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Abstract
Fish-borne infections continue to be a major public health problem, with more than 50 million people infected throughout the world. Fish-borne parasites of humans and animals, are dorso-ventrally flattened and hermaphroditic and require one or more intermediate hosts. Fish-borne trematodes have been found in the small intestines of several definitive hosts such as birds, cats, dogs, rats and humans. These hosts were infected by eating raw freshwater fish containing encysted metacercariae. Thus, this study was proposed to urgently investigate the geographic information for the prevalence of fish-borne trematode metacercariae in 10 freshwater stations in the Chi river area in Mahasarakham province of Thailand. Four hundred and twenty samples of freshwater fish from 19 different species were randomly collected and examined for fish-borne trematode metacercaria. The fish were found infected with 3 fish-borne trematode metacercariae, namely; Opisthorchis viverrini, Haplorchis taichui, and Haplorchoides species. The prevalence of fish-borne metacercariae was 28.33% (119/420), Opisthrochis viverrini 1.67% (7/420) and the intensity of metacercaria was 0.80 per fish. Our study shows that fish-borne trematode metacercariae are found in a variety of fish species, relating to Opisthorchis viverrini, H. taichui, and Haplorchoides sp. The geographic information (latitude and longitude) associated with the infection rates among susceptible species of fresh water fish was recorded and built a fish-borne geo-dataset for Geographical Information System (GIS) development. GIS can be useful in establishing strategies for the prevention of transmission of food borne diseases originating in infected fish found in water catchment areas.

1. Introduction

In the global and environmental changes, the health and biomedical informatics encompass issues from the personal to global, ranging from thorough medical records for individual patients to sharing data about disease outbreaks among governments and international health organizations. Improvement and Sustainable of a healthy population in the 21st century will require systems engineering approaches to redesign care practices and integrate local, regional, national, and global health informatics networks. Helminthic infections constitute a worldwide epidemic, and such infections are particularly prevalent in low income areas. The costs of such interventions together with animal health issues will drive the cost of effectiveness for intervention strategies (Torgerson and Macpherson, 2011). The present report was done to determine the health informatics model of helminthiasis in Thailand. The investigators evaluated how a health informatics model could be used to predict, control and eradicate infections in a cost effective manner. Fish-borne helminthiasis caused by *Opisthorchis viverrini* remains a major public health problem in many parts of Southeast Asia including Thailand, Laos PDR, Vietnam and Cambodia. (WHO, 1995, Chai et al., 2005 and Keiser and Utzinger, 2005). The current evaluation of the parasitic situation in people infected with food-borne trematodes has been reported by the World Health Organization (WHO) to be over 18 million, with the number of people at risk worldwide estimated at more than half a billion (WHO, 2004). These food-borne trematodes are especially prevalent in South East Asia, China and Korea. Recent data suggest that there are about 1.5 million people in Korea, 6 million people in China and over 5 million in Thailand infected with liver flukes, either

Clonorchis sinensis or *Opisthorchis viverrini* (Chai et al., 2005). Over fifty species of food-borne intestinal flukes belonging to the Heterophyidae and Echinostomatidae have been reported from Korea (Chai et al., 2005 and Hong, 2012), Thailand (Kliks and Tantachamrun, 1974, Namue et al., 1998., Srisawangwaong et al., 1997, Sukontason et al., 1999, Wongsawad et al., 2000, Waikagul and Radomyos, 2005, Nithikathkul and Wongsawad, 2008) and Laos (Nguyen et al., 2007). Fish-borne parasitic infections still continue to have impact on a major public health problem. Approximately 56.2 million people infected with food-borne trematodes in 2005. Estimate 7.9 million cases have severe sequelae and 7,158 died, most of them from cholangiocarcinoma and cerebral infection. Together, estimate that the global burden of food-borne trematodiasis was 665,352 DALYs [disability-adjusted life years] (Fürst et al., 2012). The water reservoir development project is an extended plan involving proper water management for consumption all year round. Trematodes in the genus *Haplorchis* of the family Heterophyidae were found in the small intestines of various definitive hosts such as humans, dogs, cats, birds and rats. Humans and other definitive hosts were infected by eating raw fresh water fish containing encysted metacercariae (Nithikathkul et al., 2013). Therefore, to reveal areal-based infection information clearly, previous research has been used GIS to analyze environmental factors that influence to the infection area (Wang, 2012). Thus, the purpose of research study was to investigate the prevalence of Heterophyidae metacercariae in freshwater fish by using GIS. Presently reports indicate that metacercaria of pathogenic heterophyid trematodes are commonly found in freshwater fish.

2. Methodology

2.1 Fish Collection

Several species of freshwater fish were captured directly from Chi river by the fishermen living nearby the Chi reservoirs in the given districts. Capture methods were by net and traditional methods. Taxonomic identification of the fish was based on the characteristics found in the Guidelines and Atlas of Freshwater Fish in Thailand.

