TREMATODE (DIGENEA) INFESTATION ON FRESHWATER SNAILS (MOLLUSCA: GASTROPODA) COLLECTED OFF RIVERS OF CROCKER RANGE PARK, SABAH

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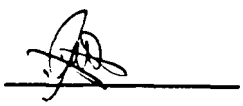

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ABSTRACT

Freshwater snail is the first intermediate host for trematode parasite that can cause snail-borne diseases in human as well as animals. This study is the first kind that deals with the parasitology of freshwater snail population in rivers around the Crocker Range Park, Sabah. The objectives of this study are to determine the parasite prevalence of freshwater snail species in rivers in this study, to compare parasite prevalence between disturbed and undisturbed rivers, to establish a checklist of trematode parasite infesting freshwater snail and finally to compare freshwater snail diversity between disturbed and undisturbed rivers in this study. This study was conducted in 14 rivers consist of seven disturbed and seven undisturbed rivers and sampling was conducted for seven monnths from July 2017 to January 2018. Snails were collected from each river and observed for parasite infestation. Parasite prevalence and snail diversity were then compared between disturbed and undisturbed rivers by using Mann-Whitney U test and Sample based rarefaction curve respectively. A total of five morpho-types of trematode parasite, which consist of 11 different species were released from 1709 individuals of freshwater snail belong to 10 species and nine families collected from 14 rivers in this study. The overall parasite prevalence of the freshwater snail species was 4.45%. Unidentified snail species under the family of Hydrobidae showed the highest parasite prevalence followed by *Paludomus* sp. (Paludomidae) and *Clea* sp. (Pachychilidae), whereas three species of snail which are *Sinotaia guangdungensis* (Viviparidae), *Pomacea* sp. (Ampillaridae) and *Physa acuta* (Physidae) recorded with zero prevalence. The comparison between undisturbed and disturbed rivers for parasite prevalence showed that there was a significant difference ($p<0.05$) where undisturbed rivers (11.30%) are more prevalent compared to disturbed river (3.66%). All parasites reported in this study considered as new record to Sabah. Freshwater snail species richness and diversity comparison between the two types of rivers in this study showed significant difference where disturbed rivers contain higher diversity and more specious (0=8, 1=3.822, 2=2.881) compared to undisturbed rivers (0=3, 1=2.55, 2=2.44). This study has provided useful information regarding freshwater snail parasitology in Malaysia.

Key Words

freshwater snail, disturbed, undisturbed, rivers, parasite infestation, prevalence, diversity, species richness

ABSTRAK

Infestatasi Trematode (Digenea) pada Siput Air Tawar (Mollusca: Gastropoda) Dikumpulkan dari Sungai-sungai Terletak di Kawasan Taman Banjaran Crocker, Sabah

Siput air tawar merupakan perumah pertengahan pertama bagi parasit trematoda yang boleh menyebebkan penyakit jangkitan helmin bawaan siput pada manusia dan juga haiwan. Kajian ini merupakan yang pertama melibatkan jangkitan parasit pada populasi siput air tawar di Sabah, Malaysia. Objektif kajian ini adalah untuk menentukan kelaziman parasit pada siput air tawar di sungai-sungai dalam kajian ini, untuk membandingkan kelaziman parasit diantara sungai terganggu and sungai tidak terganggu, untuk membuat senarai semak parasit trematoda yang menjangkiti siput dan untuk membandingkan nilai kepelbagaian siput pada jenis sungai yang berbeza. Kajian ini dijalankan pada 14 buah sungai yang terdiri daripada tujuh sungai terganggu dan tujuh sungai tidak terganggu dan kajian ini dijalankan pada Julai 2017 sehingga Januari 2018. Siput dikumpulkan dari setiap sungai dan diperiksa untuk serangan parasit. Kelaziman parasit and kepelbagaian siput kemudiannya dibandingkan di antara sungai yang terganggu dan tidak terganggu dengan masing-masing menggunakan Mann-Whitney U test *dan* Sample-base Rarefaction curve*. Sebanyak lima jenis morfologi serkaria, yang terdiri daripada 11 spesis yang berbeza telah didapati dari 1709 individu siput air tawar, dengan 10 spesis siput dari sembilan keluarga telah didapati dari 14 buah sungai yang berlainan dalam kajian ini. Kelaziman parasit secara menyeluruh dalam kajian ini ialah 4.45%. Spesis siput yang tidak dikenalpasti di dawah keluarga Hydrobidae menunjukkan kelaziman parasit yang tertinggi diikuti dengan Paludomus* sp. *(Paludomidae) dan* Clea *sp. (Pachychilidae), sementara tiga spesis siput iaitu* Sinotaia guangdungensis (Viviparidae), Pomacea *sp.* (Ampillaridae) dan Physa acuta (Physidae) *direkodkan dengan sifar kelaziman. Perbandingan diantara sungai terganggu and tidak terganggu untuk kelaziman parasit oleh* Mann-Whitney U test *menunjukkan bahawa terdapat perbezaan ketara ($p<0.05$) dimana kelaziman parasit lebih tinggi di sungai tidak terganggu (11.30%) berbanding di sungai terganggu (3.66). semua parasit yang dicatatkan dalam kajian ini adalah rekod baru di Sabah. Perbandingan kepelbagaian dan kekayaan spesis siput air tawar di antara dua jenis sungai dangan manggunakan* Sample-base rarefaction curve *dalam kajian ini menunjukkan perbezaan di sungai terganggu mempunyai kepelbagaian yang lebih tinggi dan mempunyai lebih banyak spesis (0=8, 1=3.822, 2=2.881) berbanding dengan sungai jenis tidak terganggu (0=3, 1=2.55, 2=2.44). Kajian ini telah memberikan maklumat berguna mengenai parasitologi siput air tawar di Malaysia.*

Kata kunci: siput air tawar, terganggu, tidak terganggu, sungai, infestasi parasit, kelaziman, kepelbagaian, kekayaan spesis

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LIST OF ABBREVIATIONS

BLAST	Basic Local Alignment Tool
BOLD	Barcoding of Life Database
CRP	Crocker Range Park
DNA	Deoxyribonucleic acid
E	East
GI	Geneinfo Identifier
GPS	Global Positioning System
ID	Identification
N	North
NCBI	National Center of Biotechnology Information
No.	Number
PCR	Polymerase Chain Reaction
US	United State
Sg.	*Sungai* (river)
Sp.	Species
a.s.l	above sea level
ln	Log
p	Proportion
km	Kilometer
m	Meter
mm	Millimeter

LIST OF SYMBOLS

°	Degree
%	Percent
&	and
H′	Index value
H_0	Null hypothesis
H_A	Alternative hypothesis
μ	Micro
$	Dollar

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Parasitism is one of the most interesting and medically important relationships between living organisms both in the medical and conservation fields nowadays (Pakarinen, 2011). Parasitism can be defined as the association between two species, the parasite and the host (Dhaliwal & Juyal, 2013) in which, the parasite survive by getting everything it needs from the host while damaging the host (Drisdelle, 2010). Parasitic infestation are ubiquitous in wildlife, livestock and human populations, and healthy ecosystems are often parasite rich (Cable *et al.,* 2017). Yet, their negative impacts can be extreme and human disturbance has been claimed to influence parasite prevalence therefore this need immediate amelioration (Conlan *et al.,* 2011). Thus, this interaction cannot be neglected as parasites are highly pathogenic and economically important (Yizar *et al.*, 2006; Horwitz & Wilcox, 2005).

