Diseases Evolution in a Changing Environment

Water Borne Infection Diseases in the Chao Praya River Basin, Thailand

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Foreword

The frame of the so called Water Related Diseases (WRD) do not bear a unique medical, nor epidemiological or semiological assumption, the terms are referring to a more public health oriented concept directly related to the environment. WRD encompass all diseases from accidental, chronic to transmissible, which have any major physical relation to the water at any stage of the disease. As an example WRD can be different as psychological disturbance like potomania (over drinking water), an infectious disease as yellow fever (the immature stage of the vector cannot survive out of the water) or arsenic poisoning by drinking water. In fact, WRD can be split in different kind of disease: water borne, water transmitted …

In the present study we will consider only transmissible diseases and among them the one of importance in public health for Thailand and/or among the former, the one they are a model for the understanding and preventing a particular type of transmission. Transmissible water borne disease is therefore characterized by a pathogen, a vulnerable human population, and water that make possible disease or transmission (directly, or by a vector).

Chapter 1

Introduction

Among water and beside ocean, fresh water including precipitation, lakes and rivers are globally unevenly distributed between the region and human populations. Precipitations are depending on climate and latitude, rivers and their basins have a great variability in size and flow. As for the rivers, the average run-off of the water by human population correspond to the availability of drinking water, in Asia beside having the world greatest river flow, availability of water per capita appears as the lowest. Humans are currently using 6 500 cubic kilometers, which is the half of the accessible of the world river flow (9000 cubic km) and captured river flow by dam and reservoirs (another 3500 cubic km), the remaining half of water availability contribute to the ecosystem, fisheries, recreational, hydropower and navigation (WHO, 2003, Guidelines for drinking water quality).

From that preliminary point of view and regarding to health, water accessibility for human appears quantitatively acceptable but unequally distributed with a quality largely depending on the region of the World and human development.

Human health is affected by rivers flow, rainfall, water accessibility, and drinking water quality availability. WBD, as any other diseases, can be either of communicable or environmental origin, all types of water available modulate them or the use and interaction peoples have with.

WRD can be designed also as chronic diseases as for an example, potomania, and the neurotic habit to drink excessive volume of water (psychiatric) or a body water volemia disturbance associated to an hormonal deficiency (hypovolemia). WRD can also be of occupational or recreational origin (drowning, accidental hydrocution). Finally WRD can be characterized as communicable disease (infectious diseases) when a pathogenic agent, associated to some extend to the water, is involved and responsible of a diseases. These later definition will be named as Water Borne Diseases of Infectious origin or Water Borne Infectious Diseases (WBID).

In the present study we decided to focus on the most public health relevant WBID and among them to develop several ones as a model presenting the importance of water in their epidemiology and the risk associated with environmental changes connected with water.

1.1. Water Borne Infectious Diseases (WBID)

Water, in terms of Health as to be considered from two aspects: as a fluid with its physical and biological characteristics, and by the size, the volume determined by the container (natural, artificial). Also water quality by its physical and biological characteristics (water chemistry, container and size) play a central role in the pattern of WBID and directly interact with the pathogens, the hosts, the vectors and the disease transmission.

Disease can be directly associated with water either because the pathogen can multiply or survive in the water, or water harbor the vectors of the pathogens and for the former at any state of their development.

1.1.1. A definition of a concept

One can distinguish three main types of WBID: 1/ the vector transmitted diseases with a tight relation between the vector and the water, 2/ the disease with a complex cycle involving an aquatic intermediate host and, 3/ the diseases directly transmitted by drinking water containing an infectious state of the parasite.

WBD of infectious (WBID) or communicable origin will be analyzed regarding their origin, extension and present risk in Thailand within the limit of the Chao Praya River Basin. Moreover the risk will be evaluated regarding bordering geographical entities as other river basin (i.e. : Mekong) or administrative partition (i.e : national regions or neighboring countries).

1.1.2. General epidemiology of the diseases and, hosts and vectors ecology

Like other infectious diseases one can distinguish four main players, an environment modulated by external factors, the natural cycle of the parasite sensu lato and, the human or, more extensively the host, vulnerability:

- **A host**: Human and domestic animals are carrier of pathogens; wildlife can also suffer of WBID as it is for domestic animals;
- **A pathogen**: Germs associated with water can be of all origin including virus, bacteria, and parasites;
- **A vector**: Some infectious diseases are directly transmitted from host to host (tuberculosis) or by non-biological means (water transmitted poliovirus). Other are vector transmitted disease were a vector is active and replicate and transmit the pathogen: as for example arthropods and micromammals (rodents). Also a vector can depend on the water availability and quality to survive or be spread.

As examples: mosquitoes, which are vectors of several pathogen have a larvae and nymph phase of development which need water collection to develop; ticks also can transmit diseases and are very sensitive to humidity and when flooding appear they will move to another area and the epidemiological pattern will change. Also Ph and salinity of the water are selective for mosquito's species and also for parasite with aquatic cycle. Variations of such component will have a tremendous effect on vector population and disease transmission.

The environment will also intervene in the transmission cycle and spread of the disease: river, lakes, ponds, climate, forest, and elevation, land use, etc. Infrastructure and socio-economical factors need to be taken into account for the understanding of WBID dynamics: irrigation, water supplies, and agricultural practices.

- **A transmission cycle**: Transmission cycle refer to the cycle of transmission of the pathogen which can be associated to a host and/or a vector depending on water for his survival and/or which can survive in the water. Therefore the transmission cycle can at least involves a host, a vector and a pathogen and in case of WBID, environmental condition of the water and the relationship of vertebrate host in its environment.

1.2. Changing pattern of Water Borne Infectious Diseases & Environmental dynamics relationships

As mentioned before two main water characteristics as to be taken into account: water quality, water container at large.

Changes in the water quality (chemistry, turbidity) can have a major impact mostly on the vector when he needs to develop in the water (i.e.: mosquitoes vectors of malaria or dengue fever) and/or on the pathogen depending of its ability to survive on specifics of the water as mainly pH or salinity (i.e.: vibrio cholerae).

Also, variation of the water collections in term of content play a role in concentrating or diluting the players (vector and pathogens) favoring or not the transmission between hosts of the same specie (natural cycle) or infecting a new host (primates). These variations have to be considered as of natural (lake, ponds) or artificial (containers, dam, irrigation) origins.

In term of environment, physical component of the soil, climate will naturally influence the water table level. However the water quality will also partially dependent on the content (salinity of the soil) but also on several anthropic practices (i.e.: agriculture and pesticides, intense farming).

Moreover, water will be also modified by modes of delivering drinking and irrigating water using all types and kind of water pipes and water supplies.

Altogether, we have to consider a complex interaction between the cycle of the pathogen including the germ, the vector and/or host's life cycles and, the water cycle and management (Figure). Moreover, humans interact at different level changing the environment, controlling the diseases and finally, exposing themselves to the risk of pathogen transmission.

1.3. A Global concern

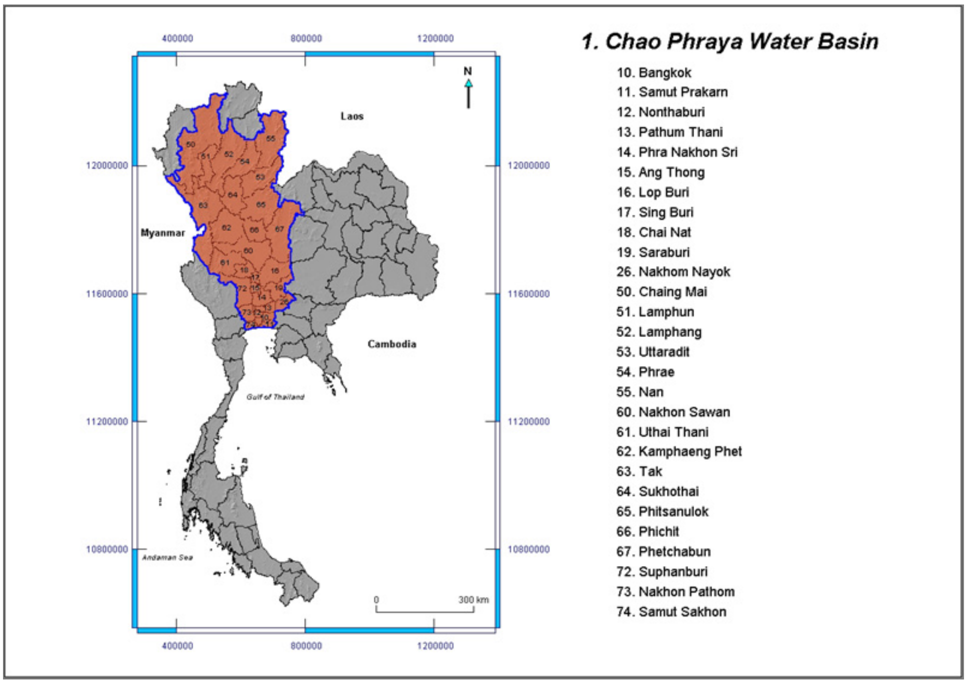
Two water related dramatic situations having clear effects on health status can be at first distinguished: the lack of water (availability of water supply, drought) and, the excess of water (flooding, rainfall). Both have immediate (water sanitation, drowning) and, indirect (nutrition linked to the lack of agricultural resources) impacts on health. However beside the direct link with the water, often climate variations are at the origin of excess both lack of water and also for both cases, WBID are at risk of spread or emergence.

