthen dam in the country. It rises 33 meters above the water and can hold 1,430 million cubic meters. The dam was constructed to alleviate flooding and for agricultural purposes. The reservoir also serves as a breeding area for fish and a recreational destinationspot for the public. Participants were randomly selected from the villages in each subdistrict using a voluntary sampling method. A total of 404 volunteers were recruited from Sai Thong (n=219), Phi Moon (n=59) and Som Det (n=126). Data on sociodemographic characteristics were collected using a questionnaire. All participants provided written consent before submitting stool specimens and questionnaires.

Fecal collection and examination: Clean plastic containers were distributed to the participants at enrollment with detailed instructions about the procedure for collecting fecal specimens. All fecal samples were collected early in the morning and stored in iceboxes before being transported to the laboratory at the Parasitic Disease Research Center (PDRC), Institute of Medicine, Suranaree University of Technology.Each specimen was prepared and examined for the presence of gastrointestinal helminths with the formalin ethyl-acetate concentration technique[9]. Each specimen was examined under a microscope and initially screened under a 10× objective; the magnifications of the low-,

medium-, and high-power objectives were 4×, 10×, and 40×, respectively. Suspected gastrointestinal helminths were subsequently examined under a high-power objective. All samples were examined by two laboratory technologists from the PDRC. Patients who were infected with helminths and other known parasites were treated with anti-helminthic drugs and asked to attend health education sessions.

Statistical analysis: Statistical analyses were performed using the computer program STATA for Windows, version 13 (StataCorp LLC, Lakeway Drive, College Station, Texas, USA). The sociodemographic characteristics of the participants are presented as frequencies and percentages for categorical variables. The number of eggs per gram of feces (epg) was calculated as follows: (number of eggs/drop × total number of drops of fecal solution)/ (gram of feces). The intensity of infection was expressed as the epg for each participant. According to the WHO guidelines, the intensity of infection was classified as "light", "moderate" or "heavy" on the basis of the fecal egg count[10,11]. The differences in the categorical variables between the infected and uninfected groups were assessed using thechi-square test with the Yates correction. Multivariable logistic regression analysis was performed to estimate the odds ratios (ORs) and 95% confidence intervals (95% CIs) to assess the associations between potential risk factors and GHIs. A P-value <0.05 was considered statistically significant.

Results

Of the 404 fecal specimens examined, 31 were positive for at least one gastrointestinal helminth, resulting in an overall prevalence of 8.91%. The overall prevalence rate was 12.57% (22/175) in males and 3.93% (9/229) in females. Participants aged >60 years had a higher prevalence rate (15.15% [15/99]) than participants in the other age groups. Participants in the illiterate grouphad a higher prevalence rate (9.76% [4/40]) than participants with other levels of education. A high prevalence of GHIs was found in participants who were employed(20.00% [13/65]). When the participants were classified by location, those in theSom Det subdistrict had a higher prevalence rate (17.46% [22/126]) than participants in other subdistricts. The sociodemographic characteristics of the participants stratified by the presence or absence of GHIs were analyzed with the chi-square test; there were significant differences insex, age, employment status and location (Table 1). Five species of helminths were identified: 2 species were identified as foodborne helminths (FBHs), and 3 species were identified as soil-transmitted helminths (STHs). The most common FBHs were *O. viverrini*(5.94% [24/404]) and *Taenia spp.* (0.50% [2/404]), and the most common STHs were *S. stercoralis*(1.98% [2/242]), *T. trichiura*(**0.25%** [**1/4**04]) and *A. lumbricoides*(**0.25%** [**1/4**04])(Table 2). Of the 31 infected participants, all had light infections with *O. viverrini, S. stercoralis*, *Taenia* spp.,*A. lumbricoides*, and *T. trichiura* (Table 3). The associations of sociodemographic characteristics with GHIs were analyzed using multivariable logistic regression analysis (Table 3). The final model showed that being male (adjusted odds ratio [aOR] 0.273 [95% CI: 0.119-0.628], $P = 0.002$) and living in theSom Det subdistrict where nears the largest earthen dam (aOR 1.73 [95% CI: 1.292 – 2.315], $P<0.001$) were significantly associated with *O. viverrini*infection (Table 4).