Trematode parasites are one of the most well-known class of parasite because they are significantly pathogen of high medical, veterinary and environmental importance (Rottu *et al.,* 2014). Trematode is grouped together with cestode under the phylum of Platyhelminthes (Parija *et al.,* 2003). Unlike cestode, trematode parasites are known to generally occur in aquatic habitat (Hasnath & Khan, 2016). The trematodes (or flukes) are leaf shaped with an outer cover called the tegument which may be smooth or spiny (Thomas, 1985). They are internal parasites of molluscs and vertebrates including human (King *et al.,* 2011). The subclass of digenea under the trematode class is the only group known to be zoonotic as they can pose risk to human health (Parija *et al.,* 2003).

Human and animals can be infected with this (digenea) parasite in two main ways. First is by direct penetration and secondly by oral ingestion (Magil, 2013; Belizario *et al.,* 2004). Some species of digenean trematode can directly penetrate the skin of the host and infect the host. Human can easily become infected with this parasite through a simple act just by spending a few minutes in contact with contaminated water that contains parasitic larvae (cercariae) released by infected freshwater snail (Lawton *et. al.,* 2015). Human and animals can also be infected by the ingestion of contaminated or improper prepared food (Liat *et al.,* 1978). Although this parasite can infect a massive array of animal groups at each point of its development, they always infect molluscs particularly freshwater snail at the first point of their life cycles (Sandland *et al.,* 2007; Prenter *et al.,* 2004).

Freshwater snail act as an important intermediate hosts for digenetic trematode parasite, which can cause snail-borne helminth diseases in human as well as in animals (King *et al.,* 2011). Freshwater snail is categorized under the phylum of Mollusca and grouped under the class of Gastropod and under the subclass of Pulmonata, together with slug (Tompa *et al.,* 1984). The major difference between these two invertebrates that make up the subclass of Pulmonata is the presence of shell, possessed or present in snails and absent in slugs. The Mollusca is an extraordinarily varied phylum of organisms with estimates of 80,000–100,000 described species (Strong *et al.,* 2007). There are approximately 14 families of freshwater snail that represented in Southeast Asia so far (Medsen & Hung, 2014) and nine families of freshwater snail have been reported in Malaysia by Ng *et al.,* (2017). Most of the snail species under the families reported in the east Malaysia, which is in the state of Sabah are an important intermediate host for trematode parasite that generally dominated the freshwater habitat particularly in river system (Ng *et al.,* 2017).

The river systems in Sabah are important not just for the aquatic organisms such as snail to live in but also, crucial for used in agriculture and for economic resources especially in the rural areas. However, as agricultural activities intensifies and become a major source of income in Sabah (Marsh & Greer 1992), effects can be seen on hydrology and sediment yield. According to Chappell *et al.* (1999), agricultural, logging and ground clearance increases the river sediments by two to fifty times in some rivers in Sabah. Soil erosion can have impact on water quality,

of which can affect humans as users of drinking water (Seve, 1999). Crocker Range Park, Sabah the longest conservation area in Sabah contain the remaining undisturbed rivers that located considerably far from any human activities as it located in the protected area. The river inside the Crocker Range Park is strictly protected from any human activities (Chung *et al.,* 2016). According to Gurvich *et al.* (2005), disturbed habitat is any relative events that disrupt ecosystem, community or population structure and change resources, substrate availability or the physical environment, while undisturbed habitat can be defined as the natural forest without any implementation and exploration of human activities. Rivers in Crocker Range Park can be considered undisturbed since it has also been claimed to have an excellent water quality (Long *et al.,* 2002).

The prevalence of digenetic parasite in freshwater snail is highly influenced by the condition of the river system itself. Human activities and climate change have been claimed by many authors as the major factors in regulating the parasite prevalence among aquatic organisms including freshwater snail (Poulin, 2011). Poulin, (2011) commented parasite prevalence in rivers depends on the level of the pollutant that embedded in the system as well as types of parasite and host. Study conducted by Sri-aroon *et al.,* (2007) and Kulsantiwong *et al.* (2015) also claimed that altered or disturbed rivers which in close contact to the agricultural west and artificial irrigation provide a suitable habitat for snails and probably for parasite as well. Besides that, snail diversity was also proven to influence parasite prevalence in the freshwater snail population (Tomba, 2006; Mohammad, 2015). Yizhar *et al.* (2006) also stated that introduced gastropod highly influences the parasite prevalence in the freshwater ecosystem. Even though, habitat disturbance and snail population has been claimed to play an important role in parasite prevalence of freshwater snail, information regarding parasite prevalence between disturbed and undisturbed rivers as well as snail population particularly in Sabah, has not been investigated and still very limited.

Since the late 19th century, the study of molluscs in Malaysia was often related to the limestone hills which can be found in Peninsular Malaysia as well as in Sabah and Sarawak (Schilthuizen *et al.,* 2003). The studies of molluscs in Sabah are slowly growing, and quite a number of research articles regarding molluscs have been published lately, yet most of the researches conducted were focusing on

land snail (Schilthuizen *et al.*, 2003; Schilthuizen & Rutjes, 2001; Liew *et al.*, 2010). Whereas, two studies conducted on the freshwater snail diversity dynamic in Sabah which was conducted by Supian & Ikhwanuddin (2002) and the latest study was conducted by Ng *et al.* (2017).

However, very little is known about the parasitology of the freshwater snail population in Malaysia especially in Sabah. The only study conducted regarding the parasite infestation of freshwater snail in Sabah was published about 30 years ago and it is the only record of parasite prevalence of freshwater snail in Sabah ever since. The study was conducted by Liat *et al.* (1976), where they conducted a survey of parasite among wild rodent and molluscan host within the vicinity of Tuaran, Sabah. They found that 56 out of 382 molluscans which include land snail, slugs and freshwater snail were naturally infected with rat-lung worm (*Angiostrongylus malaysinensis*). Hospital records during that time which was in 1974 and 1975 were examined and clinical human eosinophilic meningoencephalitis was rarely reported in Sabah. A couple of years after that, in 1978, Liat *et al.* (1978), the same person published another study regarding the freshwater snail consumption and human angiostrongliasis infection in Peninsular Malaysia. Where Liat *et al.* (1978), claimed that rat-lung worm is the causative agent of human eosinophilic meningoencephalitis and can be transmitted to human via ingestion of the freshwater snail.

Therefore, this study aimed to fill the gaps of knowledge regarding parasitology of molluscs in Malaysia especially in Sabah that is currently almost nothing is known.

This study embarks several objectives such as firstly;

1. To determine parasite prevalence of freshwater snail species in rivers located around the Crocker Range Park, Sabah.
2. To compare parasite prevalence of freshwater snail between disturbed and undisturbed rivers.
3. To establish a checklist of trematode parasite that infests freshwater snails in rivers located around the Crocker Range Park, Sabah.
4. To compare the freshwater snail diversity and abundance between disturbed and undisturbed rivers in this study.