2.2 Metacercaria Preparation and Identification

To observe the prevalence of fish borne trematode metacercariae, the fish were examined for metacercaria by pepsin digestion techniques and identified under stereoscope.

Prevalence of fish-borne metacercaria:

The percentage prevalence was calculated as follows:

$$\text{Prevalence (\%)} = \frac{\text{Number of infected fish}}{\text{Total number of fish examined}} \times 100$$

Intensity was the number of metacercaria per total number of fish.

In this study, fishes were examined for the presence of metacercariae by the digestion technique. Observed results were then summarized as cumulative prevalence for OV and mif [minute intestinal fluke] parasites in a tabular format. To create a GIS database for *O. viverrini,* each record in the prevalence table was associated with geographic coordinates where fishes were taken from using Global Positioning System (GPS) and converted into a shape file with ArcGIS Desktop program from ESRI Company. To investigate environmental factors that influence to *O. viverrini*, the GIS database for *O. viverrini* was overlaid with elevation, soil, land use, geology, and precipitation GIS datasets. The elevation data were downloaded from the ASTER Global Digital Elevation Model (GDEM) website. The geology map was provided by the Groundwater Research Center, Khon Kaen University. The soil and land use data were extracted from the provincial soil survey maps of the Land Development Department. While average annual precipitation data were interpolated from the selected Thai Meteorology Department (TMD) climate stations from year 2008 to 2012.

2.2 Results and Discussion

Nineteen species of freshwater fishes were collected and investigated harbouring fish borne trematode metacercaria (Table 1). The size and scale of the circles corresponds to the cumulative prevalence of both OV and mif parasites for all fish, divided by the total number of fish. (Figures 1). Our study showed the overall fish species were *Barbodes gonionotus, Barbonymus altus*, *Barbonymus gonionotus*, *Cyclocheilichthys enoplos*, *Cyclocheilichthys repasson*, *Epalzeorhynchos chrysophekadion*, *Hampala dispar*, *Henicorhynchus siamensis*, *Labiobarbus siamensis*, *Mystus nigriceps*, *Osteochilus vittatus*, *Paralaubuca typus*, *Pristolepis fasciatus*, *Puntioplites proctozysron*, *Puntius brevis*, *Thynnichthys thynnoides*, *Trichogaster pectoralis*, *Trichogaster trichopterus*, and *Yasuhikotakia sidthimunki*.

Table 1: Show prevalence of infected fishes in 19 freshwater fishes

Fish Species	Examined fish	Infected fish (%)
Osteochilus vittatus	5	0
Epalzeorhynchos chrysophekadion	3	0
Thynnichthys thynnoides	29	14 (48.27%)
Henicorhynchus siamensis	176	49 (27.84%)
Puntioplites proctozysron	27	22 (75.86%)
Barbonymus altus	15	10 (66.67%)
Puntius brevis	4	4 (100.00%)
Cyclocheilichthys enoplos	2	1 (50.00%)
Yasuhikotakia sidthimunki	2	0
Mystus nigriceps	1	0
Barbonymus gonionotus	14	7 (50.00%)
Barbodes gonionotus	1	0
Labiobarbus siamensis	24	13 (54.17%)
Cyclocheilichthys repasson	3	2 (66.67%)
Hampala dispar	2	0
Paralaubuca typus	45	0
Pristolepis fasciatus	45	0
Trichogaster pectoralis	16	0
Trichogaster trichopterus	6	0
Total	420	15 (3.57%)

The parasitic metacercaria in fish were; *Opisthorchis viverrini*, *Haplorchis taichui*, and *Haplorchoides* sp. The prevalence of fish-borne metacercariae was 28.33% (119/420). The prevalence of *Opisthrochis viverrini* was 1.67% (7/420) and the intensity was 0.80 per fish. Our study showed fish-borne trematode metacercariae in several species of fishes. These included *Opisthorchis viverrini*, *H. taichui*, and *Haplorchoides* sp. The geographic information (latitude and longitude) associated with the infection rates among susceptible species of fresh water fish was recorded and built a geo-dataset for GIS development. A possible future development of the project is to develop a prediction model of parasite prevalence. The model may have various environmental and geographic parameters such as height sea level and land use in the prediction model [**Y = 25.937 - 0.153 x Height Sea Level – 2.316 x Land use**]. After importing the mentioned results data in GIS, the prevalence data associated with the coordinates may be used to train the model. Once developed, the model and the GIS could be useful in the establishment of prevention strategies for transmission of food borne diseases from infected fish in the water catchment area.