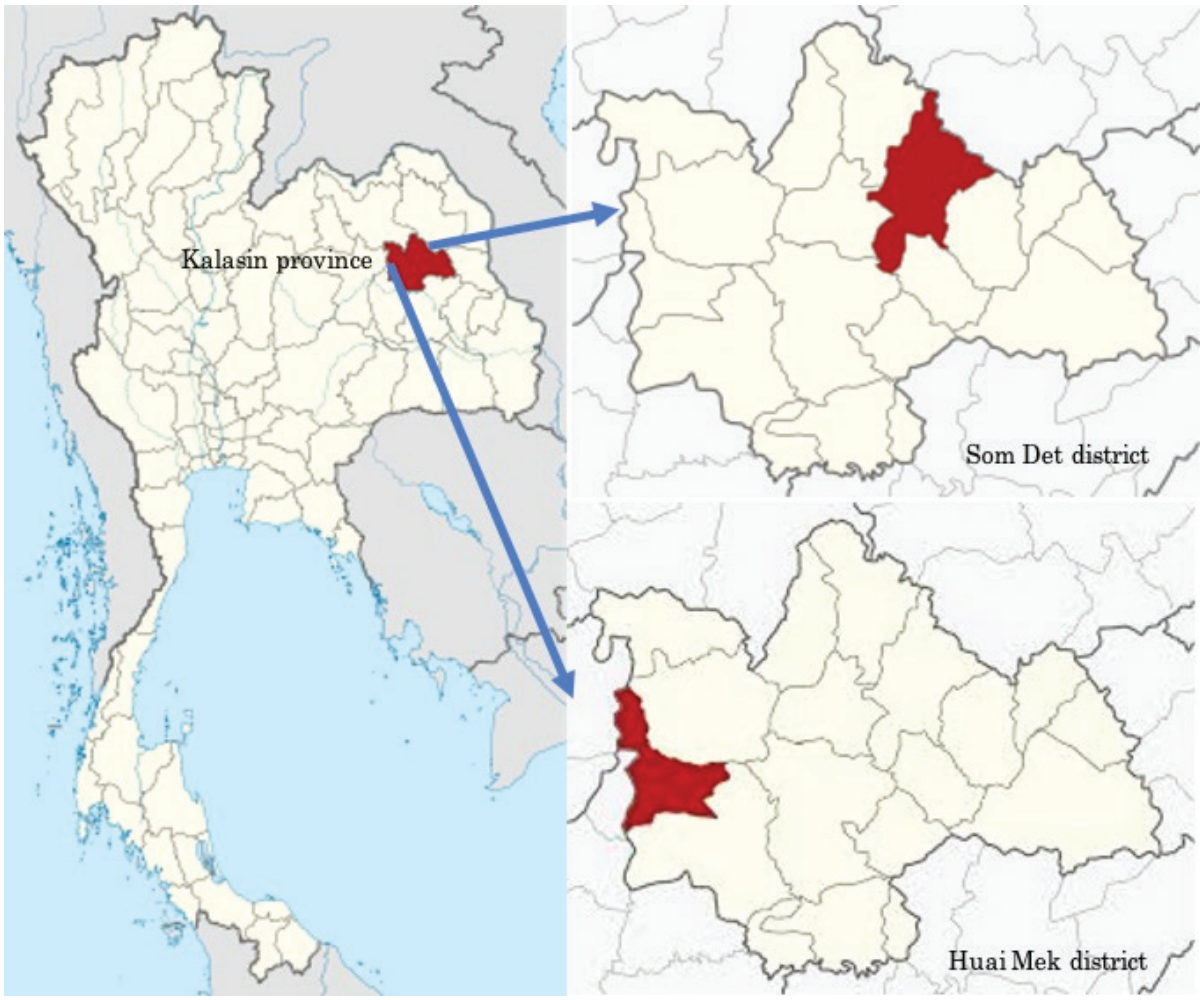

Figure 1.Map of Thailand showing the study area in Som Det and Huai Mek districts, Kalasin Province, Thailand.

Figure 2. Morphology of gastrointestinal helminth eggs and larvae identified by light microscopy in fecal samples. (A) *Opisthorchis viverrini* egg (×400). (B) *Trichuris trichiura* egg (×400). (C) *Taenia* spp. (×100). (D) *Ascaris lumbricoides* egg (×400). (E) *Strongyloides stercoralis* larvae(×400).