Hence the knowledge of parasitology of molluscs in Sabah is still lagging. There has been a very little attempt to survey the parasite infestation among molluscs group which was conducted three decades ago and the study only focuses on one species of parasite and species of freshwater snail. Ultimately this study will serve as a basis for future research not just in conservation biology but in other related fields as well such as medicine and veterinary science. This may also improve our current understanding of parasitology in freshwater snail in Malaysia especially in Sabah.

1.2 Justification

This research aimed to determine the parasite prevalence status of freshwater snail within the vicinity of Crocker Range Park, Sabah Malaysia since there is paucity regarding parasitology research in relation to the freshwater snail in Malaysia, especially in Sabah. This knowledge is crucial in various fields such as conservation biology, medical and veterinary science. A parasite can be the stabilizer and destabilizer of population size in particular areas and one of the useful environmental health indicators in an ecosystem (Yizhar *et al.,* 2006). In other fields such as veterinary science and medical field, this data is highly important to provide a more realistic information regarding the parasite that infect freshwater snail (Hasnath & Khan, 2016). It is crucial to take note that most trematode parasite that naturally infests freshwater gastropod can infect humans and animals such as liver fluke and intestinal fluke are highly prevalent in Southeast Asia countries (Chai *et al.,* 2015; Hasnath & Khan, 2016). Therefore these organisms cannot be neglected as it is medically important and it also plays a decisive role sustaining the structure and biodiversity in ecosystem (Yizhar *et al.,* 2006).

Other than that, Malaysia also has an extensive river system which could support a high density of freshwater snail and probably for parasite as well. In the states of Sabah and Sarawak specifically, rural people are still highly dependent on resources derived from extensive river systems for their livelihoods (Marsh & Greer 1992). A significant number of rural populations in Malaysia, especially in Sabah and Sarawak, consume freshwater snails which can easily be found in almost every native market around Sabah (Hamli *et al.,* 2013). As well as supporting a great diversity of freshwater snails and the livelihoods of local people, extensive river

systems also serve as a suitable ecological environment for zoonotic parasites. Moreover, some snail-borne helminth diseases have been reported to infect humans in Malaysia, yet the information about the diseases and parasite is still scarce. Thus, the risk of the rural community being infected by snail-borne parasitic diseases transmitted by animals living near river systems cannot be neglected as there are already records of snail-transmitted disease in Sabah and Sarawak (Sagin *et al.,* 2001; Rohela *et al.,* 2005).

Despite the growing number of data regarding gastropod in the past decade, there is only a single study conducted regarding the parasite interaction between parasite and freshwater snail in Sabah which was conducted about three decades ago by Liat *et al.* (1976). Hence, this research will provide very useful information that can help contribute to a more effective method in ecosystem management in the conservation field as well as in diseases management in the veterinary and medical field. Ultimately this study will help fill the gap of knowledge regarding parasite and freshwater snail interaction in Sabah that is currently far from being complete.

CHAPTER 2

LITERATURE REVIEW

2.1 Parasitism

Among all the interesting interaction involving two species of organisms, parasitism receives the greatest attention globally for its medical value and for other variety of reasons. Parasitism is an intimate interaction between two species of either plants or animals in which one live internally or externally and at the expense of the other (Esch & Fernandes, 2013). The most classical explanation that defines this relationship is the implication of this type of lifestyle which implies harm to the host and benefit to the other (parasite). The parasite will usually get the full benefit from the host while the host is harmed (Esch & Fernandes, 2013; Dhaliwal & Juyal, 2013). The parasite is usually smaller than the host and depends fully on the host for shelter and nutrients to survive. They can cause significant diseases problems particularly in developing countries and may lead to death if left untreated (Poulin, 2011).

Parasitologists have been classifying these groups of organism into two major categories based on their interaction with their host. The two major categories of the parasite are endo-parasites and ectoparasites. Ecto-parasite is referred to the parasite that lives outside or on the surface of its host, for example, lice and mites. If the parasite infects the host internally which is inside its host body, then it is known as endo-parasite. Almost all parasites are an obligate parasite, in which they cannot survive without spending at least half of their lifetime fully depending on their host as in a parasitic relationship. While, a facultative parasite is a parasite that does not necessarily require a host to reproduce and survive but can become so by accidentally eaten or direct penetration through open wounds (Robert & Janovy,2005).

REFERENCES

Abellán, P., Sánchez-Fernández, D., Velasco, J., & Millán, A. 2005. Assessing conservation priorities for insects: status of water beetles in southeast Spain. *Biological Conservation*, 121(1), 79-90.

Abramovitz, J. N. & Peterson, J. A. 1996. *Imperiled waters, impoverished future : the decline of freshwater ecosystems.* Washington, D.C : Worldwatch Institute

Achard, F., Eva, H. D., Stibig, H. J., Mayaux, P., Gallego, J., Richards, T., & Malingreau, J. P. 2002. Determination of deforestation rates of the world's humid tropical forests. *Science*, 297(5583), 999-1002.

Adema, C. M., Hanelt, B., & Seville, B. S., 2005. Parasite Infection Status of *Potamopyrgus Antipodarum* , University of Wyoming National Park Service Research, 29, 24; 11-16.

Alicia V. L., Aaron W. R., Norman A. S., & Michael H. K. 2002. Effects of habitat disturbance on a *Peromyscus leucopus* (Rodentia: Cricetidae) population in western Pennsylvania, *Journal of Mammalogy*, 93 (1), 211–219.

Allan, J. D., & Castillo, M. M. 2007. *Stream ecology: structure and function of running waters*. Springer Science & Business Media.

Anucherngchai, S., Tejangkura, T., & Chontananarth, T. 2016. Epidemiological situation and molecular identification of cercarial stage in freshwater snails in Chao-Phraya basin, Central Thailand. *Asian Pacific Journal of Tropical Biomedicine*, 6(6), 539-545.

Bacaro, G., Rocchini, D., Ghisla, A., Marcantonio, M., Neteler, M., & Chiarucci, A. 2012. The spatial domain matters: Spatially constrained species rarefaction in a Free and Open Source environment. *Ecological complexity*, *12*, 63-69.

Balian, E. V., Lévêque, C., Segers, H., & Martens, K. (Eds.). 2008. *Freshwater animal diversity assessment* (Vol. 198). Springer Science & Business Media.

Baltanás, A. 1992. On the use of some methods for the estimation of species richness. *Oikos*, 484-492.

Belizario Jr, V. Y., de Leon, W. U., Bersabe, M. J. J., Baird, J. K., & Bangs, M. J. 2004. A focus of human infection by Haplorchis taichui (Trematoda: Heterophyidae) in the southern Philippines. *Journal of Parasitology*, *90*(5), 1165-1169.

Blankespoor, H. D., Esch, G. W., & Johnson, W. C. 1985. Some observations on the biology of *Collyriclum faba* (Bremser in Schmalz, 1831). *The Journal of Parasitology*, 469-471.

