THE BIOLOGY AND ECOLOGY OF *SCHISTOSOMA SPINDALE* IN RELATION TO THE EPIDEMIOLOGY OF CERCARIAL DERMATITIS IN PENINSULAR MALAYSIA

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BY

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PRAYER

Oh! Lord I prostrate before thee

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ABSTRAK

BIOLOGI DAN EKOLOGI *SCHISTOSOMA SPINDALE* BERHUBUNGAN DENGAN EPIDEMIOLOGI DERMATITIS SERKARIA DI SEMENANJUNG MALAYSIA

Objektif kajian ini adalah menkaji pelbagai faktor yang menyumbangkan kepada epidemiologi dermatitis serkaria yang diakibatkan oleh *Schistosoma spindale* di semenanjung Malaysia, dengan tumpuan khas pada suatu tempat endemik di Labu, Negeri Sembilan.

S. spindale telah dicamkan sebagai agen penyebab kepada wabak dermatitis serkaria di 8 Km Jalan Labu, Negeri Sembilan. Daripada sembilan spesies siput yang diperiksa, hanya *I. exustus* didapati positif untuk *S. spindale*, dengan kadar jangkitan 16.69%. Suatu tinjauan sosial atas penduduk yang dihinggapi dari kawasan ini telah menunujukkan bahawa petani padi telah memberhentikan penanaman padi untuk dua musim disebabkan oleh dermatitis. Daripada 30 orang dewasa yang ditinjau, 21 menunjukkan jangkitan dermatitis. Kebanyakan orang dewasa yang ditinjau (77%) adalah petani padi, berumur di antara 15-64 tahun.

Pengkajian atas 6472 siput yang telah dikumpul dari seluruh semenanjung Malaysia telah menunjukkan bahawa daripada 11 spesies yang dikumpul, serkaria *S. spindale* hanya dijumpai dalam *Indoplanorbis exustus*. Dalam kajian

ini, Johor, Trengganu dan Kedah telah dicamkan sebagai tempat baru untuk kehadiran *S. spindale* dalam *I. exustus*.

Dalam suatu tinjauan atas prevalens semulajadi *S. spindale* dalam perumah definitif di semenanjung Malaysia, adalah didapati bahawa *Bandicota indica* mempunyai kadar prevalens (25%) dan intensiti jangkitan min (74 cacing/haiwan) yang tinggi sekali di antara semua haiwan yang dikaji. Di antara haiwan ruminant, prevalens jangkitan didapti tinggi sekali dalam *Bubalus bubalis* (21.57%) bila dibanding dengan *Bos indicus* (11.21%) dan *Capra hircus* (6.06%). Adalah didapati bahawa *S. spindale* ditaburkan dalam haiwan ruminant di seluruh negara dengan prevalens yang tinggi sekali di Perlis dan Trengganu (lebih dari 20%) dan rendah sekali di Johor, Kedah dan Perak (kurang dari 5%). Di antara spesies rodent, prevalens dan intensiti jangkitan min untuk *S. spindale* didapti tinggi sekali pada *B. indica* (25% dan 74 cacing/haiwan positif masing-masing).

Bila haiwan lair dan domestik didedahkan kepada sekaria *S. spindale* dalam makmal, adalah didapati bahawa dalam haiwan besar, parasit bermatang dalam 30 hari, dengan ova cacing matang dalam kambing. Dalam haiwan lain, cacing mencapai kematangan dengan masa lebih panjang (dalam 2-3 bulan). Jangkitan 100% diperhatikan dalam empat spesies, iaitu, *Macaca fascicularis*, *Meriones unguiculatus*, *Cavea porcellus*, dan *Oryctolagus caniculus*.

Bila siput *I. exustus* didedahkan kepada serkaria *S. spindale* dalam makmal, adalah didapati bahawa kadar kematian prapaten (PDR) adalah tinggi sekali (100%) pada siput yang didedahkan kepada 5 dan 6 mirasidium/siput. Tempoh jangkitan min (MDI) diperhatikan lebih tinggi (60 hari) untuk siput yang diberikan 3 mirasidium/siput, bila dibandingkan dengan yang diperhatikan dalam kumpulan lain. *S. spindale* didapati menunjukkan subperiodisiti diurnal atau phototaksis, dengan membebaskan lebih banyak serkaria pada waktu siang daripada waktu waktu malam. Pada waktu siang, pembebasan serkaria maksimum (82.4%) dirakamkan di antara 0900 dan 1200 jam, dengan puncak pada 1030 jam, dan menurun dari masa itu.