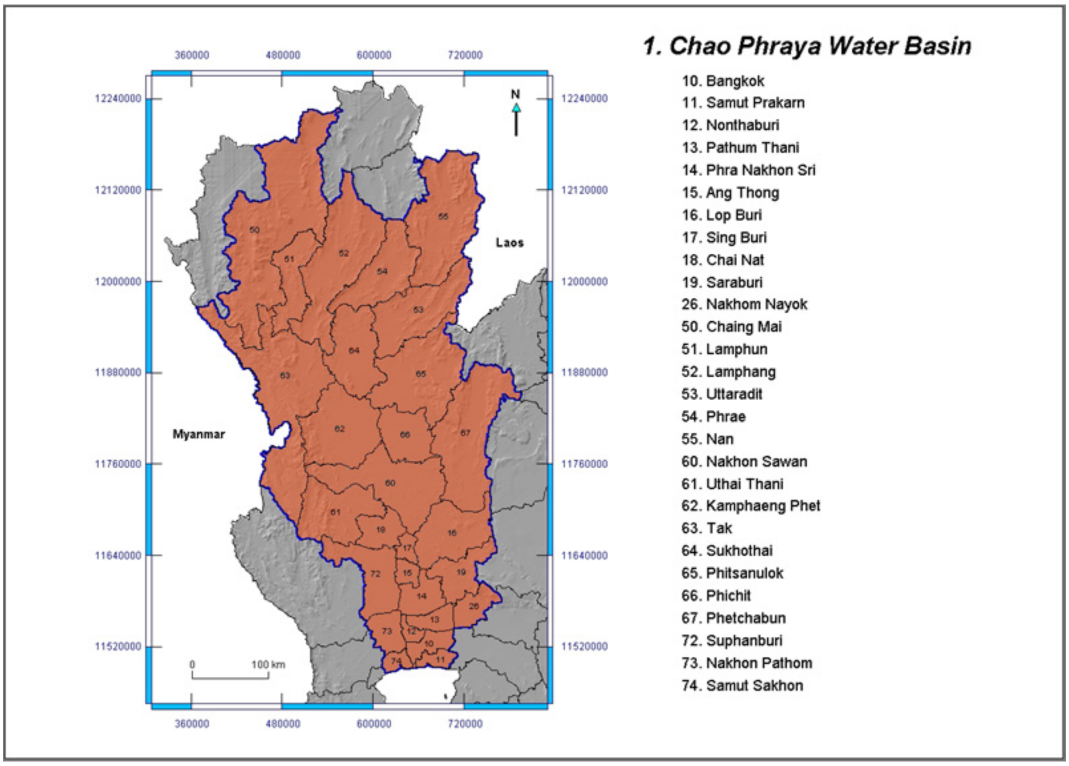
Drought and flooding have bee plaguing for centuries continental desertic or sub-desertic area and, coastal area. The inter-tropical zone, under the influence of monsoon, have often experienced flooding and excessive drought, both followed by infectious diseases often of enteric origin cause by contaminated drinking water. And this goes to water availability and access, also dependent on multiple factors as climate and rainfall but also politics of water delivery.

Chapter 2

Geographical environment in Chao Phraya river basin, WBID related

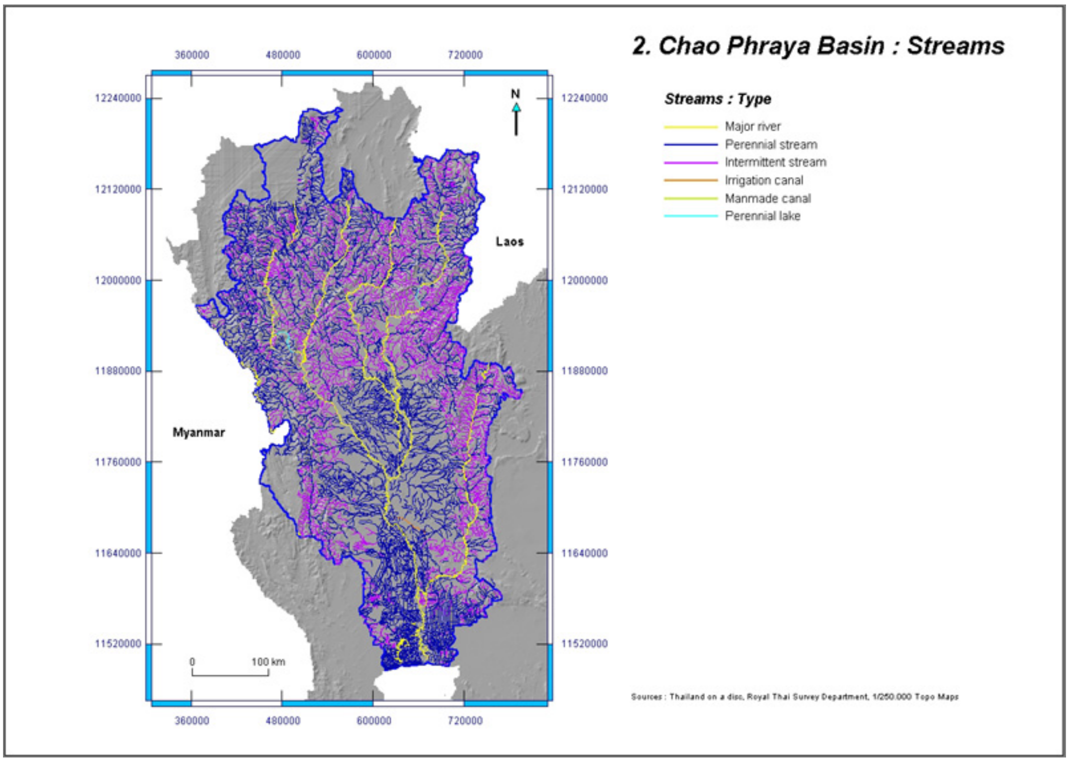
2.1. Situation





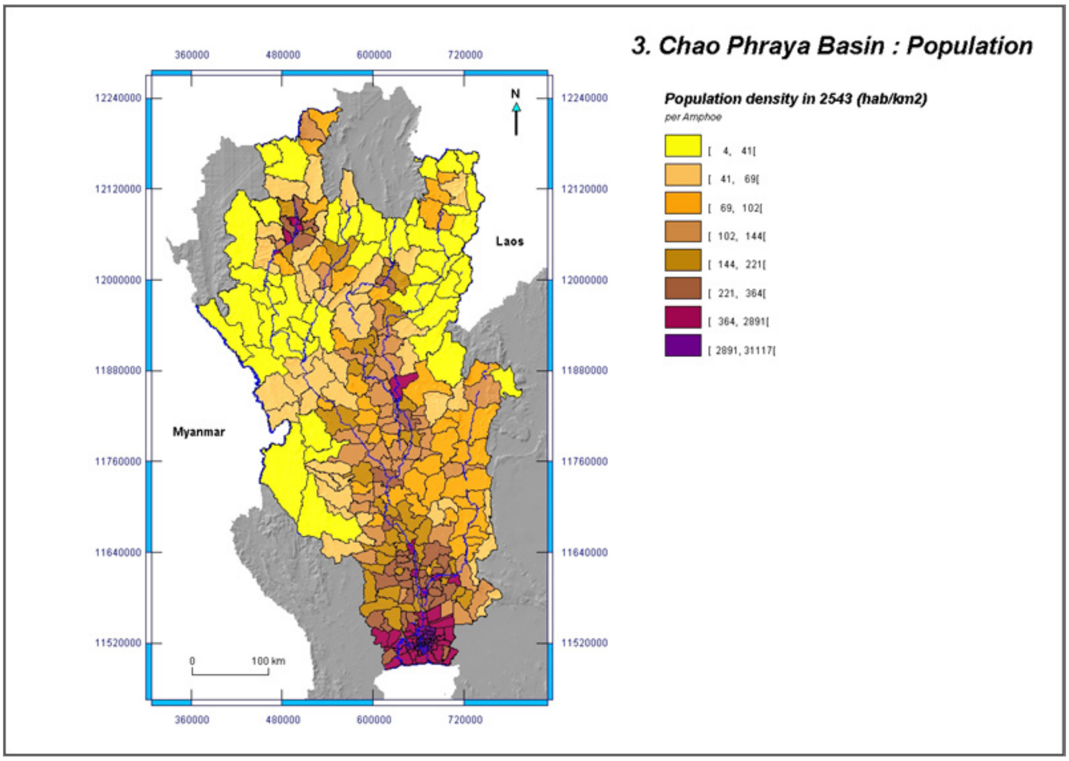
Provinces of Thailand in the Chao Phraya river Basin