Bouchet, P., Rocroi, J. P., Frýda, J., Hausdorf, B., Ponder, W., Valdés, Á., & Warén, A. 2005. Classification and nomenclator of gastropod families Malacologia 47(1-2),1-368.

Brandt, R. A., (1974). The non-marine aquatic Mollusca of Thailand. *Archiv für Molluskenkunde* 105: 1–423.

Briers, R. A. 2003. Range limits and parasite prevalence in a freshwater snail. *Proceedings of the Royal Society of London B: Biological Sciences*, 270(2), 178-180.

Brosse, S., Lek, S., & Townsend, C. R. 2001. Abundance, diversity, and structure of freshwater invertebrates and fish communities: an artificial neural network approach. *New Zealand Journal of Marine and Freshwater Research*, 35(1), 135-145.

Brown, M. J., Schmid-Hempel, R., & Schmid-Hempel, P. 2003. Strong context-dependent virulence in a host–parasite system: reconciling genetic evidence with theory. *Journal of Animal Ecology*, 72(6), 994-1002.

Burroughs, T., Knobler, S., & Lederberg, J. 2002. The emergence of zoonotic diseases: understanding the impact on animal and human health: workshop summary. In *The emergence of zoonotic diseases: understanding the impact on animal and human health: workshop summary.* National Academy Press.

Cable, J., Barber, I., Boag, B., Ellison, A. R., Morgan, E. R., Murray, K., Pascoe, E. L., Sait, S. M., Wilson, A. J., & Booth, M. 2017. Global change, parasite transmission and disease control: lessons from ecology, *Biological sciences*, 372(1719), 20160088.

Chai, J. Y., Murrell, K. D., & Lymbery, A. J. 2015. Fish-borne parasitic zoonoses: *International journal for parasitology*, 35(11-12), 1233- 1254.

Chappell, N. A., Ternan, J. L., & Bidin, K. (1999). Correlation of physicochemical properties and sub-erosional landforms with aggregate stability variations in a tropical ultisol disturbed by forestry operations. *Soil & Tillage Research,* 50, 55–71.

Cheng, T. C. 2012. *General Parasitology.* Elsevier.

Chiarucci, A., Bacaro, G., Rocchini, D., Ricotta, C., Palmer, M., & Scheiner, S. 2009. Spatially constrained rarefaction: incorporating the autocorrelated structure of biological communities into sample-based rarefaction. *Community ecology*, 10(2), 209-214.

Chontananarth, T., & Wongsawad, C. 2010. Prevalence of Haplorchis taichui in field-collected snails: a molecular approach. *The Korean journal of Parasitology*, *48*(4), 343.

Chontananarth, T., Thanawan Tejangkura, N. W., & Chimburut, C. 2017. Morphological characteristics and phylogenetic trends of trematode cercariae in freshwater snails from Nakhon Nayok Province, Thailand. *The Korean Journal of Parasitology*, 55(1), 47.

Chung, A. Y. C., Bosuang, S., Majapun, R., & Nilus, R., 2016. Diversity and geographical ranges of insects in Crocker Range Forest Reserve, Sabah, Malaysia, *Journal of Tropical Biology and Conservation,* 13: 135-155.

Clarke, K. R., & Warwick, R. M. 1994. An approach to statistical analysis and interpretation. *Change in Marine Communities*, 2, 117-143.

Clements, R., Koh, L. P., Lee, T. M., Meier, R., & Li, D. 2005. Importance of Reservoirs for the Conservation of Freshwater Molluscs in a Tropical Urban Landscape*, Biological Conservation*, 128:136-146.

Colwell, R. K., Chao, A., Gotelli, N. J., Lin, S. Y., Mao, C. X., Chazdon, R. L., & Longino, J. T. 2012. Models and estimators linking individual-based and sample-based rarefaction, extrapolation and comparison of assemblages. *Journal of Plant Ecology*, 5(1), 3-21.

Conlan, J. V., Sripa, B., Attwood, S., & Newton, P. N. 2011. A review of parasitic zoonoses in a changing Southeast Asia. *Veterinary Parasitology*, *182*(1), 22-40.

Cook, G. C. 1992. Effect of global warming on the distribution of parasitic and other infectious diseases: a review. *Journal of the Royal Society of Medicine*, *85*(11), 688.

Craig, P., & Macpherson, C. (Eds.). 2012. *Parasitic helminths and zoonoses in Africa*. Springer Science & Business Media.

Cross, J. H. 1969. Fasciolopsiasis in Southeast Asia and the Far East: a review, *Medical Ecology Department*, 177-199.

Cross, J. H., 1992, Intestinal Capillariasis, *Clin. Microbiol.* Rev., 2; 120-129

Cywińska, A. 2005. Epidemiology of fascioliasis in human endemic areas. *Journal of Helminthology*, 79(3), 207-216.

Dar, Y. D. 2009. Study on xiphidiocercariae from Radix natalensis. *Egypt. Vet. Med. Soc. Parasitol. J*, 5, 115-27.

Dar, Y. D., & El-Husseny, I. M. 2013. Experimental infection of Radix natalensis and Culiseta longiareolata larvae with Plagiorchiid xiphidiocercariae in Egypt. *J Egypt Soc Parasitol*, 43(3), 679-87.

Dhaliwal, B. B. S., Juyal, P. D., 2013. *Parasitic Zoonoses*, Springer.

Dillon, R. T. 2000. *The ecology of freshwater molluscs*. Cambridge University Press.

Dokulil, M. T., 2014. Environmental Impacts of Tourism on Lakes, *Environmental Impacts of Tourism on Lakes*, 81-88.

Douglas, D., 2011 Land snail species diversity and composition between different forest disturbance regimes in central and eastern Kentucky Forests , (Doctoral Dissertations) *Eastern Kentucky University.*

Dress, A. W., Flamm, C., Fritzsch, G., Grünewald, S., Kruspe, M., Prohaska, S. J., & Stadler, P. F. 2008. Noisy: identification of problematic columns in multiple sequence alignments. *Algorithms for molecular biology : AMB*, 3, 7.

Dudgeon, D., Arthington, A. H., Gessner, M. O., Kawabata, Z. I., Knowler, D. J., Lévêque, C. & Naiman R., J., 2006. Freshwater biodiversity: importance, threats, status and conservation challenges. *Biological Reviews*, 81(2), 163-182.

Esch, G. W., & Fernández, J. C. (Eds.). 2013. *A functional biology of parasitism: Ecological and evolutionary implications*. Springer Science & Business Media.

Evans, N. A. 1982. Effects of copper and zinc on the life cycle of *Notocotylus attenuatus* (Digenea: Notocotylidae). *International Journal for Parasitology*, 12(4), 363-369.

Fajri, S. R., NPrimawati, S., Hadi, I., & Tresnani, G. 2018. New Record of *Rhinopoma microphyllum* with the Invested Parasites and Microbes in the Developed Ecotourism Area of South Lombok Island NTB. In *Journal of Physics:Conference Series*, 953(1), IOP Publishing.

Farahnak, A.,Vafaie-Darian, R., & Mobedi, I., 2006. A faunistic survey of cercariae from fresh water snails: *Melanopsis* spp. and their role in disease transmission, *Iranian Journal of Public Health*, 4(35), 70-74.