Suatu tinjauan yang mengambil satu tahun dalam tapak kajian yang endemik untuk dermatitis serkaria di 8 Km Jalan Labu, Negeri Sembilan, telah menunjukkan bahawa *S. spindale* mempunyai suatu potensi zoonosis yang tinggi dalam kawasan itu. Di antara tiga jenis habitat berair di kawasan kajian ini, siput *I. exustus* dari habitat sungai didapati mempunyai kadar prevalens yang tinggi sekali untuk jangkitan *S. spindale* (39.46%), bila dibandingkan dengan kadar prevalens pada siput dari sawah padi (1.32%) dan dari tapak empangan (21.18%). Di antara rodent, burung dan haiwan domestik dari kawasan ini yang telah diperiksa untuk jangkitan *S. spindale*, hanya kerbau dan tikus *padang R. j. tiomanicus* didapati positif.

Lebih dari 40 spesies tumbuhan air didapti berkaitan dengan habitat siput dalam kawasan, termasuk spesies dominan seperti berikut: ubi keladi (*Colocasia esculaenta*), "pondweed", "yellow burhead", "Asiatic eelgrass", "knotweed umum", dan paku-pakis seperti *Ludwigia hyssopifolia* dan *L. prostrata*.

Peranan semua faktor yang menyumbangkan kepada epidemiologi dermatitis serkaria yang diakibatkan oleh *S. spindale* di semenanjung Malaysia juga dibincang, dengan tumpuan khas atas kawasan endemik di 8 Km Jalan Labu, Negeri Sembilan.

ABSTRACT

The objective of this study was to study various factors that contributed to the epidemiology of cercarial dermatitis caused by *Schistosoma spindale* in peninsular Malaysia, with particular focus on an endemic area in Labu, Negri Sembilan.

S. spindale was incriminated as the causative agent in the outbreak of cercarial dermatitis at the 8th Km Labu Road, Negri Sembilan. Out of 9 species of snails examined, only *I. exustus* was positive for *S. spindale* with a 16.69% infection rate. A social profile survey of the affected residents of this area showed that the paddy farmers discontinued rice planting for two seasons because of the dermatitis. Of the 30 adults surveyed, 21 people showed signs of dermatitis. A majority of the adults surveyed (77%) were paddy farmers, aged between 15-64 years old.

A study of 6472 snails collected throughout peninsular Malaysia revealed that out of the 11 species of snails collected, cercariae of *S. spindale* were found only in *Indoplanorbis exustus*. In this study, Johore, Trengganu and Kedah were identified as new localities for the presence of *S. spindale* in *I. exustus*.

In a survey of the natural prevalence of *S. spindale* in definitive hosts in peninsular Malaysia, it was found that *Bandicota indica* had the highest prevalence rate (25%) and mean intensity of infection (74 worms/animal) among all animals studied. Among the ruminants, the prevalence of infection was found highest in *Bubalus bubalis* (21.57%) as compared to *Bos indicus* (11.21%) and *Capra hircus* (6.06%). *S. spindale* is distributed in ruminants all over the country with the prevalence being highest in Perlis and Trengganu (above 20%) and lowest in Johor, Kedah and Perak (less than 5% infection). Among the rodents species, the prevalence and mean intensity of infection of *S.spindale* were highest in *B. indica* (25% and 74 worms/positive animal respectively).

When wild and domestic animals were exposed to *S. spindale* cercariae in the laboratory, it was found that in the large animals, the parasites were found to mature within 30 days, with matured worm ova found in goats. In the other animals, the worms attained maturity later (within 2-3 months). A 100% infection was observed in four of the species, namely, *Macaca fascicularis, Meriones unguiculatus, Cavea porcellus,* and *Oryctolagus cuniculus.*

When *I. exustus* snails were exposed to *S. spindale* cercariae in the laboratory, it was found that the prepatent death rate (PDR) was the highest (100%) among the snails that were exposed to both 5 and 6 miracidia/snail. Mean duration of

infection (MDI) was observed to be higher (60 days) among the snails which were given 3 miracidia/snail, when compared to that observed in the other groups of snails. *S. spindale* was found to exhibit a diurnal or phototactic subperiodicity, releasing more number of cercariae during the day light hours as compared to the night hours. During the day time, the maximum shedding of cercaria (82.4%) was recorded between 0900 and 1200 hours, peaking at 1030 hours, and declining from then onwards.

A one year survey in the study area endemic for cercarial dermatitis at the 8th Km Labu Road, Negeri Sembilan, showed that *S. spindale* has a high zoonotic potential in this area. Among the three water habitat types in this study area, the *I. exustus* snails from the river habitat were found to have the highest prevalence rates for *S. spindale* infection (39.46%) as compared with the prevalence rate among the snails obtained from the paddy fields (1.32%) and from the dam site (21.18%). Among the rodents, birds, bats and domestic animals from this area examined for *S. spindale* infection, only the buffalo and the field rat *R. j. tiomanicus* were found positive.

More than 40 species of water plants were found associated with the snail habitats in the study area, including the yam (*Colocasia esculaenta*), pondweed, yellow burhead, Asiatic eelgrass, the common knotweed, and ferns such as *Ludwigia hyssopifolia* and *L. prostrata.*

The role of all the factors contributing to the epidemiology of cercarial dermatitis caused by *S. spindale* in peninsular Malaysia, with particular focus on the endemic area at the 8th Km Labu Road, Negeri Sembilan, was discussed.