2.2. Streams

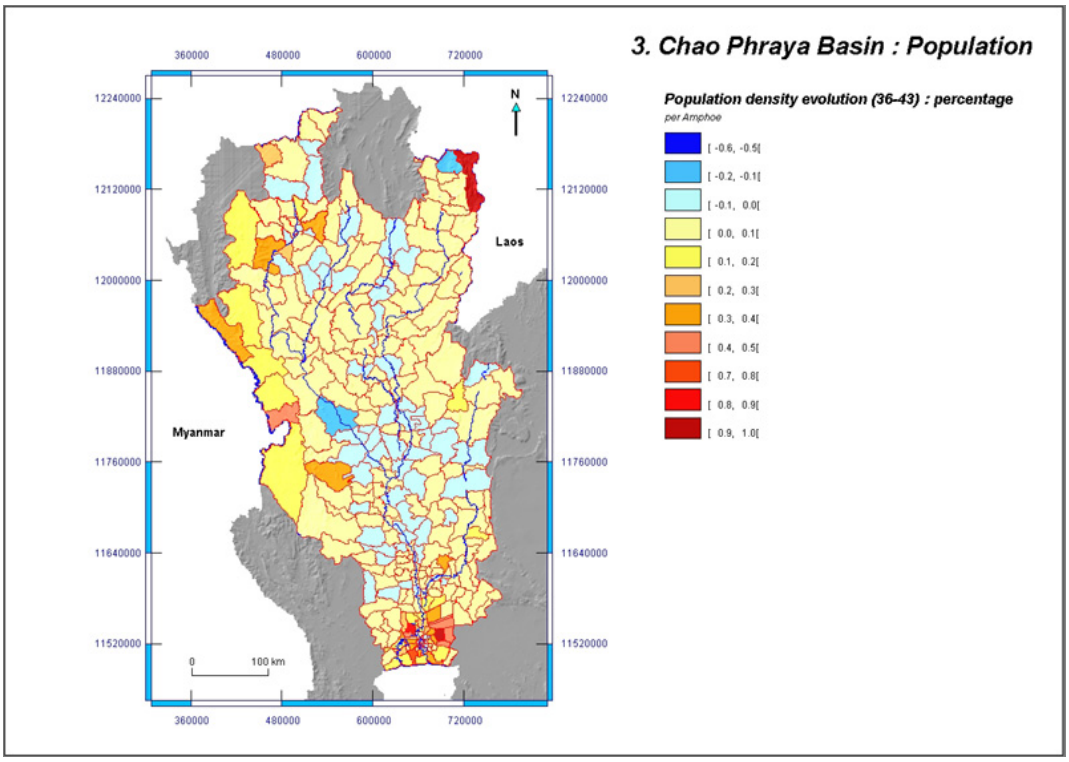


The stream network in the Chao Phraya river Basin

2.3. Population

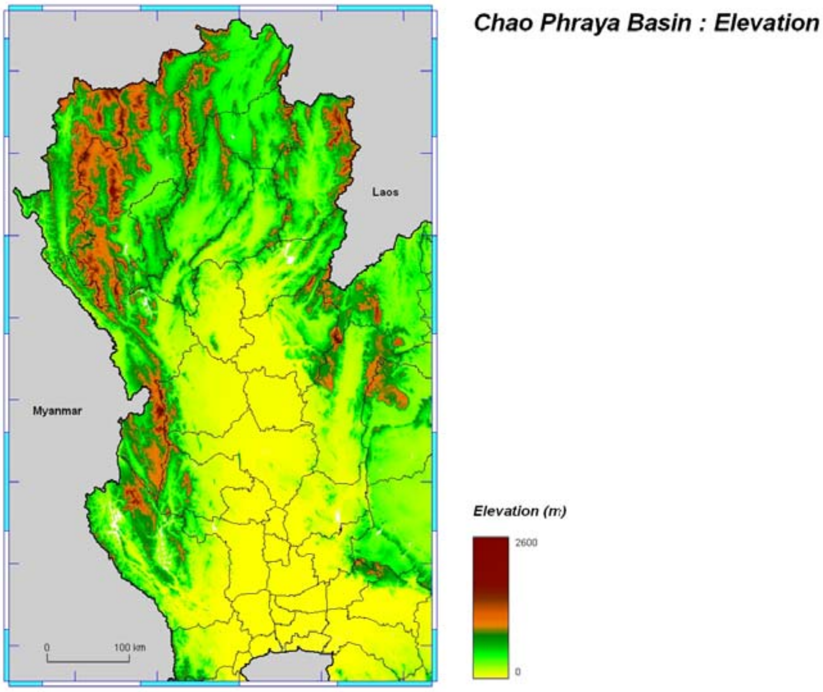


Population density, 2000

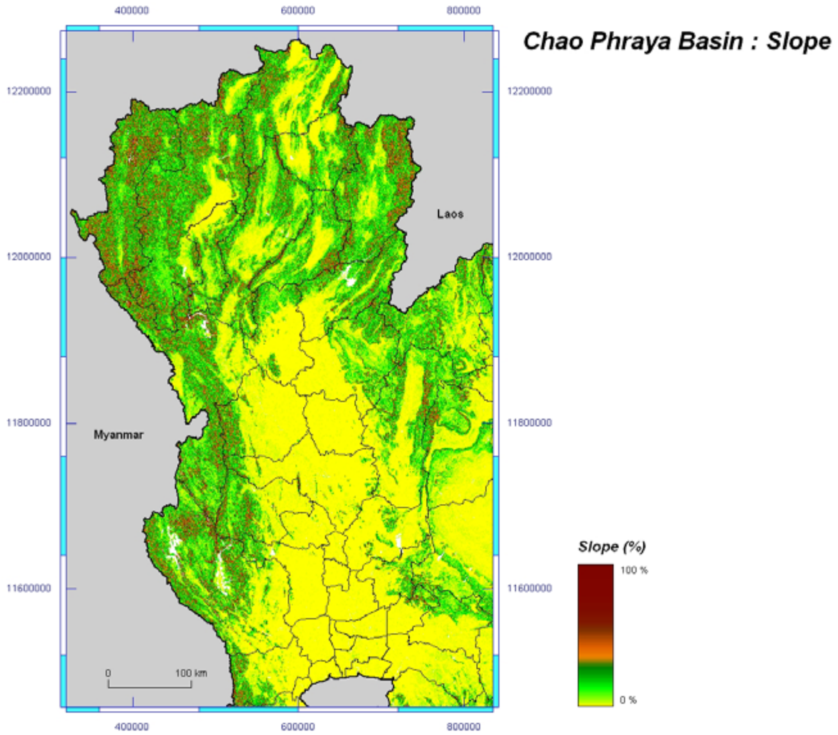


Population density evolution, 1993-2000

2.4. Elevation and Slope

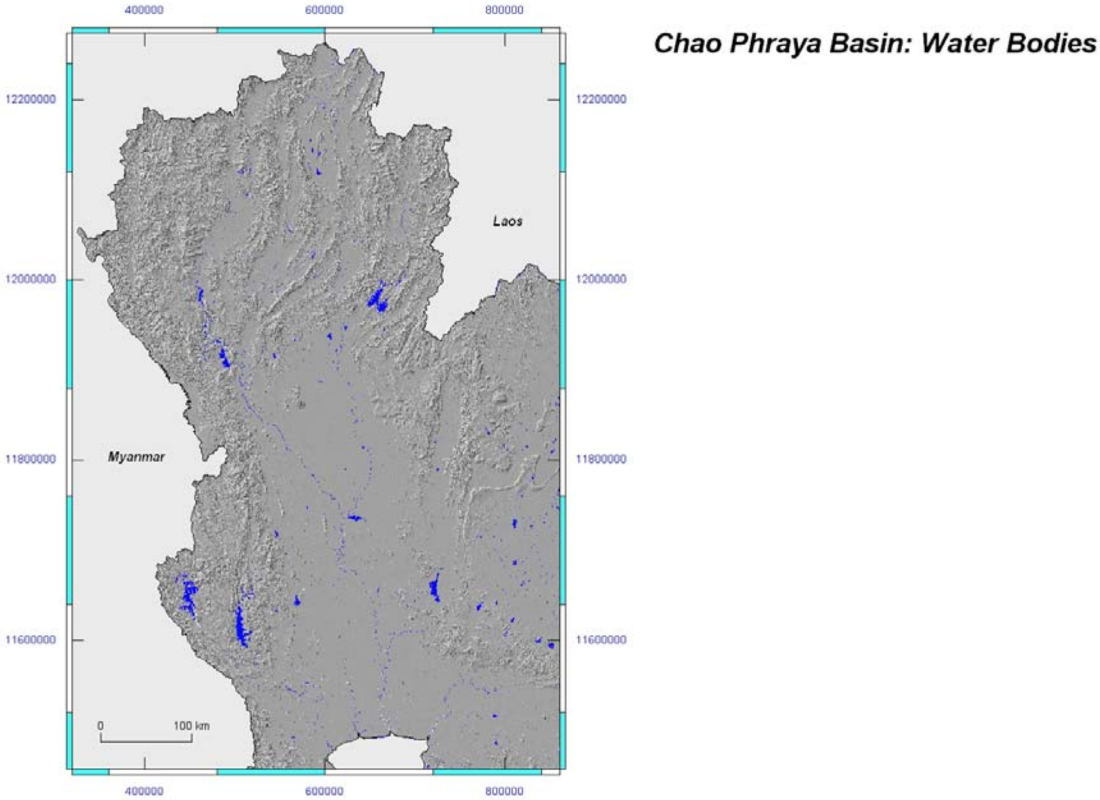


Elevation in the Chao Phraya river Basin (from SRTM-3 data set, USGS)