Fayer, R. 2004. Cryptosporidium: a water-borne zoonotic parasite. *Veterinary parasitology*, 126(1-2), 37-56.

Fried, B., & Toledo, R. (Eds.). 2009. *The biology of echinostomes: from the molecule to the community*,Vol. 9, Springer Science & Business Media.

Gajadhar, A. A. 2015. Introduction to foodborne parasites. In *Foodborne Parasites in the Food Supply Web*, Woodhead Publishing.

Gandaseca, S., Wahab, N. L. A., Pazi, A. M. M., Rosli, N., & Zaki, P. H. 2016. Comparison of Water Quality Status of Disturbed and Undisturbed Mangrove Forest at Awat-Awat Lawas Sarawak. *Open Journal of Forestry*, 6(1), 14-18.

Gilbert, B. M., & Avenant-Oldewage, A. 2016. Effects of altered water quality and trace elements on the infection variables of *Paradiplozoon ichthyoxanthon* (Monogenea: Diplozoidae) from two sites in the Vaal River system, South Africa. *Acta Parasitologica*, 61(1), 52-62.

Glöer, P., & Pešić, V., 2012. The Freshwater Snails (Gastropoda) Of Iran, With Descriptions Of Two New Genera And Eight New Species , *ZooKeys* , 219:11 61.

Goater, T. M., Goater, C. P., & Esch, G. W. 2013. *Parasitism: The Diversity and Ecology of Animal Parasites*. Cambridge University Press.

Goedknegt, M. A., Welsh, J. E., Drent, J., & Thieltges, D. W. 2015. Climate change and parasite transmission: how temperature affects parasite infectivity via predation on infective stages. *Ecosphere*, 6(6), 1-9.

Gonçalves, J. P., Oliveira-Menezes, A., Junior, A. M., Carvalho, T. M., & de Souza, W. 2013. Evaluation of Praziquantel effects on *Echinostoma paraensei* ultrastructure. *Veterinary Parasitology*, 194(1), 16-25.

Graczyk, T. K., & Fried, B. 1998. Echinostomiasis: a common but forgotten food-borne disease. *The American Journal of Tropical Medicine and Hygiene*, 58(4), 501-504.

Green, A. J., El Hamzaoui, M., El Agbani, M. A., & Franchimont, J. 2002. The conservation status of Moroccan wetlands with particular reference to waterbirds and to changes since 1978. *Biological Conservation*, 104(1), 71-82.

Grosholz, E. D. 199). Contrasting rates of spread for introduced species in terrestrial and marine systems. *Ecology*, 77(6), 1680-1686.

Grove, D. M., Zajac, A. M., Spahr, J., Duncan Jr, R. B., & Sleeman, J. M. 2005. Combined infection by avian poxvirus and Collyriclum faba in an American crow (*Corvus brachyrhynchos*). *Journal of Zoo and Wildlife Medicine*, 36(1), 111-114.

Gunn, A., & Pitt, S. J. 2012. *Parasitology: an integrated approach*. John Wiley & Sons.

Gurvich, D. E., Tecco, P. A., & Díaz, S. 2005. Plant invasions in undisturbed ecosystems: the triggering attribute approach. *Journal of Vegetation Science*, 16(6), 723-728.

Haines, A. 1991. Global warming and health. *BMJ: British Medical Journal*, 302(6778), 669.

Hamelink, J., Landrum, P. F., Bergman, H., & Benson, W. H. 1994. *Bioavailability: Physical, Chemical, and Biological Interactions*. CRC Press.

Hamli, H., Idris, M. H., Abu Hena, M. K., Wong, S. K., & Arshad, A. 2013. Checklist and habitat descriptions of edible gastropods from Sarawak, Malaysia. *Journal of Fisheries and Aquatic Science*, 8(2), 412-418.

Harinasuta C., 1984. Epidemiology and control of schistosomiasis in Southeast Asia. *Southeast Asian J Trop Med Public Health*, 15: 431-8.

Hart, A. 2001. Mann-Whitney test is not just a test of medians: differences in spread can be important. *BMJ: British Medical Journal*, 323(7309), 391.

Hasnath, M., & Khan, M. A. G. 2016. Community structure and systematic study of Helminth parasites of freshwater snails of the Chittagong University Campus. *Bangladesh Journal of Zoology*, 44(1), 9-30.

Haynes, A., 1990, The Number of Gastropods on Pacific Islands and the Theory of Island Biogeography, Malacologia , 237-248.

Hechinger, R. F. 2012. Faunal survey and identification key for the trematodes (Platyhelminthes: Digenea) infecting *Potamopyrgus antipodarum* (Gastropoda:Hydrobiidae) as first intermediate host. *Zootaxa*, 3418(1), 1-27.

Heneberg, P., Faltýnková, A., Bizos, J., Malá, M., Žiak, J., & Literák, I. 2015. Intermediate hosts of the trematode *Collyriclum faba* (Plagiochiida: Collyriclidae) identified by an integrated morphological and genetic approach. *Parasites & vectors*, 8(1), 85.

Hortal, J., Borges, P. A., & Gaspar, C. 2006. Evaluating the performance of species richness estimators: sensitivity to sample grain size. *Journal of Animal Ecology*, 75(1), 274-287.

Horwitz, P., & Wilcox, B. A. 2005. Parasites, ecosystems and sustainability: an ecological and complex systems perspective. *International Journal for Parasitology*, 35(7), 725-732.

Hubendick, B. 1958. Factors conditioning the habitat of freshwater snails. *Bulletin of the World Health Organization*, 18(5-6), 1072.

Johnson, S. D., 1968, A Note on an Extreme Freshwater Habitat and its Biota, Vidyodaya. *Arts. Sci. LeU* ., 84-88.

Jutting, B. WSS van, 1956. Systematic studies on the non-marine Mollusca of the Indo-Australian Archipelago. V. Critical revision of the Javanese freshwater gastropods. *Treubia*, 23(2), 259-477.

Kanki, P., & Grimes, D. J. (Eds.). 2012. *Infectious diseases: Selected entries from the encyclopedia of sustainability science and technology*. Springer Science & BusinessMedia.

Kanoksil, W., Larbcharoensub, N., Soontrapa, P., Phongkitkarun, S., Sriphojanart, S., & Nitiyanant, P. 2010. Eosinophilic appendicitis caused by *Schistosoma japonicum*: a case report and review of the literature. *Southeast Asian J Trop Med Public Health*, 41(5), 1065-70.

Keating, K. 2012. *Statistical analysis of pyrosequence data.* (Doctoral dissertation) - Kansas State University.

King, K. C., Jokela, J., & Lively, C. M. 2011. Trematode parasites infect or die in snail hosts. *Biology Letters*, 7(2), 265-268.

Komiya, Y. 1961. The excretory system of digenetic trematodes. The excretory system of digenetic trematodes. *Committee of Jubilee Publication,* 341 pp.

Krailas, D., Namchote, S., Koonchornboon, T., Dechruksa, W., & Boonmekam, D. 2014. Trematodes obtained from the thiarid freshwater snail *Melanoides tuberculata* (Müller, 1774) as vector of human infections in Thailand. *Zoosystematics and Evolution*, 90, 57.