3. Conclusion

The distribution of fish-borne trematode infections is highly focal, dependent on the presence of susceptible second intermediate hosts, the prevalence of fish-borne parasitic infections in the definitive host and behavioral patterns of the definitive hosts. The infections are endemic in areas where raw fish eating habits are deeply rooted in the culture and are difficult to change. The Ministry of Public Health continues to encourage intense targeted educational programs for high risk populations to discourage the consumption of raw fish. In addition, the Ministry of Public Health has concluded that mass treatment for helminthiasis in the Thai population targeting high risk individuals may be a cost-effective way to allocate limited funds. These types of approaches and further study on the correlation of clinical symptoms with environmental and geographic information may offer a comprehensive strategy to the helminthes dilemma.

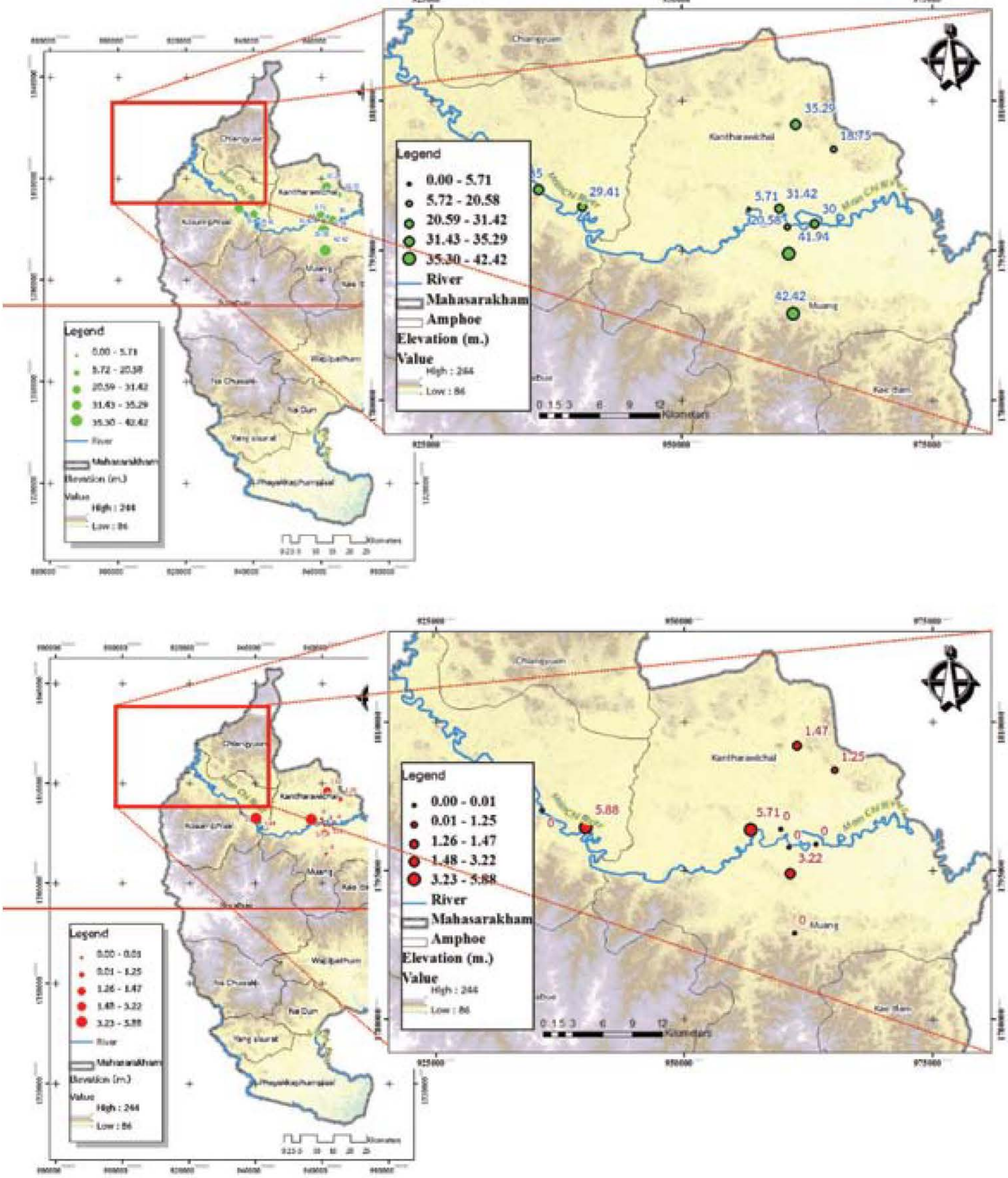

Figure 1: The diagrams show the proportion between OV and mif parasites (OV in red and mif in green colour)

Height above sea level and Land use correlated with the prevalence of fish-borne parasitic zoonosis metacercaria [Y] in cyprinoid fish, Mahasarakham province, north east Thailand.

$$Y = 25.937 - (0.153 \times \text{Height above Sea Level}) - (2.316 \times \text{Land use})$$

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