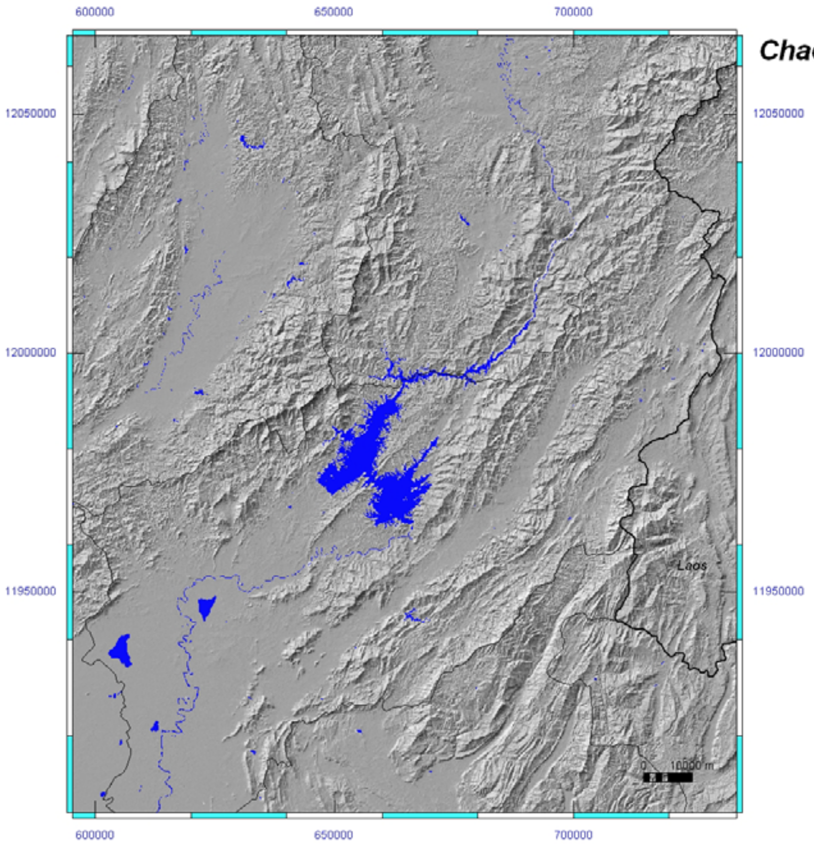


Slope in the Chao Phraya river Basin

2.5. Water bodies



Water bodies in the Chao Phraya water basin (source: Landsat V, Royal Forest Dept.)

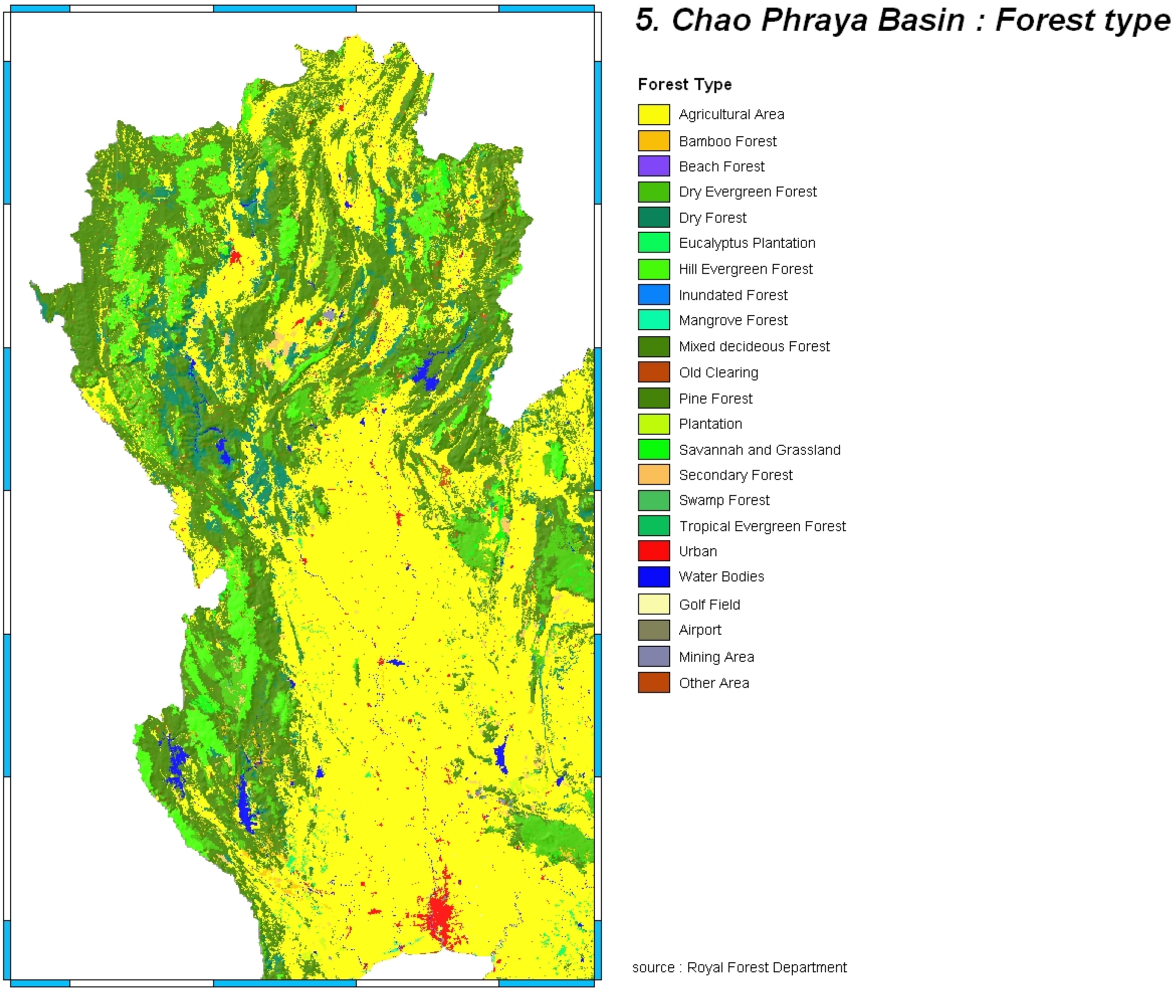


Chao Phraya Basin: Water Bodies

North-east provinces (Phrae)

Sirikit Reservoir

2.6. Forest cover



Forest cover, from Landsat TM image classification

Chapter 3

Vector transmitted water borne infectious diseases: some major or emerging threats

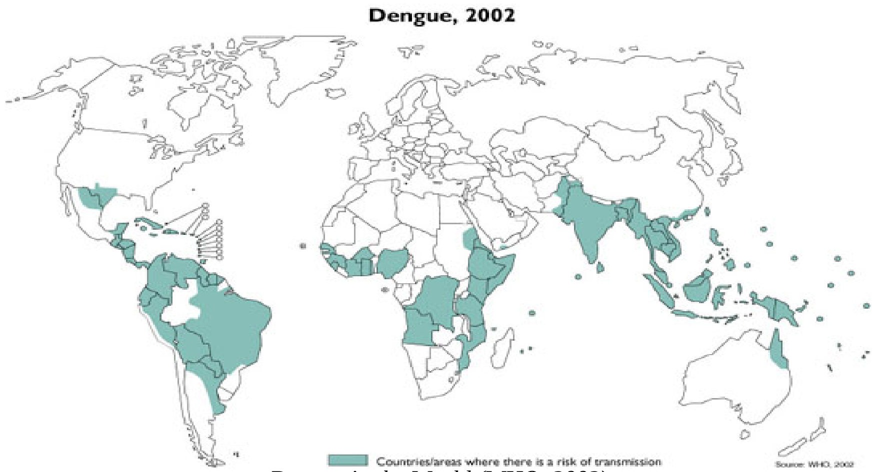
In order to describe within the frame of WBID we have decide to present three entities, which are supposed to be a major models of WBID in Thailand including their public health importance, their cycle of transmission modulated by environmental factors.

Vector-borne diseases are until now, among the most important health problems. Beside vector control, therapeutic and prevention, they still represent a major and constant risk to a large part of the World's population.

The pathogen, a parasite *sensu lato,* is relaying on a complex natural cycle involving a vector and sometime a reservoir in order to survive in nature. Vectors can be arthropods (mosquitoes, ticks) and also vertebrates (rodents or bats). Reservoirs are often a vertebrate which can be infected by the pathogen but develop a mild or unapparent disease and can transmit the germ to another vector. Reservoirs or secondary hosts act also as amplifier of the pathogen by infecting more than one vector and moving into other area free of the disease.

3.1. Dengue Fever

Dengue Fever is a mosquito-borne infection which has become world-wide a major international public health concern. Dengue is found in tropical and sub-tropical regions and predominantly in urban and semi-urban areas. Dengue haemorrhagic fever (DHF) is a potentially lethal complication, which was first recognized in the 1950s during the dengue epidemics in the Philippines and Thailand. Today DHF affects most Asian countries and has become a leading cause of hospitalisation and death among children. There are four distinct closely related, viruses that cause dengue. After been infected by one it provides lifelong immunity against that serotype and confers only a partial but transient protection against subsequent infection by the other virus serotypes.