Kress, W. J., & Erickson, D. L. 2008. DNA barcodes: genes, genomics, and bioinformatics. *Proceedings of the National Academy of Sciences of the United States of America*, 105(8), 2761-2.

Krishnasamy, M., Inder Singh, K., Ambu S., Chong N.L., HanjeetKaur, Jeffery J. & Rosli R. 1995. Cercarial dermatitis among rice field workers in Labu, Negeri Sembilan, Peninsular Malaysia. *Trop Biomed,* 12: 109-113.

Kudlai, O., Stunžėnas, V., & Tkach, V. 2015. The taxonomic identity and phylogenetic relationships of Cercaria pugnax and C. helvetica XII (Digenea: Lecithodendriidae) based on morphological and molecular data. *Folia Parasitologica*, 62(003).

Kulsantiwong, J., Prasopdee, S., Piratae, S., Khampoosa, P., Thammasiri, C., Suwannatrai, A., & Tesana, S. 2015. Trematode Infection Of Freshwater Snail, Family Bithyniidae In Thailand. *Southeast Asian Journal of Tropical Medicine and Public Health,* 46(3), 396-405.

Labaude, S., Rigaud, T., & Cézilly, F. 2015. Host manipulation in the face of environmental changes: Ecological consequences. *International Journal for Parasitology: Parasites and Wildlife*, 4(3), 442-451.

Lafferty, K. D. 1997. Environmental parasitology: what can parasites tell us about human impacts on the environment?. *Parasitology today*, 13(7), 251-255.

Lafferty, K. D., & Kuris, A. M. 1999. How environmental stress affects the impacts of parasites. *Limnology and Oceanography*, 44(32), 925-931.

Lawton, S. P., Lim, R. M., Dukes, J. P., Kett, S. M., Cook, R. T., Walker, A. J., & Kirk, R. S. 2015. Unravelling the riddle of Radix: DNA barcoding for species identification of freshwater snail intermediate hosts of zoonotic digeneans and estimating their inter-population evolutionary relationships. *Infection, Genetics and Evolution*, 35, 63-74.

Liat, L. B., Fong, Y. L., Krishnansamy, M., Ramachandran, P., & Mansor, S. 1978. Freshwater snail consumption and angiostrongliasis (rat-lung worm) in Malaya, *Tropical and Geographical Medicine,* 30(2): 241-246.

Liat, L. B., Wah, L.T., Cheah, W., & Fong, Y. L. 1976 Angiostrongilus malaysinensis From Tuaran, Sabah with Reference to the distribution to the Parasite in Malaysia, *Journal of Tropical Medicine and Public Health*, 7(3):384-389.

Liew, T. S., Schilthuizen, M., & Lakim, M. 2010. The Determinants Of Land Snail Diversity Along A Tropical Elevational Gradient: Insularity, Geometry And Niches, *Journal of Biogeography*, 37: 1071–1078.

Likens, G. E. (Ed.). 2010. *River ecosystem ecology: a global perspective*. Academic Press.

Liu, H., Zhang, Z., Huang, G., Gu, X., Wang, C., Wang, Y., & Lu, Z. 2017. Infection of Oligochaetes, *Limnodrilus hoffmeisteri* (Annelida: Oligochaeta), in the Nasal Cavity of a Chinese Man. *The Korean journal of parasitology*, *55*(1), 77-79.

Lodge, D. M., Stein, R. A., Brown, K. M., Covich, A. P., Brönmark, C., Garvey, J. E., & Klosiewskt, S. P. 1998. Predicting impact of freshwater exotic species on native biodiversity: challenges in spatial scaling. *Australian Journal of Ecology*, 23(1), 53-67.

Long, S. M., Abang, F., & Rahim, K. A. A. 2002. The Macroinvertebrate Community Of The Fast Flowing Rivers In The Crocker Range National Park Sabah, Malaysia. *ASEAN Review of Biodiversity and Environmental Conservation* , 1-8.

Lotz, J. M., & Palmieri, J. R. 1985. Lecithodendriidae (Trematoda) From *Taphozous Melanopogon* (Chiroptera) In Perlis, Malaysia. *Proceedings of the Helminthological Society of Washington*, 52(1), 21-29.

Lovenbalk, J., Hjarne, D., Taoutaou, A. A., Mertz, O., Dirir, M., Dyg, P. M., Lassen, K. M., & Sehested, M. 2003. Opportunities and constraints for agricultural intensification in communities adjacent to the crocker range National Park Sabah, Malaysia. *ASEAN Review of Biodiversity and Environmental Conservation (ARBEC)*, *3*.

Lozon, J. D., & MacIsaac, H. J. 1997. Biological invasions: are they dependent on disturbance?. *Environmental Reviews*, *5*(2), 131-144.

Madsen, H., & Hung, N. M. 2015. Reprint of "An overview of freshwater snails in Asia with main focus on Vietnam". *Acta tropica*, 141, 372-384.

Magill, A. J. 2013. *Hunter's Tropical Medicine and Emerging Infectious Disease, Expert Consult-Online and Print, 9: Hunter's Tropical Medicine and Emerging Infectious Disease*. Elsevier Health Sciences.

Mahmoud, A. A. 2001. *Schistosomiasis: Setting the stage. In Schistosomiasis* (pp. 1-5). Word Scientific.

Mani, M. S. 2013. *Ecology and biogeography of high altitude insects* (Vol. 4). Springer Science & Business Media.

Mard-Arhin, N., Prawang, T., & Wongsawad, C. 2001. Helminths of freshwater animals from five provinces in northern Thailand. *Southeast Asian Journal of Tropical Medicine and Public Health*, 32, 206-209.

Marsh, C. W., & Greer, A. G. 1992. Forest land-use in Sabah, Malaysia: an introduction to Danum Valley. *Phil. Trans. R. Soc. Lond. B*, 335(1275), 331-339.

Marvier, M., Kareiva, P., & Neubert, M. G. 2004. Habitat destruction, fragmentation, and disturbance promote invasion by habitat generalists in a multispecies metapopulation. *Risk Analysis: An International Journal*, 24(4), 869-878.

Mas-Coma, M. S., Esteban, J. G., & Bargues, M. D. 1999. Epidemiology of human fascioliasis: a review and proposed new classification. *Bulletin of the World Health Organization*, 77(4), 340.

Matos, F. A., Sant'Anna, V., Maldonado Júnior, A., & Pinheiro, J. 2018. Morphology of Echinostoma paraensei Lie & Basch, 1967 (Trematoda) cercariae. *Brazilian Journal of Biology*, 78(2), 391-393.

Matthews, B. E. 1998. *An Introduction to Parasitology*. Cambridge University Press.

McGinnis, S., & Madden, T. L. 2004. BLAST: at the core of a powerful and diverse set of sequence analysis tools. *Nucleic Acids Research*, 32(2), 20-25.

Mennerat, A., Nilsen, F., Ebert, D., & Skorping, A. 2010. Intensive farming: evolutionary implications for parasites and pathogens. *Evolutionary Biology*, 37(2-3), 59-67.