CHAPTER 1

1. 0 LITERATURE REVIEW

1. 1 GENERAL INTRODUCTION

The flukes of the family Schistosomatidae (Trematoda) are parasites of the blood vascular system of mammals, birds and humans, and are world-wide in distribution (Cort,1950; Chu,1958). The infection of man by these flukes results in a few disease syndromes, namely cercarial dermatitis, acute schistosomiasis (Katayama fever), and related tissue changes resulting from egg deposition (Malek, 1980; Garcia and Bruckner, 1993).

Acute schistosomiasis is the result of the infection of the blood vascular system by adult stages of these flukes in their natural hosts. The three major human-infecting species are *Schistosoma mansoni*, *S. japonicum*, and *S. haematobium*. In Southeast and Fareast Asian countries, *S. japonicum* and *S. mekongi* are resposible for the major and endemic forms of human schistosomiasis occurring in this region (Kumar & Burbure, 1986). In Malaysia, the only indigenous schistosome that causes acute schistosomiasis in man is *S. malayensis*, a schistosome infecting aborigines in peninsular Malaysia (Greer *et al*, 1988).

The penetration of the human body by cercariae of the human-infecting schistosomes will also result in cercarial dermatitis, an allergic rash on the skin in previously exposed individuals. The invasion of the skin is effected by the aid of histiolytic secretions poured out through the cephalic secretory ducts opening anteriorly through the wall of the oral sucker of these cercariae. In persons who are frequently exposed to water containing such cercariae of human schistosomes, small petechial and urticarial wheals may appear on the skin only to subside later (Sandosham and Lie, 1969).

However, cercarial dermatitis in man is also caused by the cercariae of schistosome species (zoonotic schistosomes) that normally infect birds and other vertebrates. In such cases, the skin reaction is more severe (Sandosham and Lie, 1969). Since humans are not suitable definitive hosts for these cercariae, the larval flukes do not enter the blood system and mature, but rather perish in the process of attempting to penetrate the skin. As they do so, they also sensitize the areas of attack, resulting in itchy rashes on the skin. This disease condition is called cercarial dermatitis or "swimmer's itch" (Cort, 1928). It is also variously known as clamdigger's itch, Gulf coast itch, el-caribe, and koganbyo. In Malaysia, it is known among the local people as "sawah itch."

Up to the present time, not much systematic research has been carried out to study the epidemiology of cercarial dermatitis in Malaysia. Recently, this

disease assumed serious proportions and caused much distress and suffering among rice growers in a Malay village in Negri Sembilan (Krishnasamy *et al*, 1995). Thus there has arisen a great need to study the various factors contributing to the occurrence of the disease in Malaysia. This will in turn help the relevant health authorities to propose steps and measures for the control and prevention of cercarial dermatitis.

The aim of the present study is therefore to study some aspects of the biology and ecology of *S. spindale* in relation to the epidemiology of cercarial dermatitis in Malaysia. This will provide a database of information for the proposal of steps to control this disease in future in this country.

1. 2 CLARIFICATION OF THE TERM "CERCARIAL DERMATITIS"

Classically, the term "schistosomal dermatitis" or "schistosome dermatitis" has been used to describe the dermatitis produced in man by the cercariae of certain species of avian and mammalian schistosomes which are foreign to human beings (Chandler and Read, 1961; Belding, 1965). Cort (1928) was the first to use this term to describe cercarial dermatitis caused by non-human schistosomes. However, this term was also used synonymously and interchangeably by others with the term "cercarial dermatitis" whenever this

disease is discussed (Chandler and Read, 1961; Noble and Noble, 1976; Cheng, 1986).

In order to distinguish between the cercarial dermatitis caused by schistosomes infecting humans only (e.g. *Schistosoma mansoni*, *S. haematobium* and *S. japonicum*) and that caused by schistosomes which normally are found in avian or non-human mammalian hosts, Malek (1980) used the term "cercarial dermatitis" to describe the former and the term "schistosome dermatitis" to describe the latter. However, many other authors do not seek to distinguish between the two forms of cercaria-caused dermatitis and discuss both forms under the term "cercarial dermatitis" (Cheng, 1986; Garcia and Bruckner, 1993; Sandosham and Lie, 1969). This broad approach is taken in this study.

1. 3 CLINICAL MANIFESTATION OF CERCARIAL DERMATITIS

1. 3.1 Cercarial dermatitis caused by human schistosomes

Cercarial dermatitis in humans follows the penetration of skin by cercariae, and the reaction may partly be due to previous host sensitization. Few clinical manifestations are associated with primary exposure, but on subsequent exposure, both humoural and cellular immune responses are elicited (Catto *et al*, 1980; CDC, 1992). That cercarial dermatitis is a sensitization reaction had

been demonstrated when Egyptians with known schistosome infections were exposed to cercariae of *S. mansoni* and *S. haematobium* (Barlow, 1936).