Dengue in the World (WHO, 2002)

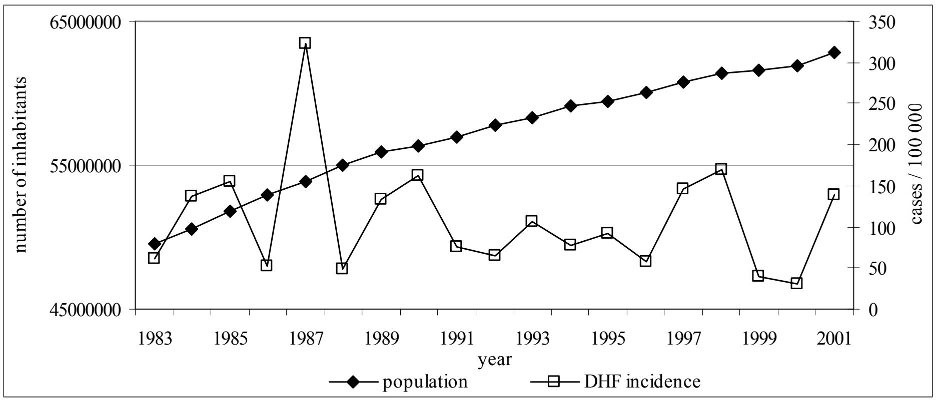
3.1.1. The disease

The dengue is due to an arbovirus transmitted by mosquito vectors, Aedes aegypti and Aedes Albopictus. The dengue virus belongs to the flaviviriidae family, comprising also the Yellow fever and Japanese encephalitis viruses. Dengue virus presents 4 forms (4 serotypes): D1, D2, D3 and D4. An infection by one of the four serotypes induces in the host a specific and permanent immune protection for this serotype, but no long term crossed protection towards the other serotypes. A mother transfers a temporary (less than 6 months) protection to her new born child. Aedes aegypti is an anthropophilic species, as females bite human and lay their eggs in man-made containers (can, tires, jars) near houses. These breeding sites being largely dependant on rainfall to be filled, the dengue incidence exhibits generally a strong seasonal component with higher incidences observed during the rainy season.

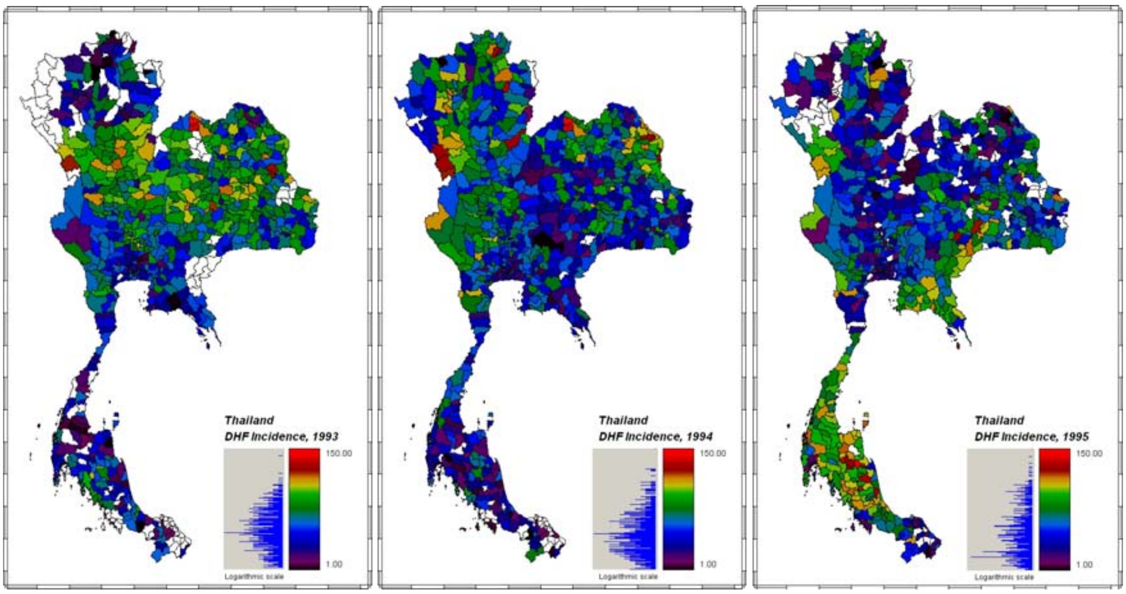
The Dengue Hemorrhagic Fever (DHF) and Dengue Shock Syndrome (DSS) are severe forms of the dengue infection likely to lead to death. They appeared during the 50's in the SEA region where the classic form of dengue was previously endemic. In Thailand, the spread of DHF was simultaneous with the increasing urbanization and important environmental changes in the country. Endemic and epidemic transmission of dengue viruses are important threats for most of the tropical countries.

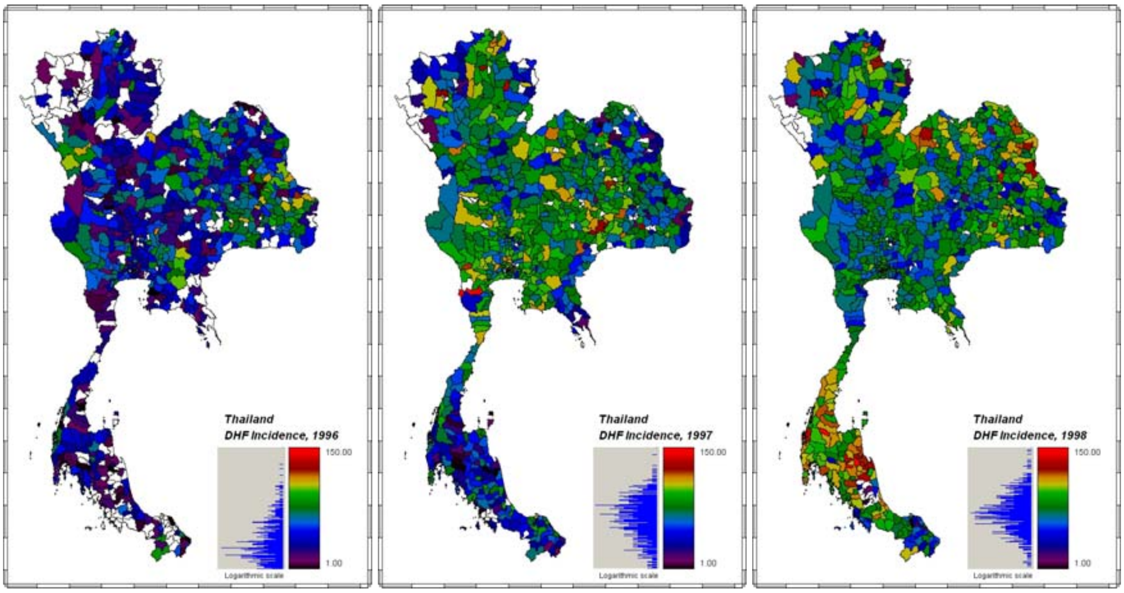
Potential distribution of Aedes Aegypti (WHO, 1998)

Geographic spread of epidemic DHF in Asia by decade, 1950-1996 (Gubler and Kuno, 1997)



Incidence of DHF and demography in Thailand. Epidemiological data: Incidence for 100 000 inhabitants, Demographic data: number of inhabitants. 1983-2001





DHF Incidence in Thailand, 1993-1998, by district, in number of cases per 10000 inhabitants (MOPH/IRD)

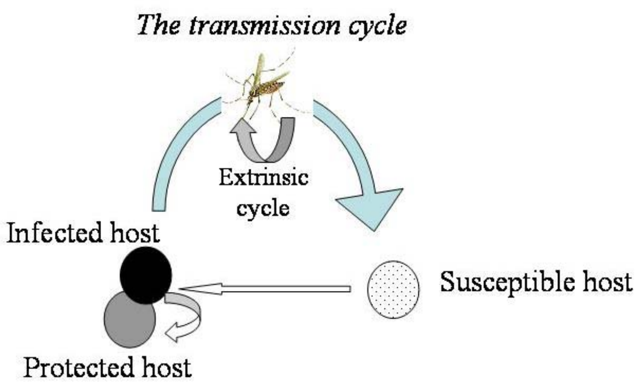
3.1.2. Control of Dengue

As no treatment against the virus infection is available, control of the disease focuses mainly on three strategies:

- The elimination of breeding sites aims to reduce the density of potential vectors. It is mainly based on community participation, people being informed by governmental organization about the risk of dengue transmission related to the presence of man-made potential breeding sites and asked to eliminate them.
- The spray of ULV pesticide is an alternative used during outbreaks to decrease the transmission.
- The future vaccine will allow protecting younger classes of population and increasing the herd immunity.

3.1.3. Transmission of dengue viruses

The urban transmission cycle of dengue viruses is of a typical arthropod borne disease pattern and rather simple as there is only one host (figure 1). The mosquito vector bites an infected man and after the extrinsic cycle (multiplication of the virus and spread to salivary glands) can transmit the virus to a susceptible host.



Transmission cycle of a dengue virus in an urban environment: the only host is human and Aedes aegypti is the main vector.