Miller, E. L. 1935. Studies on North American cercariae. *The Journal of Parasitology*, 21(4), 244-254.

Mohammad, M. K. 2015. The parasitic infection of the freshwater snails collected in central Iraq. *Int. J. Curr. Microbiol*, 4(3), 47-55.

Möhl, K., Große, K., Hamedy, A., Wüste, T., Kabelitz, P., & Lücker, E. 2009. Biology of Alaria spp. and human exposition risk to Alaria mesocercariae—a review.*Parasitology Research*, 105(1), 1.

Morris R. J. 2010. Anthropogenic impacts on tropical forest biodiversity: a network structure and ecosystem functioning perspective. *Philosophical transactions of the Royal Society of London. Series B, Biological sciences*, *365*(1558), 3709-18.

Nachar, N. 2008. The Mann-Whitney U: A test for assessing whether two independent samples come from the same distribution. *Tutorials in Quantitative Methods for Psychology*, 4(1), 13-20.

Ng, T. H., Dulipat, J., Foon, J. K., Lopes-Lima, M., Zieritz, A., & Liew, T. S. 2017. A preliminary checklist of the freshwater snails of Sabah (Malaysian Borneo)

deposited in the BORNEENSIS collection, Universiti Malaysia Sabah. *ZooKeys*, (673), 105.

Odermatt, P., Lv, S. & Sayasone, S. 2010. Less common parasitic infections in Southeast Asia that can produce outbreaks. *Advances in parasitology*, Vol. 72, pp. 409-435, Academic Press.

Ortega, Y. R., & Sterling, C. R. (Eds.). 2018. *Foodborne parasites*. Springer.

Pakarinen, S. 2011. Host-parasitoid relationship in different Cotesia melitaearum and Melitaea cinxia populations around the Baltic Sea. (Master Thesis) University of Helsinki.

Palmer, M. W. 1990. The estimation of species richness by extrapolation. *Ecology*, 71(3), 1195-1198.

Parija, S. C., Marrie, T. J. & Koirala, S. 2003. Trematode Infection. *Electronic Medicine, last updated April*, 10, 1-20.

Polley, L. R. 2015. Foodborne parasites and climate change: Possible impacts and challenges. In *Foodborne Parasites in the Food Supply Web*, pp. 23-47, Woodhead Publishing.

Poulin. R. 2011. Evolutionary Ecology of Parasites: Second Edition, Princeton University Press, New Jersey.

Power, M. E., 2009, Regulators of biotic process in stream and river ecosystem, *River Ecosystem Ecology,* 166-172.

Prabharabha, H, Mazumdar, M., & Baruah, U, K. 2014. Habitat diversity of freshwater snail in Goalpara India, *Journal of Agriculture and Veterinary Science*, 1: 107. 114.

Prenter, J., MacNeil, C., Dick, J. T. A. & Dunn, A. M. 2004. Roles of parasites in animal invasions. Trends Ecol. Evol. 19: 385-390.

Radomyos, B., D. Bunnag, & T. Harinasuta. 1983. *Haplorchis pumilio* (Looss) infection in man in northeastern Thailand. *Southeast Asian Journal of Tropical Medicine and Public Health*. 14: 223- 227.

Ratnasingham, S., & Hebert, P. D. 2007. BOLD: The Barcode of Life Data System (http://www. barcodinglife. org). *Molecular Ecology Notes*, 7(3), 355-364.

Riehn, K., Hamedy, A., Große, K., Zeitler, L., & Lücker, E. 2010. A novel detection method for *Alaria alata* mesocercariae in meat. *Parasitology Research*, 107(1), 213-220.

Riehn, K., Hamedy, A., Saffaf, J., & Lücker, E. 2013. First interlaboratory test for the detection of *Alaria* spp. mesocercariae in meat samples using the *Alaria*

spp. mesocercariae migration technique (AMT). *Parasitology Research*, 112(7), 2653-2660.

Roberts, L., & Janovy, J. R. 2005. Foundation of Parasitology. M*ac Graw Hill Publishers,* USA.

Rodpai, R., Intapan, P. M., Thanchomnang, T., Sanpool, O., Sadaow, L., Laymanivong, & Maleewong, W. 2016. *Angiostrongylus cantonensis* and *A. Malaysiensis* Broadly Overlap in Thailand, Lao PDR, Cambodia and Myanmar: A Molecular Survey of Larvae in Land Snails. *PloS one*, 11(8).

Rohela, M., Jamaiah, I., Menon, J., & Rachel, J. 2005. Fasciolopsiasis: a first case report from Malaysia. *The Southeast Asian Journal of Tropical Medicine and Public health*, 36(2), 456.

Roni, P. (2005). *Habitat rehabilitation for inland fisheries: global review of effectiveness and guidance for rehabilitation of freshwater ecosystems* (No. 484). Food & Agriculture Org.

Ross, A. G., Olveda, R. M., Acosta, L., Harn, D. A., Chy, D., Li, Y. & Williams, G. M. 2013. Road to the elimination of schistosomiasis from Asia: the journey is far from over. *Microbes and infection*, 15(13), 858-865.

Routtu, J., Grunberg, D., Izhar, R., Dagan, Y., Guttel, Y., Ucko, M., & Ben-Ami, F. 2014. Selective and universal primers for trematode barcoding in freshwater snails. *Parasitology research*, 113(7), 2535-2540.

Rzad, I., & Busse, P. 2015. *Collyriclum faba* (Digenea: Collyriclidae) in migrant Phylloscopus trochilus (Aves: Sylvidae) in Egypt: the first record of the parasite on the African continent. *Turkish Journal of Zoology*, 39(2), 359-364.

Sagin, D. D., Ismail, G., Fui, J. N., & Jok, J. J. 2001. Schistosomiasis malayensis-like infection among the Penan and other interior tribes (Orang Ulu) in upper Rejang River Basin Sarawak Malaysia. *The Southeast Asian Journal of Tropical Medicine and Public Health*, 32(1), 27.

Sakai, S., Nais, J., & Fah, Y. S., 2003. *Water Resources Management in and Around Crocker Range Park: Workshop Proceedings*, Park Management Component, Kota Kinabalu, Sabah, Malaysia. 23 Nov. 2002.

Sala, O. E., Chapin, F. S., Armesto, J. J., Berlow, E., Bloomfield, J., Dirzo, R. & Leemans, R. (2000). Global biodiversity scenarios for the year 2100. *science*, 287(5459),1770-1774.

Sandland, G. J., Detwiler, J., & Minchella, D. J., 2007, Undestanding Ecological Principle Through Parasitology Pedagogy, *Department of Biological Science*, 28: 295-308.

Sarstedt, M., & Mooi, E. 2014. Cluster analysis. In *A concise guide to market research* (pp. 273-324). Springer, Berlin, Heidelberg.

Sarwade, A. B., Pati, S. K., & Kamble, N. A. 2015. Diversity of Molluscan fauna from freshwater bodies of Sangli District: A comprehensive study in relation to environmental variables. *International Journal of Pharmaceutical Sciences and Research*, 6(8), 3563.