Table 1. Positivity for gastrointestinal helminth eggs stratified by general characteristics (n=404)

Variables	No. samples n(%)	No. positive n(%)	Infection rate (%)	P-value	Chi-square test
Sex					
Male	175(43.31)	22(12.57)	6.19	0.001*	10.455
Female	229(56.68)	9(3.93)	2.23		
Age (yr)					
≤20	6(1.48)	0	0	0.025	12.803
21 – 30	7(1.73)	1(14.29)	0.25		
31 – 40	29(7.18)	3(10.34)	0.74		
41 – 50	107(26.48)	4(3.74)	0.99		
51 – 60	156(38.61)	8(5.13)	1.98		
> 60	99(24.50)	15(15.15)	3.71		
Education					
Illiterate	40(9.90)	4(9.76)	0.25	0.841	1.416
Primary	260(64.37)	21(8.08)	5.20		
Secondary	92(22.77)	5(5.43)	1.24		
College	3(0.74)	0	0		
Other	9(2.23)	1(11.11)	0.25		
Employment status					
Employed	65(16.09)	13(20.00)	3.22	0.004*	17.092
Famer	249(61.63)	14(5.62)	3.47		
Shopkeeper	23(5.69)	0	0		
Housewife	25(6.19)	3(12.00)	0.74		
Government officer	5(1.24)	0	0		
Other	37(9.16)	1(2.70)	0.25		
Location (subdistrict)					
Sai Thong	219(0.74)	7(3.20)	1.73	0.001*	25.675
Phi Moon	59(14.60)	2(3.39)	0.50		
Som Det	126(31.19)	22(17.46)	5.45		
Data are presented as the frequencies (%). *Chi-square test					

Table 2. Gastrointestinal helminth infections among 404 rural villagers in Huai Mek and Som Det districts, Kalasin Province, northeastern Thailand

Type of gastrointestinal helminth	No. positive	Prevalence (%)
Opisthorchis viverrini	24	5.94
Strongyloides stercoralis	8	1.98
*Teania*spp.	2	0.50
Trichuris trichiura	1	025
Ascaris lumbicoides	1	0.25
Total	**36**	**8.91**

Table 3. Egg counts (eggs per gram of feces) used to describe the intensity of infection (n=404)

Type of gastrointestinal helminth	Intensity of infection (egg count per gram)	Level of intensity
Opisthorchis viverrini	180.12 (22-1564)	light
Strongyloides stercoralis	71.50 (12-252)	light
Teania spp.	225(184-266)	light
Trichuris trichiura	110	light
Ascaris lumbicoides	20	light

Table 4. Factors associated with gastrointestinal helminth infection in the multivariable logistic regression analysis

Variables	No. samples n(%)	No. positive n(%)	Infection rate (%)	*OR	95% CI	P-value	**ORadj	95% CI	P-value
Sex									
Male	175 (43.31)	22(12.57)	5.45	0.285	0.128-0.635	0.002*	0.273	0.119-0.628	0.002*
Female	229 (56.68)	9(3.93)	2.23						
Age (yr)									

Cont... **Table 4. Factors associated with gastrointestinal helminth infection in the multivariable logistic regression analysis**

Variables	No. samples n(%)	No. positive n(%)	Infection rate (%)	*OR	95% CI	P-value	**ORadj	95% CI	P-value
≤20	6(1.48)	0	0	1.47	0.978-2.209	0.064	1.363	0.895-2.076	0.149
21 – 30	7(1.73)	1(14.29)	0.25						
31 – 40	29(7.18)	3(10.34)	0.74						
41 – 50	107(26.48)	4(3.74)	0.99						
51 – 60	156(38.61)	8(5.13)	1.98						
> 60	99(24.50)	15(15.15)	3.71						
Education									
Illiterate	40(9.90)	4(9.76)	0.25	0.832	0.482-1.437	0.510	0.996	0.531-1.868	0.990
Primary	260(64.37)	21(8.08)	5.20						
Secondary	92(22.77)	5(5.43)	1.24						
College	3(0.74)	0	0						
Other	9(2.23)	1(11.11)	0.25						
Employment status									
Employed	65(16.09)	13(20.00)	3.22	0.737	0.509-1.066	0.105	0.731	0.52-1.028	0.072
Famer	249(61.63)	14(5.62)	3.47						
Shopkeeper	23(5.69)	0	0						
Housewife	25(6.19)	3(12.00)	0.74						
Government officer	5(1.24)	0	0						
Other	37(9.16)	1(2.70)	0.25						
Location (subdistrict)									
Sai Thong	219(0.74)	7(3.20)	1.73	1.735	1.300-2.315	0.000*	1.73	1.292-2.315	0.000*
Phi Moon	59(14.60)	2(3.40)	0.50						
Som Det	126(31.19)	22(17.46)	5.45						