In a given area, the characteristics of the transmission dynamics are generally stable:

- The range of time for the complete transmission cycle (i.e. incubation in human, extrinsic cycle in the vector and contamination of a new host) lasts around 2 to 3 weeks.

- The life's time of *Aedes* lasts around 3 to 5 weeks, meaning that the vector population dynamics scale ranges over weeks or month.

- The host dynamics ranges over years according to demographic and socio economic changes.

Meanwhile, beside this apparent stability, in endemic areas where more than one serotype circulate, the immunological status of the population becomes quickly extremely complex, with individuals likely to be protected (immune) towards any combination of the prevailing serotypes. Moreover, local changes may occur at a shorter time scale following movement of people for work or tourism, or dengue epidemics that quickly modify the immunological status of the population.

3.1.4. Relation dengue – water.

Being transmitted by a vector with an aquatic cycle and which density is primarily dependant on the productivity of breeding sites, dengue transmission has to be strongly dependant on the quantity and dynamics of water, would it be from rainfalls or distributed by human.

3.1.4.1. Water network

Considering the most frequent type of breeding sites used by Aedes females to lay their eggs in Thailand, which are jars for the storage of water from the rain, it seems that the increase in the development of water network observed in Asia (Table 1), should lead to a reduction of the proliferation of this species. Meanwhile, studies developed in Bangkok and recent surveys in the Chao Phraya basin (Walairut Tuntaprasart, personal communication) show that a high proportion of water jars are permanently filled with water and that the seasonality of dengue incidence is not only based on the dynamics of breeding sites. Other climatic, environmental and sociological factors are also important. In many houses where tap water is available, numerous jars are still kept and in order to be filled with rainfall or tap water. The relative increase in incidence observed in rural areas of the Central Plain of Thailand, compared to urban areas, can be, in part, related to the relatively higher increase in connections to water network in that rural areas. Moreover recent observations describing Aedes aegypti larvae in septic tanks and waste waters need also to be taken in account.

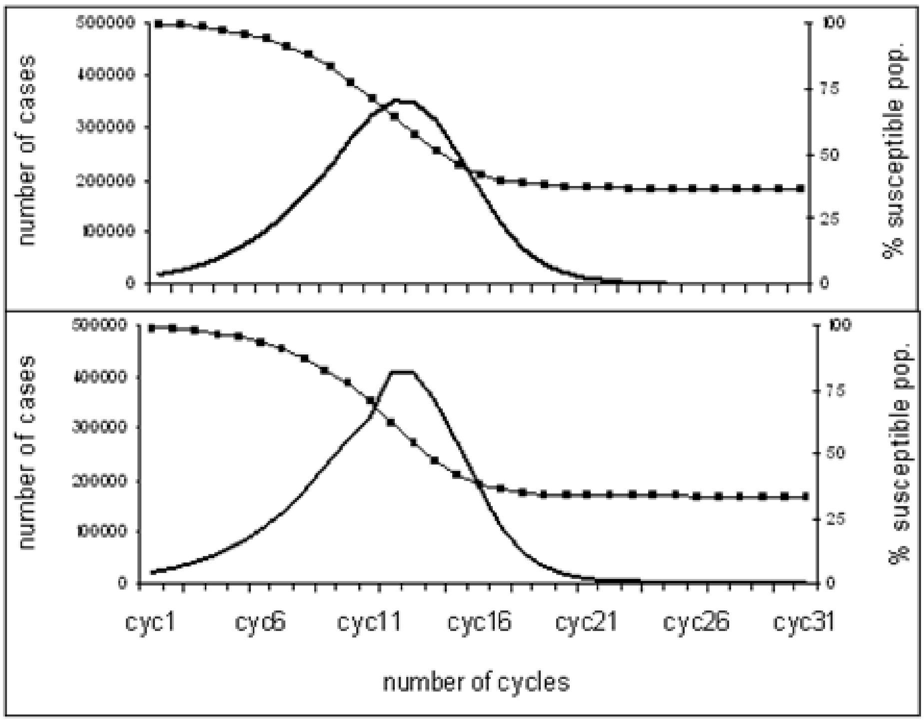
	1990 Population (millions)				2000 Population (millions)			
	Total Pop.	Pop. served	Pop. unserved	% served	Total Pop.	Pop. served	Pop. unserved	% served
Urban water supply	1029	972	57	**94**	1352	1254	98	**93**
Rural water supply	2151	1433	718	**67**	2331	1736	595	**75**
Total water supply	3180	2405	775	**76**	3683	2990	693	**81**
Urban sanitation	1029	690	339	**67**	1352	1055	297	**78**
Rural sanitation	2151	496	1655	**23**	2331	712	1619	**31**
Total sanitation	3180	1186	1994	**37**	3683	1767	1916	**48**

Table 1: Development of water supplies in Asia (data from UNICEF).

3.1.4.2. Water management

Water management such as dams or irrigation development, are likely to transform the environment but also the distribution of human settlements. Displacement of villages preceding the construction of dams, arrival of migrants attracted by the improvement in agriculture provided by irrigation programs, lead to deep modifications in the human settlement organization.

Migrants may be healthy carriers of pathogens, such as those infected by the dengue virus of which only around 10% exhibit symptoms. On another hand high number of migrants could decrease the global herd immunity of a population giving the infected mosquito statistically more chance to transmit the dengue viruses.



Impact of migrants: Simulation of the incidence and level of herd immunity in Bangkok population according to a logistic model (above) and in the same model, but with the arrival of a non immune population in the age class 15-45 years old during the cycle 10 (down).

3.1.4.3. Dispersal of dengue virus

The spread of dengue viruses is due, inside a community, to vectors (flight range less than 1 km) and healthy carriers, but among communities it is mainly dependant on human displacements.

The quantitative aspects of the modalities of the disease dispersal inside human communities are not well known, as many factors interfere, related to the vector density, the virus serotypes, the herd immunity, the structure of the urban environment and external factors, such as the climate. In a first approach, it appears that a key factor is the close contact between host and vector populations, necessary to the transmission. Arrival of migrants may lead to a closer contact, favorable to an increase in transmission. Meanwhile, as this will simultaneously induce a quick increase in the density of protective immunity among neighbors, the probability for a mosquito to transmit the virus to a non immune host will decrease rapidly, such as the incidence. A key factor, as it has been shown for other transmissible diseases, is the size of the studied unit. In small areas changes are likely to be more rapid than in large areas, which have to be considered as groups of independent small areas where changes are not necessarily simultaneous inducing a more progressive pattern in the global changes of incidence.

Spatial Entities(number)	Size scale (km2)	Population	Time scale
Country (1)	500 000	6 x 107	Year - Month
Province (76)	10 000	106	Month - week
District	1 000	105	Month - Week
Sub-district	100	104	Month – Week - Day
Village	10*	102 – 103	Week – Day

* Village size: it is more pertinent to use the size of the inhabited area than the administrative limits that include a high percentage of areas where the transmission of dengue do not occur (fields, forests…).

Scales of the spatial, demographic data (administrative units in Thailand) and scale of the time at which changes in incidence may be studied.

But the main factor in the emergence of epidemics and related to migrants is the importation of dengue serotypes for which the local population has a low immune protection. This has been frequently described in island countries, such as French Polynesia, but also in endemic areas such as Thailand. Meanwhile, a prerequisite is that the arrival zone needs to exhibit a favorable environment, roughly similar to the departure zone, mainly with the presence of vectors and a favorable climate, at least at the time the migrants arrive.

3.1.5. Conclusion

The impact of modifications in water management on Dengue transmission are mainly related to:

- Movement of population following improvement of life conditions that may import new viruses in an area with a low immune protection and change the level of herd immunity;

- Increase in the density of habitat allowing a higher contact between host and vector population;

- Development of the water distribution allowing the population to store water in containers likely to become breeding sites.

On another hand, the edification of new villages is a good opportunity to develop preventive strategies to avoid the installation of vector population likely to transmit the viruses.

References

WORLD HEALTH ORGANIZATION. Dengue haemorrhagic fever: Diagnosis, treatment, prevention and Control (second edition). WHO. 1997 (Geneva)

Tonn R.J., Sheppard P.M., Macdonald W.W., Bang Y.H. - Replicate surveys of larval habitats of Aedes aegypti in relation to Dengue haemorrhagic fever in Bangkok, Thailand. Bull. World Health Organ. 1969 ; 40 : 819-829

Kuno G. - Review of the factors modulating dengue transmission. Epidemiol Rev. 1995; 17: 321-335