Schilthuizen, M., Hsieh-Nee Chai, & Kimsin, T. E. 2003, Abundance And Diversity Of Land-Snails (Mollusca: Gastropoda) On Limestone Hills In Borneo, *The Raffles Bulletin of Zoology*, 51(1): 35-42.

Schilthuizen, M., & Rutjes, H. A. 2001., Land Snail Diversity In A Square Kilometer Of Tropical Rainforest In Sabah, Malaysia Borneo, *Journal of Molluscan Studies*, 67(4): 417-423.

Sève, J. (1999). *A review of Forestry sector policy issues in Indonesia* (p. 39). Natural Resources Management Program, Jakarta.

Shekhar, K. C. 1991. Epidemiological assessment of parasitic zoonoses in Malaysia. *The Southeast Asian Journal of Tropical Medicine and Public Health*, 22, 337-9.

Shinn, G. L. 1993. Formation of egg capsules by flatworms (phylum Platyhelminthes). *Transactions of the American Microscopical Society*, 18-34.

Siddall, R., & Des Clers, S. 1994. Effect of sewage sludge on the miracidium and cercaria of Zoogonoides viviparus (Trematoda: Digenea). *Helminthologia*, 31,143-153.

Smallwood, T. B., Giacomin, P. R., Loukas, A., Mulvenna, J. P., Clark, R. J., & Miles, J. J. (2017). Helminth Immunomodulation in Autoimmune Disease. *Frontiers in immunology*, *8*, 453.

Smyth, J. D., & Wakelin, D. 1994. *Introduction to animal parasitology*. Cambridge university press.

Soberón, M. J., & Llorente, B. J. 1993. The use of species accumulation functions for the prediction of species richness. *Conservation biology*, 7(3), 480-488.

Spratt, D. M. 2015. Species of Angiostrongylus (Nematoda: Metastrongyloidea) in wildlife: a review. *International Journal for Parasitology: Parasites and Wildlife*, *4*(2), 178-189.

Spyra, A. N. E. T. A., Serafinski, W., & Strzelec, M. 2007. The species diversity of freshwater snails (Gastropoda) in differently managed fishponds in South-Western Poland. *Ecology Bratislava*, 26(1), 83.

Sri-aroon, P., Butraporn, P., Limsoomboon, J., & Kaewpoolsri, M., 2007. Freshwater mollusks at designated areas in eleven provinces of thailand according to the water resource development projects. *Southeast Asian Journal of Tropical Medicine and Public Health,* 38(2), 294-301.

Sripa, B., Kaewkes, S., Intapan, P.M., Maleewong, W., & Brindley, P.J., 2010. Food-borne trematodiases in Southeast Asia epidemiology, pathology, clinical manifestation and control. *Adv. Parasitol.* 72, 305–350.

Sritongtae, S., Namchote, S., Krailas, D., Boonmekam, D., & Koonchornboon, T. 2015. Cercarial infections of brackish water snails on the east coast of southern Thailand. *JITMM Proceed*, 4, 1-15.

Steinbauer, M. J., Otto, R., Naranjo-Cigala, A., Beierkuhnlein, C., & Fernández-Palacios, J. M. 2012. Increase of island endemism with altitude–speciation processes on oceanic islands. *Ecography*, 35(1),23-32.

Strong, E. E., Gargominy, O., Ponder, W. F., & Bouchet, P. 2007. *Global diversity of gastropods (Gastropoda; Mollusca) in freshwater. In Freshwater Animal Diversity Assessment* , Springer.

Supian, Z., & Ikhwanuddin, A. M. 2002. Population dynamics of freshwater molluscs (Gastropod: Melanoides Tuberculata) in crocker range park, Sabah. *ASEAN Review of Biodiversity and Environmental Conservation (ARBEC)*, 1(1), 1-9.

Sures, B., Nachev, M., Selbach, C., & Marcogliese, D. J. 2017. Parasite responses to pollution: what we know and where we go in 'Environmental Parasitology'. *Parasites & vectors*, 10(1), 65.

Tatem, H. E. 1977. Accumulation of naphthalenes by grass shrimp: Effects on respiration, hatching, and larval growth. In *Fate and Effects of Petroleum Hydrocarbons in Marine Ecosystems and Organisms* , 201-209.

Tay, J., & Chong, K. Y. 2005. Deramakot Forest Reserve: the future is now. *In Search Of Excellence: Exemplary forest management in Asia and the Pacific*, 283.

Tildesley, M. J., House, T. A., Bruhn, M. C., Curry, R. J., O'Neil, M., Allpress, J. L., Smith, G., & Keeling, M. J. 2010. Impact of spatial clustering on disease transmission and optimal control. *Proceedings of the National Academy of Sciences*, 107(3), 1041-1046.

Tomba, A. 2006. *Effects of Trematode Parasites on Habitat Use and Disturbance Response of Freshwater Snails in the Genus Elimia* (Doctoral dissertation). Auburn University.

Tompa. A. S., Verdonk, N. H., van den Biggelaar, J. A. M., & Wilbur, K. M., .1984. *The Mollusca. Volume 7: Reproduction*, Academic Press, USA.

Torchin, M. E., Byers, J. E., & Huspeni, T. C. 2005. Differential parasitism of native and introduced snails: replacement of a parasite fauna. *Biological Invasions*, 7(6), 885-894.

Ukong, S., Krailas, D., Dangprasert, T., & Channgarm, P. 2007. Studies on the morphology of cercariae obtained from freshwater snails at Erawan

Waterfall, Erawan National Park, Thailand. *Southeast Asian Journal of Tropical Medicine and Public Health*, *38*(2), 302.

Wallace. J. B., & Eggert, S. L. 2009. Bentic Invertebrate Fauna, Small stream, *River Ecosystem Ecology* , 98-115.

Wasiluk, A. 2013. Alaria alata infection-threatening yet rarely detected trematodiasis. *J Lab Diagn*, *49*, 33-37.

Whiles, M. R., & Grubaugh, J. W., 2009, Benthic invertebrates fauna, river and floodplain ecosystem , *River Ecosystem Ecology* , 116-125.

Whittaker, R. J., Triantis, K. A., & Ladle, R. J. 2008. A general dynamic theory of oceanic island biogeography. *Journal of Biogeography*, 35(6), 977-994.

Wong, L. C. 2007. Development of Malaysia's agricultural sector: Agriculture as an engine of growth. In *ISEAS Conference on the Malaysian Economy: Development and Challenges*. January 2007.

Yizhar, R., Dagan, Y., Ucko, M., & Ben-Ami, F., 2006. Survey of Parasite of Freshwater Snails in Israel, Department of Zoology, Tel Aviv University, Israel.

Youn, H. 2009. Review of zoonotic parasites in medical and veterinary fields in the Republic of Korea. *The Korean Journal of Parasitology*, 47, 133.

Zainalabidin, F. A., Azmi, M. S. N. N., Bakri, W. N. W. O., Sathaya, G., & Ismail, M. I. 2015. Screening for Zoonotic Fascioliasis in Slaughtered Large Ruminants in Abattoirs in Perak, Malaysia. *Tropical Life Sciences Research*, 26(2), 121.