After cercarial skin penetration, petechial hemorrhages with edema and pruritis occur. The subsequent maculopapular rash, which may become vesicular, may last 36 hours or more. The chances of development of skin lesions increases with an increase in number of cercariae which die or are killed in the skin. Most of the enzymes of the cercariae are secreted immediately on penetration of the outer layer (Standen, 1953). Cercarial secretions and excretions produce immunologic and toxic reactions. Mechanical damage due to penetration and movement of the cercariae is believed to be highly localized (Bruce *et al*, 1970).

For human schistosome species, it is believed that more cercariae of *S. mansoni* and *S. haematobium* die in the skin than cercariae of *S. japonicum.* As a result, cercarial dermatitis is not as frequently noted with *S. japonicum* infections as with *S. haematobium* and *S. mansoni* infections. (Malek,1980; Garcia and Bruckner, 1993).

1.3.2 Cercarial dermatitis caused by non-human schistosomes

In cercarial dermatitis caused by non-human schistosomes the immune response is more immediate and intense, especially in previously sensitized

individuals, when compared to cercarial dermatitis caused by human schistosomes (Cort, 1928; CDC, 1992). The dermatitis begins with a prickly sensation followed by the development of extremely itchy papules, which sometimes become pustular and may be accompanied by considerable swelling. The dermatitis caused by the penetration of the cercariae of schistosomes of birds and mammals is essentially a sensitization phenomenon (Margono, 1968).

Clinically, a prickling itch occurs within about five minutes after penetration of the human skin. The itching and prickling sensations will last a few hours; the pruritis becomes intense in 6 to 7 hours. The itching will persist and became so severe that it will interfere with sleep for the next two nights. Meanwhile, reddish macula about the size of a pin will develop within 30 minutes after penetration; later it will become red papules and in 24 hours large papules or nodules 8 to 10 mm in diameter develop. These are usually accompanied by erythrema, edema, and intense pruritis, with the subsequent formation of vesicles, each vesicle being 1-2 mm in diameter and surrounded by an arteriolar flare.

By 52 hours after penetration of the cercariae, the cercariae are completely destroyed and the tunnel in which the cercariae rested is filled with exudate, leucocytes, lymphocytes, and an amorphous eosinophilic mass. The entire

dermis shows much edema, indicative of a well-marked inflammatory response (Hunter, 1971).

On the fourth day after exposure the lesions will begin to fade and will be replaced by tiny black spots, surrounded by greyish pigmentation which will persist for about a month (Krishnasamy *et al*, 1995). However, rubbing or scratching complicates the course of the dermatitis, whereby the vesicles rupture, and become pustular when they are secondarily infected. The repair process will be delayed a few more days in such cases (Hunter, 1971).

1.4 ETIOLOGIC AGENTS OF CERCARIAL DERMATITIS CAUSED BY NON-HUMAN SCHISTOSOMES

1.4.1 Etiologic agents worldwide

The distribution of cercarial dermatitis is world-wide (Cort, 1950; Chu, 1958). In 1928, Cort had summarized the records of all cases of cercarial dermatitis from all over the world caused by non-human schistosomes. Records were updated in later reviews by Cort (1950) and Chu (1958). Sandosham and Lie (1969) stated that more than 30 species of non-human flukes were capable of causing cercarial dermatitis in man around the world. Recently, Malek (1980) has made a comprehensive review of the various causative cercariae---both freshwater and marine---of cercarial dermatitis.

In freshwater lakes of North America, cercariae of the genera *Trichobilharzia* and *Bilharziella*, which normally infects birds, are the most common dermatitis-producing flukes (Edwards and Jansch, 1955; Ulmer, 1958; Hunter, 1960). Species include *T. ocellata, T. physellae, T. stagnicolae* and *B. polonica*. Similar freshwater cases have been reported from the Netherlands, Switzerland and Austria, being caused mainly by *T. ocellata* (Salome, 1954; Bonsel *et al*, 1958).

For marine swimmer's itch, one of the most common causative agent on both the east and west coast of North America is *Austrobilharzia variglandis*, a natural blood parasite of gulls. Its cercariae develop in the common mudflat snail, *Nassarius obsoletus*, (Chu, 1952; Stunkard and Hinchliffe, 1952). In Australia, Bearup (1956) studied many cases of dermatitis which were caused by the cercariae of a marine fluke, *Austrobilharzia terrigalensis*, which develop in marine snails.

1.4.2 Etiologic agents in Malaysia

A review of the Asian schistosomes of animal and humans has been compiled and updated by Kumar and Burbure (1986). A high incidence of schistosomiasis and cercarial dermatitis has been recorded in Asian regions including India, Sri Lanka, Bangladesh, Indonesia, Thailand, Vietnam and Laos.