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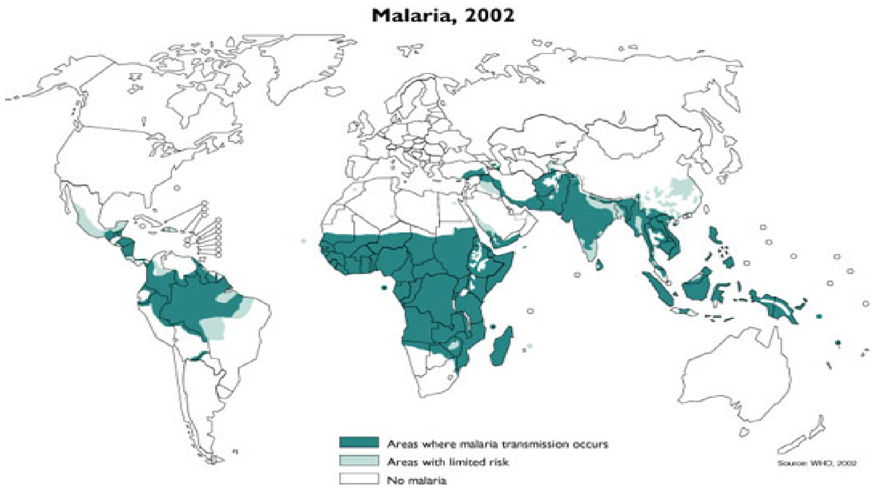
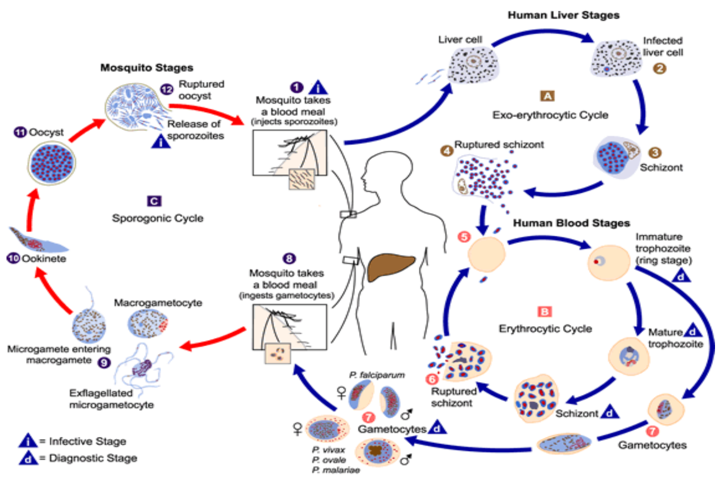
3.2. Malaria

Malaria is a mosquito-borne infection which is world-wide a major international public health concern, found in tropical and sub-tropical regions. Clinical manifestations of malaria are fever (temperature above 40° C)/intermittent fever, chills-feeling cold, shivering, sweating, headache, muscle and/or joint pains, body weakness, vomiting, splenomegaly, that may appears about 9 to 14 days after the infectious mosquito bite. Severe or complicated malaria include cerebral malaria (impaired consciousness; psychosis, convulsions and coma), severe haemolytic anaemia with Hb < 8gm/dl, acute renal failure, sepsis, pneumonia, hyperparasitaemia, hyperthermia.

3.2.1. The disease



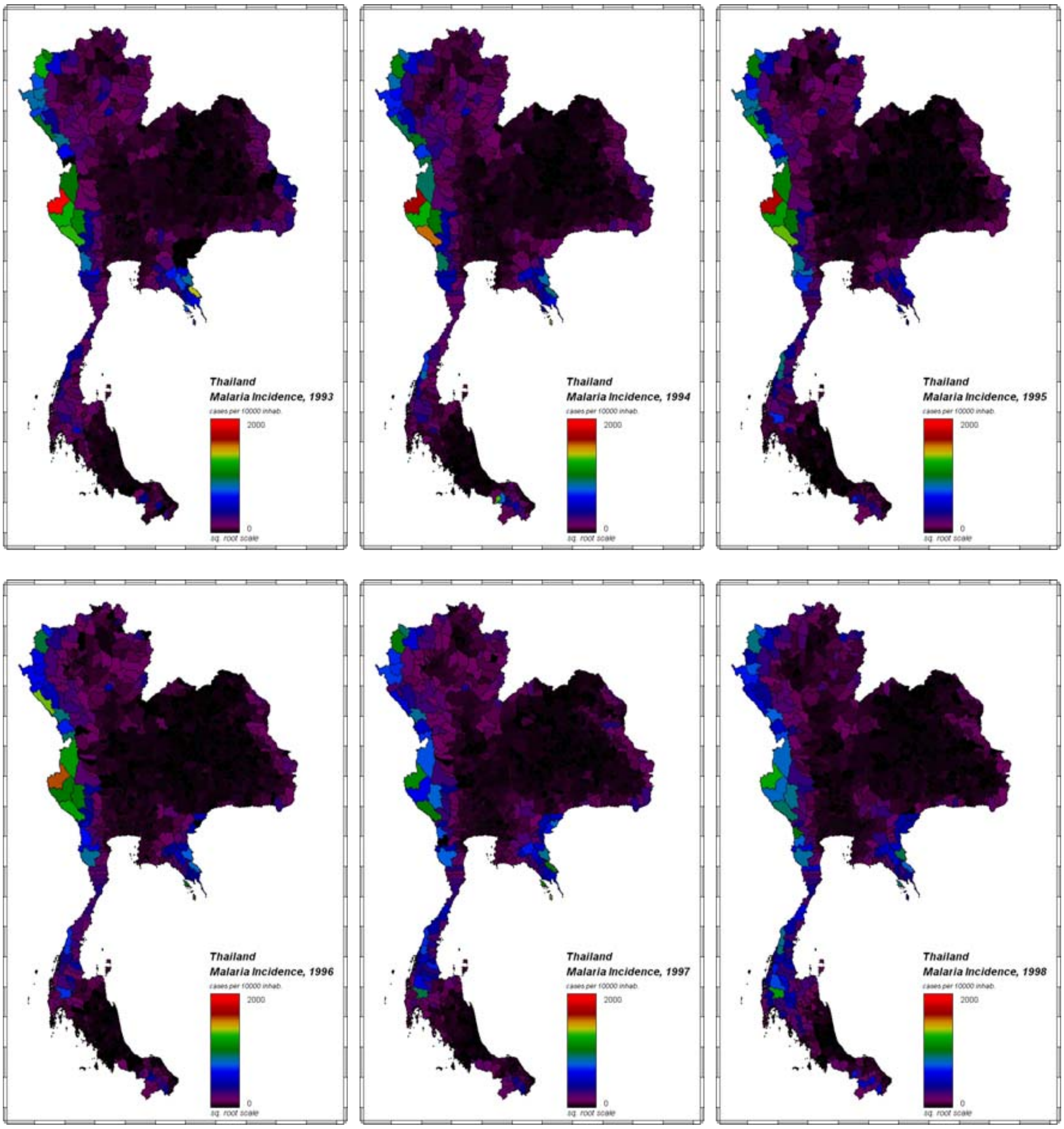
Malaria in the world (WHO 2002)



Transmission cycle for malaria infection

3.2.2. Malaria in Thailand

In 1949 malaria was the leading cause of death in Thailand with over 38,000 deaths, a rate of 201.5 per 100,000 populations. The only two control measures being available were drug distribution and mosquito protection. A WHO-UNICEF Malaria Control Demonstration Project was conducted in a northern province. During the same period the Thai Government established similar projects in other areas. The results of these projects showed that DDT residual spraying was encouraging. In 1951 the government, with US assistance, developed countrywide Malaria Control Program. By 1955 the control program was gradually extended to cover 12 million populations. Active case detection was also started in some areas. In 1963 malaria death rate showed a reduction to 22.8/100,000 populations. The first plan of operation for the Malaria Eradication Program commenced, according to WHO policy. Following difficulties of funding and technical constraints, Malaria Control Program was developed in 1971-1973 with more attention directed to the forested areas and was considered as a long term project in the Fifth Five -Year National Socio -economic development plan. In 1995 following the adoption of the Global Malaria Control Strategy and the recommendations of the external and internal review panels, the malaria control policy was revised.



Malaria incidence 1993-1998, by district, in number of cases per 10000 inhabitants (IRD/MOPH)

3.2.3. The population vulnerability

In Thailand, malaria remains a significant threat in high-transmission areas located primarily in hilly, forested regions along the Myanmar, Cambodian, and Laotian borders. All four species of human malaria occur in Kanchanaburi Province. Together, Plasmodium falciparum and P. vivax account for 95% of diagnosed cases while P. malariae and P. ovale make up the remaining 5%. Transmission occurs all year long with the majority of cases during the rainy season. Royal Thai Army troops deployed along the Thai/Myanmar border experience malaria attack rates of up to 30% in a 3-4 month deployment.

According to the World Organization of the Health for the malaria, Thailand is a C category country. The risk to contract disease is small. Only the Cambodia and Laos border areas are really dangerous. The South of the country and Bangkok are considered as healthy.

The epidemiological data has continued to show downward trend in total cases since 1989. The API was reduced from 5.7o/oo in 1989 to 2.0 o/oo in 1995. 59% of the cases are P. falciparum. 115,220 lab confirmed cases were reported in 1993 down from 168,370 in 1992. But malaria situation starts worsening since 1995. The reported cases have gone up from 82,743 in 1995 to 131,055 in 1998 and SPR has also gone up from 1.8 % to 3.1% during the same period. High malaria transmission areas were found along the international borders where more than 40,000 imported cases were reported in 1998. Majority of cases were forest-related and reported from Thai-Myanmar border and Thai-Cambodia border. Multidrug resistant foci are widely spread on the border with Myanmar and Cambodia. An. dirus, An. minimus and An. maculatus are the primary vectors of the country.