*Crude odds ratio from univariate analysis, **Adjusted odds ratio for all other variables

Discussion

GHIs continue to be a major health problem in many countries. This is particularly true for FHBs and STHs, which have been recognized as important public health problems in developing countries[1,12],including Thailand, especially in rural areas where there remains a lack of hygiene and an inadequate supply of clean water[13,14]. In this study, our data showed that the overall prevalence of GHIs among the rural participants was 8.91%. Compared with the results reported inother studies in KalasinProvince (33.65%), this prevalence was lower[8]. This could be due in part to the implementation of active control programs for helminths by the Ministry of Public Health. Our study showed that the prevalence was higher in males than in females. The sex difference may be due to male-specific behavioral factors such as eating raw meat and working in agriculture[15,16].A greater proportion of men work in muddy rice fields without footwear, whereas a greater proportion of women work as housewives and wear shoes while walking around in their houses and villages[7,17]. In our study, the prevalence of GHIs in the older age group was higher than that in the younger age group. This result is similar tothose reported by previous studiesthat showed that older people need to undergo screening for GHIs and that interventions need to focus on this population[18,19]. This may be because older people still tend to have lower education levels, live in conditions with poor sanitation and have a culturally embedded habit of eating uncooked food[14, 20-21]. A relatively high prevalence was found in the participants who were illiterate. This is similar toprevious studies that found that people in the community with low level of education, especially farmers and other workers, have a relatively high prevalence of parasitic infections[12-14]. In particular, farmers may be at risk due to conditions in the field, and many men work in muddy rice fields without footwear[13,14,17]. Health education programs should target this group and teach them about the benefits of avoiding raw food wearing shoes. In this study, our data indicated that Som Det districthad a higher prevalence of GHIs than other districts. This may be due in part to the fact that thefarms where they work and the houses where they liveare located in the same area near a large freshwater dam, which increases the risk of infection. A previous study reported that GHIs were was associated withliving at lower elevations in KhonKaenProvince, northeastern Thailand. This study indicated that lower elevation was associated with a higher infection rate than higher elevations[14, 18]. Moreover, a previous study showed the prevalence of and risk factors for *O. viverrini* infection among cats and dogs in six districts surrounding the Ubolratana Dam. Cats and dogs can be infected by*O. viverrini* and may play an important role in the transmission and maintenance of this disease in areas around large dams[22]. In our study,we focused on humans, and there were infected individuals in all the villages. Therefore, more efforts from the local administration, particularly with regard tohealth education campaigns among the villagers, are needed to preventGHIs by improving sanitation; accomplishing this goal would improve the general health of the villagers. The most common FBHs were identified as *O. viverrini* and *Taenia spp.*, which is concerning because*O. viverrini* is a carcinogenic liver fluke that causes serious problems in Thailand. Our data showed that some participants were infected with*O. viverrini*, but the prevalence was lower than in previous studies. In Thailand, the Ministry of Public Health reported that the percentage of *O. viverrini* infectionsidentified during the period 2009 to 2013 was 8.7%. Yahom*et al*.[8] reported that the prevalence of*O. viverrini*infections in KalasinProvince was 5.76%.In KalasinProvince, 27.4% of people were infected with liver flukes[4]. These results indicate that *O. viverrini* is still affectingthe Thai population at the village level. Although this study found a relatively low prevalence and light intensity, these liver flukes

still exist and are widely distributed, with prevalence ratessimilar tothose in other areas. Coinfections identified, with 5 cases of *O. viverrini*, *S. stercoralis* and *Taenia* spp. coinfections.