Of the Asian schistosomes, six species are found in Malaysia, infecting humans, animals and birds. These are namely, *S. spindale, S. nasale, S. incognitum. S. malayensis* and *Trichobilharzia brevis* and *Pseudobilharzia lonchurae* (Table 1.1). Two species, namely *S. malayensis* and *P. lonchurae,* are confined to Malaysia only. The rest of the four species are very commonly found in Asian countries. They are not known to occur outside the Asian continent under natural conditions.

However, only two of the schistosome species found in Malaysia, namely *S. spindale* and *T. brevis*, cause cercarial dermatitis in humans (Buckley, 1938; Basch, 1966).

1.5 EPIDEMIOLOGY OF CERCARIAL DERMATITIS

Epidemiology is the study of "all the elements contributing to the occurrence or nonoccurrence of a disease in a population" (Webster's New World Dictionary, 1988). In other words, it is the study of factors contributing to the occurrence of any specific disease in any locality or country. For cercarial dermatitis, the various factors that would bring about the infection of humans in a particular locality include the following:

Table 1.1. Summary of schistosomes of animals, birds and humans in Malaysia

Features	*Schistosoma spindale*	*Schistosoma nasale*	*Schistosoma incognitum*	*Schistosoma malayensis*	*Trichobilharzia brevis*	*Peseudobilharziella lonchurae*
Definitive hosts	Goat, cattles, buffalo, sheep, horses, donkey, Rodents and dogs Monkey	Buffalo, cattles, (rarely sheep, goats, and horse)	Pig, dog, Rodents	Human, Animal & Rodents	Birds	Birds
Intermediate hosts	*Indoplanorbis exustus*	*Indoplanorbis exustus*	*Lymnaea luteola australis* and *Radix auricularia rubiginosa*	*Robertsiella kapo-rensis, R. gismani*	*Lymnaea rubiginosa*	*Lymnaea rubiginosa*
References	(Montgomery,1906; Buckley, 1938; Krishnasamy *et al*, 1991)	(Rao,1933; Saharee *et al,* 1984)	(Chandler, 1926; Lee *et al*,1986)	(Murugasu & Dissanaike, 1973; Greer *et al*, 1988)	(Basch, 1966)	(Fischthal & Kuntz 1973)
Geographical distribution	India, Thailand, Indonesia, Laos, Vietnam, Malaysia	India, Burma, Sri Lanka, Bangladesh, Malaysia	India, Thailand, Indonesia, Malaysia	Malaysia	Malaysia, Indonesia,	Sabah, Malaysia
Tegument of male worms	Atuberculate	Highly tuberculate	Highly tuberculate	Atuberculate	Atuberculate	Atuberculate
No. of testes	4 - 7 (mostly 6)	2 - 4 (mostly 4)	2 - 7 (mostly 7)	6 - 8 (mostly 7)	38 - 71 (many)	Many (numerous)
Position of ovary	Pre-equatorial to equatorial	Post-equatorial (Middle fifth of the body)	Anterior third of body	Anterior half of body	Post-equatorial	Anterior half of body
No of ova in uterus	15 - 25	1 - 2 (mostly 1) ?	Many ?	1 (many)	1 (mostly) one egg at time	1(mostly)

(a) The presence of the causative parasites.

(b) The presence of the definitive mammalian or avian hosts of the parasites.

(c) The presence of the snail intermediate hosts of the parasites.

(d) Factors leading to the exposure of humans to the causative cercariae. These include human work habits, leisure activities, etc.

(e) The biology of the causative parasites which contribute to the infection of humans, including cercaria production, cercaria shedding periodicity, etc.

(f) The climatic factors affecting the factors listed above.

The various epidemiological factors listed above are all important in contributing to the incidence of cercarial dermatitis in any specific locality. Only a thorough knowledge of these factors will allow the local health authorities to plan rationally to prevent and control the occurrence of the disease. These factors are reviewed in detail in the following sections.

1.6 EPIDEMIOLOGY OF CERCARIAL DERMATITIS CAUSED BY *S. SPINDALE* WITH SPECIAL EMPHASIS ON THE SITUATION IN MALAYSIA

1.6.1 Initial reports of cercarial dermatitis in Malaysia and other countries

S. spindale is a common schistosome in the caval blood of cattle, water buffaloes, sheep and goats in India, Malaysia, Thailand, Zambia, and Sumatra

(Beaver and Jung,1984). It was first discovered by Montgomery (1906) from cattle in Muktesar, India. Subsequently Vrijiburg (1907) recorded it in Sumatra in Indonesia. In Thailand, it was found frequently in cattle, buffaloes and rodents (Harinasuta and Kruatrachue, 1964; Schneider *et al*, 1975 and Bunnag *et al*,1980), In other Asian countries like Vietnam, Laos, South Africa and Zambia it was found in a variety of animals including the water buffalo, goat, cattle and sheep.

In Malaysia, animal schistosomes were first reported by Buckley (1938) on a case of dermatitis in Malays who were rice cultivators. Buckley (1938) had isolated cercariae from *Indoplanorbis* snails in the area, and used these cercariae to produce experimental dermatitis on himself, and by experimental infection of mice, proved that the schistosome was *S. spindale*. Later, Sandosham (1954) reported on the presence of cercariae of another species that caused dermatitis among paddy farmers in Negri Sembilan. These cercariae were isolated from *Lymnaea crosseana* (*L. rubiginosa*) snails, and belonged to the category of non-human furcocercous cercariae called the "Elvae" group. He tentatively called the cercariae Cercariae malayi I, and placed it under the genus *Trichobilharzia.* This cercaria was further investigated by Basch (1966) and was given the name of *Trichobilharzia brevis*, a bird schistosome.

1.6.2 Geographical distribution of *S. spindale*

Outside Malaysia, *S. spindale* occurs in India, Thailand, Sri Lanka, Indonesia, Laos,Vietnam and Africa (Buckley,1938; Porter,1938; Bregeon,1952; Harinasuta & Kruatrachue, 1964; Schneider *et al*, 1975; Krishnasamy *et al*, 1998).

In Malaysia, *S. spindale* has been reported from many states, including Negeri Sembilan, Selangor, Perlis, Kedah, Johor and Trengganu (Buckley, 1938; Sandosham, 1954; and Lie *et al.*, 1970). In 1969, Sandosham and Lie made an extensive search for *S. spindale* in different places near Kuala Lumpur and found many areas highly positive. The prevalence rate in pond and ditch was 1.1-16.4%.

On the other hand, *T. brevis* has been found only in Negri Sembilan and Selangor in Malaysia; elsewhere. this fluke has been reported from Indonesia . (Margono,1968). Sandosham and Lie (1969) found *T. brevis* near Kuala Lumpur in the paddy field, pond, and the ditches, etc. The prevalence rate of *T. brevis* was reported to be 1.9% in Kuala Pilah.

1.6.3 Avian and mammalian hosts of the etiologic agents

Many schistosome species possess the ability to infect and develop in a wide range of animal species (Carney *et al*, 1977). Reports have indicated that the Javanese, Thai and Sulawesi strains of *S. incognitum* can devolop in a wide range of mammalian species (Lee and Wykoff, 1966). Pigs, dogs and rats were found to be the natural hosts while in the laboratory, cat, sheep, goat, cow, rabbit, guinea pig, albino rats, and mouse were found to be susceptible to infection by this species.

The six schistosome species found in Malaysia have been isolated from more than 50-60 species of animals, comprising ruminants, rodents, dogs, monkeys, humans, and birds. One of the agents for cercarial dermatitis in Malaysia, *S. spindale*, is found in many animal species, including the water buffalo, goat, sheep, cattle, equines and dog (Beaver and Jung.,1984; Soulsby, 1986; Kumar & Burbure,1986). Experimental infections were successfully carried out in calves and guinea pigs by Rao (1934). In peninsular Malaysia, it was first reported from water buffalo and cattle (Buckley, 1938; Euzeby, 1956; Krishnasamy *et al*, 1991; Sandosham & Lie, 1969). On the other hand, *T. brevis* naturally infects ducks and birds, (Basch, 1966).

In man, the cercariae of *S. spindale* and *T. brevis* cannot develop into adults but die in the skin after penetration, at which place they cause acute itchiness in sensitized individuals.

1.6.4 Snail intermediate hosts of the etiologic agents

In Malaysia, Buckley (1938) had isolated the schistosome cercariae causing dermatitis from *Indoplanorbis exustus* snails and identified them as being from the species *S. spindale*. It has not been found in other molluscs in Malaysia (Palmieri *et al*, 1977). In South Africa, *S. spindale* has been found infecting the snails *Indoplanorbis pfeifferi* and *Isidora tropica* (Porter,1926). It has also been isolated from *Lymnaea acuminata*, *L. luteola* and *Bulinus tropicus* in India and Africa (Yamaguti, 1971).

The host snail for the other schistosome species (*T. brevis*) that also causes cercarial dermatitis in man in Malaysia is *Lymnaea rubiginosa* (*L. crosseana*) (Sandosham, 1954; Sandosham and Lie, 1969). In Indonesia, the snail host is *L. javanica* (Margono, 1968).

1.6.5 Habitats associated with hosts of *S. spindale*

Of the six known schistosome species in Malaysia, *S. spindale* and *T. brevis* have strong ricefield association while the other species are mainly related to irrigation canals, drains and pristine jungle habitats. However, throughout Southeast Asia and also in Malaysia, *S. spindale* can be found in all fresh water habitats, with either stagnant or slow running water (Lai & Yong, 1986).