The results of the present study aresimilar tothose of a previous study that found*S. stercoralis* and *O. viverrini* infections in rural communities in northeast Thailand. The prevalences of *S. stercoralis* and *O. viverrini* infections have not declined[15]. Active control programs for helminthsstill need to be implemented by the Ministry of Public Health. The most common STHs were *S. stercoralis*, *T. trichiura*and *A. lumbricoides*. This study showed that the most prevalent STH found in human feces was*S. stercoralis*, which isa common nematode in Thailand. The findings indicated*S. stercoralis* infections are more prevalent than infections with other types of STHs.Direct skin contacts with soil that results from walking around barefoot and poor sanitary standards are both risk factors for contracting these infections[7].*S. stercoralis* infections are more common in tropical and subtropical countries with hot and humid climates[23,24]. KalasinProvinceis located in the equatorial zone, and the average temperatures remain relatively high, even in the cooler and rainy seasons. The climate helps explain the high prevalence of infection in this area[7].Ribas*et al*.[25]reported gastrointestinal infections and environmental water contamination in a rural village in northern Lao's PDR. The level of microbial pathogen contamination was associated with the level of human activity, with greater levels of contamination found at the downstream site than at the village and upstream sites. Furthermore, the microbial population was detected in the local river, which was the natural source of the water consumed in the village. Adequate warmth and moisture are key environmental features promoting the survival of STHs and FBHs. Other common STHs were *T. trichiura*and *A. lumbricoides*. Therefore, preventive measures should be taken to protect people from contracting thesehelminthic infections.

Conclusion

In conclusion, our results show that GHIs withFBHs and STHs still occur in rural communities near large reservoirs. The data from this study will be useful for guiding and improving future prevention and control strategies with regard to infections with *O. viverrini*and other helminths in this province. Interventions should concentrate on the personal hygiene of the population and improvements in sanitation to reduce the prevalence of GHIs in this area.

Ethical Clearance: This study was approved by the Ethics Committee for Research Involving Human Subjects of the Nakhon Ratchasima Provincial Health Office, Thailand (NRPH042). Informed consent was obtained from all the participants.

Source of Funding: Department of Disease Control, Ministry of Public Health, Thailand 2019, andthe SUT research and development fund, Suranaree University of Technology (SUT), Thailand 2019.

Conflicts of Interest: The authors declare no conflicts of Interest, financial or otherwise.

References

1. World Health Organization. Soil-transmitted helminthic infections (cited 2021 February 5]. Available from: https://apps.who.int/neglected_diseases/ntddata/sth/sth.html.
2. Hotez PJ, Bottazzi ME, Strych U, et al. Neglected tropical diseases among the Association of Southeast Asian Nations (ASEAN): overview and update. PLoS Neglected Tropical Diswase. 2015;9(4):e0003575.
3. Wongsaroj T, Nithikathkul C, Rojkitikul W, et al. National survey of helminthiasis in Thailand. Asian Biomedicine. 2014;8:779-783.