1.6.6 Working habits of humans infected with cercarial dermatitis in Malaysia

As the local name suggests, "sawah-itch" in Malaysia is found mainly among rural workers who toil among the ricefields of the nation, with the water buffalo being directly responsible for the continuous infection of *Indoplanorbis exustus* snails in the endemic localities. The water buffalo is used extensively in the cultivation of the paddy fields. No cases of marine cercarial dermatitis has been reported in Malaysia thus far.

1.6.7 Seasonal dynamics of infection

Not many detailed studies have been reported on the seasonal dynamics of infection of animals by schistosomes. Fairley and Jasudasan (1930a) had reported that for *S. spindale* infection in India, the infection rate in the mollusc

hosts was highest during the cooler months from November to March and lowest during the monsoon period from June to Septemper.

In *S. incognitum*, the infection rate in *Radix rubignosa* fluctuated according to seasons and habitats, but was lower when compared with other pulmonate species such as *Indoplanorbis exustus* (Bunnag *et al*, 1983). Ambu (unpulished data) has found that the highest transmisson was observed during the dry season for *Schistosoma malayensis*. Soparker (1921) noted that the incidence of infection for *S. spindale* was highest during the autumn months while the lowest incidence was seen during late winter and early spring season.

1.6.8 Clinical manifestations of cercarial dermatitis in Malaysia

In cercrarial dermatitis caused by *S. spindale*, Buckely (1938) and Sandosham and Lie (1969) reported that infected rice field workers feel a severe itching in the ankles and legs, and on the back of both hands as soon as they enter into the ricefields. The irritation continued into the following day, resulting in scratching of the infected skin. A scratch dermatitis is produced, which becomes secondarily infected and shows lesions indistinguishable from those seen as a result of scratching and sepsis following severe skin irritations of any form.

When Sandosham and Lie (1969) repeated the experimental work of Margono (1968) on the human skin with *T. brevis* cercariae, they reported that within 45 minutes, small moderately itchy papules appeared after infective cercariae were placed on the skin. Each papule produced a narrow hyperaemic zone while the reddish spots disappeared two hours later. However the small papules were moderately itchy and disappeared in 48 hours.

1.7 BIOLOGY OF SCHISTOSOMES IN RELATION TO THE EPIDEMIOLOGY OF CERCARIAL DERMATITIS

The life cycle of schistosomes infecting humans is very well known (Hyman, 1951; Belding, 1965). Among the various aspects of the life cycle which have a direct bearing on the epidemiology of cercarial dermatitis are shedding periodicity and cercariae penetration of human hosts.

1.7.1 General life cycle of *S. spindale*

The body structure and life history of the *S. spindale* adult has been well described by Porter (1926) while the body structure of the cercaria of *S. spindale* has been thoroughly described by Soparkar (1921). The structure of the Malaysian strain *S. spindale* has been redescribed by Krisnasamy *et al.* (1991). Experimental studies on its life cycle were also carried out in buffalos and goats (Liston and Soparkar, 1918; Fairley and Jasudasan,1927).

The *S. spindale* adults live in the caval blood of its definitive host (cattle, water bufflo, goat, and others) and produce eggs which are elongate, measuring in length from 163μ to 258μ (Porter, 1926). The eggs leave the hosts with the faeces, and hatch in the external environment. Hatching of the egg is explosive, and produces miracidia which looks for and penetrate the snail intermediate hosts. In the snail hosts, the larval stages are sporocysts, each containing three to five cercariae in different stages of development at one time. The bifid-tailed cercariae are active, surface-frequenting swimmers. The cercariae emerge from the intermediate host, directly penetrate the final host and develop into adult flukes (Montgomery, 1906).

1.7.2 Cercariae emergence and behaviour

The results of the research that has been conducted on the emergence of schistosomatiod cercariae from intermediate hosts and their subsequent behaviour reveal no overall pattern for many schistosomes. Smyth (1966) has given a detailed account on the emergence of cercariae from their molluscan hosts. Many physico-chemical factors in the environment affect the release of cercariae from their hosts, including temperature, light, humidity, oxygen and pH.

S. mansoni shed cercariae under direct sunlight (or day light), but like *S. bovis*, cercariae emerge regularly at all hours of the day and night. However, they are more influenced by day light than by diffused light. In *S. doutthai*, shedding takes place only in the evening or at night. Margono (1968) reported that most *T. brevis* cercariae emerged regardless of time of day. Transfering them from one container to another container with water may change the environment so as to initiate of the shedding the cercaria.

Greer and Ow-yang (1985) reported that the cercariae of the Malaysian schistosome *S. malayensis* are shed from snails most abundantly during late afternoon and early evening. The cercarial emergence was greater 9-12 hours after the light phase began. This behaviour is similar to that of the *S. japonicum* Philippine strain (Nojima *et al.*, 1980).

According to the review by Shekhar & Pathmanathan (1987), the pattern of emergence of schistosome cercariae varies from species to species. Cercarial shedding in the early hours of the day is an occupational hazard to the farmers who work in cercariae-infested waters. Shostak and Esch (1990) suggested that each snail exhibited a characteristic pattern of cercarial emergence.

Superimposed on the pattern of periodic emergence is variation in the numbers of cercariae emerging daily. Most investigators agree that light is more

important than temperature in stimulating cercarial release (McClelland, 1965; Asch 1972). Asch (1972) further suggested that studies of snail physiology and the biochemical interrelationships between developing cercariae and their snail host may ultimately reveal a rhythm to cercarial emergence.

According to Sandosham (1953), *S. spindale* cercariae are phototactic and negatively geotactic, surfacing towards the bright side of the room. They hang head down wards with the tail stem in line with the body, with the furcae spread apart. They swim actively for the most part with the tail forward. The cercariae become inactive after 24 hours.

1.7.3 Cercarial penetration into the final host

After emergence, the cercaria swims about vigorously for some time and then comes to rest at the bottom or attached to the under side of the surface of the water. Entry into the definitive host is an active process for the cercaria.

A susceptible mammal, which comes in contact with 'infected water' (e g., water containing viable cercariae) is liable to infection (Faust, 1949).The cercaria is basically a juvenile trematode with a tail.The digestive system is rudimentary with mouth situated subterminally in the middle of a powerful oral sucker, and with an eosophagus and a pair of short intestinal caecae. The nervous system

consists of a diffuse, spool-shaped mass of fibres behind the oral sucker (Smyth, 1966).

Penetration occur on the skin of the host in a manner similar to that utilized by the miracidium. In securing entry into the host the cercariae uses the discharge of lytic chemical substances from the head end of the cercaria. This helps to digest the surface of the skin to allow penetration into the host tissue. As soon as the cercariae enters the host it discards its tail (Faust, 1949).

The cercariae of a schistosome undergoes a number of physiological changes during penetration into the final host resulting in its rapid transformation into a schistosomulum. The changes that take place consist of (1) release of the tail, (2) rapid and almost complete secretion of the contents of the penetration glands, (3) a change in the antigenic nature of the surface, and (4) development of sensitivity to water so that the schistosomulum is unable to tolerate a return to water (Stirewalt, 1966).

The penetration of the epidermis suggests that the cercaria initially attaches itself by its central sucker and destroys the tissues at the point of entry by use of digestive enzymes discharged from the anterior end of the body. Gordon and Griffiths (1951) and Standen (1953), showed that the cercaria uses lashing movements of its tail to assist in penetration. According to Fairley *et al.* (1930),

the cercaria can penetrate unbroken skin without resort to entry by way of the hair follicles. They observed penetration by way of the hair follicles by *Schistosome spindale* in guinea pigs. Direct entry was also observed by many others, including Fujinami and Nakamura (1909), Miyagawa (1912), Leiper (1915, 1916, 1918), Lutz (1919), Vogel (1932), Koppisch (1937), Pinto and De Almeida (1945), Gorden and Griffiths (1951), and Standen (1953).

1.8 CONTROL OF CERCARIAL DERMATITIS

Control of schistosomiasis is usually carried out using an integrated approach, combining chemotherapeutic treatment of the definitive hosts with environmental control, chemical control and biological control.The control of cercarial dermatitis should theoretically follow the same approach, with the exception that chemothrapeutic treatment is not applicable to the infected human hosts, where non-human schistosomes are involved.

Chemotherapeutic treatment is defined as the use of a drug to treat adult infections in human or in reservoir definitive hosts. In the control of cercarial dermatitis, this therapy can be applied, where possible, to the hosts which are the source of the dermatitis-causing cercariae (e.g. the goat, cattle or buffalo in *S. spindale* infection).

Environmental control can take many forms, including measures taken to reduce human-water contact, and modification of snail habitats to reduce snail populations. Blas (1976) reported that seepage control is a good method to use along the margins of streams, foot-hills, pools, and even swamps and marshes for snail control. It is at such places that the intermediate hosts find favorable conditions for breeding. Seepage is eliminated wherever possible to completely eradicate the snails.

Chemical control is applied by the use of molluscicides to destroy the implicated snail hosts. Chemicals used include copper carbonate or copper sulphate, particularly along the shallow waters where the snails most frequently breed. Faust (1949), Piekarski (1962) and Soulsby (1968) suggested that snails can be controlled efffectively with molluscides such as Bayers SR73, pentachlorophenol and copper sulphate.

For biological control of snails, the use of several competitors, predators and pathogens has been recommended. These include various carnivorous leeches, certain crustaceans (crabs, crayfishes, ostracods), aquatic coleoptera, fishes (*Gambusia* spp., *Lebistes* spp. and *Tilapia* spp.), amphibians (certain species of salamanders), birds (ducks), and mammals (water rats) which feed on the snails (Malek, 1980).