4. Wichaiyo W, Parnsila W, Chaveepojnkamjorn W, Sripa B. Predictive risk factors towards liver fluke infection among the people in Kamalasai District, Kalasin Province, Thailand. SAGE Open Medicine.2019;7:2050312119840201.
5. Kaewpitoon N, Kaewpitoon SJ, Pengsaa P, Sripa B. *Opisthorchis viverrini*: the carcinogenic human liver fluke. World Journal of Gastroenterology. 2008;7;14:666-674.
6. Sripa B, Bethony JM, Sithithaworn P, et al. Opisthorchiasis and *Opisthorchis*-associated cholangiocarcinoma in Thailand and Laos. Acta Tropica. 2011;120:S158-168.
7. Prasongdee TK, Laoraksawong P, Kanarkard W, et al. An eleven-year retrospective hospital-based study of epidemiological data regarding human strongyloidiasis in northeast Thailand. BMC Infectious Disease. 2017;17:627.
8. Yahom S, Kullawat J, Boonsai D, et al. The prevalence of intestinal parasitic infections in Maha Sarakham and Kalasin provinces. Journal of Tropical Medicine and Parasitology. 2013;36:29-33.
9. Cociancic P, Rinaldi L, Zonta ML, Navone GT. Formalin-ethyl acetate concentration, FLOTAC Pellet and anal swab techniques for the diagnosis of intestinal parasites. Parasitology Research. 2018;117:3567-3573.
10. Elkins DB, Sithithaworn P, Haswell-Elkins M, et al. *Opisthorchis viverrini*: relationships between egg counts, worms recovered and antibody levels within an endemic community in northeast Thailand. Parasitology. 1991;102:283-288.
11. Montresor A, Crompton DWT, Hall A, et al. Guidelines for the evaluation of soil- transmitted helminthiasis and schistosomiasis at community level. Geneva: World Health Organization; 1998. WHO document WHO/CDS/SIP/98. 1 (available from the program parasitic diseases and vector control, World Health Organization, CH1211Geneva 27, Switzerland).
12. Tefera E, Belay T, Mekonnen SK, et al. Prevalence and intensity of soil transmitted helminths among school children of Mendera Elementary School, Jimma, Southwest Ethiopia. The Pan African Medical Journal. 2017;27:88.
13. Boonjaraspinyo S, Boonmars T, Kaewsamut B, et al. A cross-sectional study on intestinal parasitic infections in rural communities, northeast Thailand. Korean Journal of Parasitology. 2013;51:727-734.
14. Rattanapitoon SK, Pechdee P, Boonsuya A, et al. Prevalence and intensity of helminths among inhabitants of the Chi River and Lahanna water reservoir areas of Northeastern Thailand. Tropical Biomedicine. 2020;37:730–743
15. Laoraksawong P, Sanpool O, Rodpai R, et al. Current high prevalences of *Strongyloides stercoralis* and *Opisthorchis viverrini* infections in rural communities in northeast Thailand and associated risk factors. BMC Public Health. 2018;18:940.
16. Suntaravitun P, Dokmaikaw A. Prevalence of intestinal parasites and associated risk factors for infection among rural communities of Chachoengsao Province, Thailand. Korean Journal of Parasitology. 2018;56:33-39.
17. Khieu V, Schär F, Marti H, et al. Prevalence and risk factors of Strongyloides stercoralis in Takeo Province, Cambodia. Parasite Vectors. 2014;7:221.
18. Kaewpitoon SJ, Rujirakul R, Wakkuwattapong R, et al. *Opisthorchis viverrini*infection among people in the border areas of three Provinces, Northeast of Thailand. Asian Pacific Journal of Cancer Prevention.2016;17:2973-2977.
19. Kaewpitoon SJ, Ponphimai S, Petdee P, et al. The prevalence of intestinal helminthic infection

in rural villagers, Northeastern Thailand. TropicalBiomedicine. 2019;36:152-164.

20. Rangsin R, Mungthin M, Taamasri P, et al. Incidence and risk factors of *Opisthorchis viverrini* infections in a rural community in Thailand. American Journal of Tropical Medicine and Hygiene. 2009;81:152-155.
21. Songserm N, Promthet S, Wiangnon S, Sithithaworn P. Prevalence and co-infection of intestinal parasites among thai rural residents at high-risk of developing cholangiocarcinoma: a cross-sectional study in a prospective cohort study. Asian Pac J Cancer Prev. 2012;13:6175-9.
22. Aunpromma S, Kanjampa P, Papirom P, et al. Prevalence and risk factors for *Opisthorchis viverrini* among cats and dogs in six districts surrounding the Ubolratana dam, an endemic area for human opisthorchiasis in northeastern Thailand. Southeast Asian Journal of Tropical Medicine and Public Health. 2016;47:1153-1159.
23. Paula FM, Costa-Cruz JM. Epidemiological aspects of strongyloidiasis in Brazil. Parasitology. 2011;138:1331-1340.
24. Schär F, Trostdorf U, Giardina F, et al. *Strongyloides stercoralis*: Global Distribution and Risk Factors. PLoS Neglected Tropical Disease. 2013;7:e2288.
25. Ribas A, Jollivet C, Morand S, et al. Intestinal Parasitic Infections and Environmental Water Contamination in a Rural Village of Northern Lao PDR. Korean Journal of Parasitology. 2017;55:523-532.