Although successive Thai governments have tried to eradicate the disease, general economic development seems to be the factor that finally rid the country of malaria. In the 1970s and 1980s, rapid economic progress led to a major increase in the urban population, especially in the major cities like Bangkok. The proliferation of air conditioning there, especially in domestic dwellings, also made life difficult for the mosquitoes. The government's concerted strategy of improving the city's sanitation, covering sewerage channels and cleaning up the stagnant pools where the mosquitoes bred helped finally put an end to the dangers of malaria. So too did a massive campaign of spraying pesticides in infested areas.

3.2.4. Problem and constraint

Multidrug resistant malaria falciparum is spreading. Resistant malaria falciparum to chloroquine and S/P resistance is wide spread, mefloquine and quinine resistance has been reported.

Importation of antimalarial drugs across international borders. Uncontrolled population migration, cross border and within country, related to sociopolitical unrest and economic activities in forest-related and endemic areas. Although vectors are susceptible to insecticides, primary vectors are exophilic.

3.2.5. The spread and dynamics of the disease

Plasmodium falciparum and Plasmodium vivax together contribute approximately 50% of malaria in Thailand. The two parasites share the same vectors (A. dirus, A. minimus). Mixed infections have been reported in less than 1% of cases. Plasmodium vivax in Thailand relapses frequently. The proportion of infections which relapse (Rv) is approximately 50% (20 - 80%). Therefore the true rate of mixed infection in Thailand is:

[0.33/ Rv] x P.falciparum % + [0.08] x P.vivax % or for Rv 0.5 to 1, and 50:50 P.f / P.v, is 22 - 37% overall and in falciparum malaria is 33-66%. Mixed infection is very common. Within host competition among related parasites is a well known phenomenon. Mutual suppression between malaria species has been recognised for over 50 years (Malaria therapy Julius Wagner Jaureg 1857-1940).

Following treatment of acute falciparum malaria in Thailand, with rapidly eliminated antimalarials, approximately 33% of patients develop vivax malaria within the following month without reexposure (Looareesuwan and all, 1987). Following treatment of acute vivax malaria in Thailand, with chloroquine, approximately 8% of patients develop falciparum malaria within the following month without reexposure (Krudsood et al 1999, Pukrittayakamee et al 2000). Vivax recurrences after acute falciparum malaria are considered to result from relapses not recrudescences, because:

1. P.falciparum and P.vivax are equally sensitive to quinine or artemisinin derivatives (Pukrittayakamee et al, 2001, Chotivanich et al, in press).
2. The therapeutic response is inversely proportional to parasitaemia at the time of treatment

3.3. Japanese Encephatilis

3.3.1. The Natural cycle: A complex epidemiology

JE is an arboviral disease (mosquito transmitted disease) affecting young children and, causing severe neurological manifestations. Wild or domestic reservoir of virus are infecting mosquitoes which secondarily infect humans; Infected viremic (virus in the blood stream) can also infect mosquitoes and create a chain of virus transmission with the human non immune community.

The Japanese Encephalitis Virus (JEV) natural cycle of maintenance presents a multiple level of a complex transmission. Several types of JEV (genotypes one to four), a variety of potential vectors (mosquitoes), hosts (mammals and birds) and, vertebrate reservoirs (swines and domestic animals) are interact one to each others and play a role which is modulated by environmental factors (spatial and temporal). Also JEV transmission pattern has change and it is evolving under the influence of changing factors in an evolving environment.

From 1970 to 1995, endemic transmission and a major epidemic, occurred in the Northern part of Thailand (Chiang Mai Province). The overall prevalence of JE showed at that time a North-South negative gradient. However, in the South (Southern Region) epidemiological, geographical and ecological information remain until now, poorly documented.

From the early 70s to date, epidemiological pattern of JE appear to have evolved. Although, the immunization campaign has clearly played an important role, viral encephalitis including JEV and DEN and other virus are still recoded. A recent evolution towards a very low incidence is observed over all provinces.

Virus. Three genotypes (Genotype I, GII and GIII) have been isolated from human, mosquitoes and pigs in Thailand.The phylogeny of PrM and E genes indicate that genotype of the strain isolated from the Northern Thailand belong to GI and that from the South belong to GII. However their regional epidemiological importance has not been yet ascertained.

Vectors. The four main potential vector species in Thailand are, like in South East Asia, Culex tritaeniorhynchus, Culex gelidus, Culex fuscocephala and Culex vishnui. These species have in common to be exophilic, exophagic, night biting and their breeding places are quiet pools. C. tritaeniorhynchus is mainly found in paddy fields and has been largely responsible for JE transmission in Thailand during the major epidemics of 1969 to the end of the 80's. C. gelidus, C. fuscocephala and C. vishnui are also frequently found in ground pools and capable of carrying the JE virus. These species are mainly biting on animals such as cattle or pigs but their trophic preferences seem to be inconstant, dependant on the relative density of available hosts. In 1974 in Chiang Mai area, were found mostly feeding on cattle (> 70%), then on pigs (10 %); ten years later, findings were different showing that 80% of the blood meals were taken on pigs and less than 20 % on cattle. In most of the studies these species are rarely biting humans (< 1%).

The biology of these species explains the seasonal pattern observed in the main epidemics in the North of Thailand from 1970 to 1990, as they are mainly dependant on the rain to fill their potential breeding sites. In Chiang Mai, the rainfall starts in March, and exhibit two peaks in May and August; mosquito density increases from April, peaks in July then decreases. JE isolations begin at the end of April and the first cases in human are observed from mid-May and incidence peaks during the rainy season. During the cold season, November to January the temperature can be very low, with minima close to 0°C in mountainous areas. The incidence is then very low inducing a strong seasonality as only 16% of the cases are reported during the 6 months with the lowest average incidence (1983-1995). Despite very low temperature observed in the Northern provinces, it does not seem that the vector species entered hibernation. Moreover, overwintering of virus is not "necessary" to maintain the prevalence of the JE virus, as the trade of pigs is often based on importation in smaller farms of piglets from centralized farms.

This pattern is also observed in the Northeast of Thailand but less marked. Meanwhile, in the Center and in the South no seasonality can be observed in the incidence, despite similar pattern in vector dynamics. Mosquito vector abundance (C. tritaeniorhynchus and C. Gelidus) in suburban Bangkok has been shown to be greatest in the monsoon season (May-October) and lowest in the dry season (January-February) with 96% of JE isolates collected from mosquitoes trapped during the monsoon season. Despite the seasonal fluctuations of mosquito vector abundance and JE seropositivity, there is however a little seasonal variation of human JE cases in the planes of central Thailand.

Meanwhile, since the last 10 years dramatic changes has been observed. A decrease of incidence is notified in the whole Thailand, mainly in the North, where it is likely to be in part due to the immunization campaigns developed since 1990. The main “historic” species C. tritaeniorhynchus, C. gelidus, C. vishnui and, C. fuscocephala, seem to have a much less large distribution and are replaced by C. quinquefasciatus. This later was rarely found during the studies performed in the North and the Center of Thailand (1970-1995) representing often less than 1% of the total mosquitoes caught and, has then been rarely tested for JE infection. In recent studies in the four regions of Thailand C. quinquefasciatus constitutes more than 90% of the females caught and several pools have been found positive for JEV (Unpublished data). C. quinquefasciatus is known as a potential vector of JEV including vertical transmission, exhibits a wide range of host preferences but with a high level of anthropohily and ornitophily and breeds in human made breeding sites (waste water). In Vietnam, where C. tritaeniorhynchus has recently disappeared, C. fatigans (= C. quinquefasciatus) is the only Culex species that has been found positive for JEV since 1978. Because of its anthropophily and its development in urban area, its role as a potential vector of JE virus needs to be addressed. Its predilection for artificial breeding sites filled by human allowing him to be less dependant on the rainfall than other species, could explain the low seasonality observed in arboviral VE and JE incidence during the last 10 years.

Hosts and reservoir. The basic epidemiologic scheme of JEV transmission during the main epidemics in Thailand includes a continuous transmission among pigs (amplifier host) and a frequent transmission to human, rarely developing the disease. The transmission to humans seems to reach around 5 to 10 % per year (as more than 70% of the population was found seropositive in Chiang Mai in 1982) during epidemic periods. Transmission among pigs is even higher and can reach 100 % per month. The role of other JEV hosts such as domestic ungulates, wild animals, birds, reptiles that are found positive in serology but harboring a low viremia when infected, seems to be insufficient for their implication in the transmission cycle. For the same reasons and also because of the vector biting preferences, transmission from human to human seems also unlikely despite the high seroprevalence in humans.

Studies on the origin of the blood meals in mosquito are based on large number of mosquito caught in the same place. The results are global and characterize the local population of vector. Meanwhile, we have seen that the host preference is mainly dependant on the density of potential hosts. Moreover the transmission to human implies that the same females having taken an infecting blood meal on an infected animal will then change their host preference and bite on a human. This phenomenon is probably rare and inferior to the 1% of blood meals recorded for humans. Again the role of C. quinquefasciatus has to be explored.

Recent changes in the epidemiology of VE in Thailand may be related to dramatic environmental changes of the country during the last 30 years: Agriculture and water management (deforestation and irrigation), and large use of pesticide in agriculture or for malaria vector control may have contributed to the control of certain rural vector species, but is not likely to have affected the urban ones such as C. quinquefasciatus. In rural areas, cows or pigs were traditionally kept during the night under elevated traditional house. The close proximity of different potential host could allow vectors to bite on animals and on human. However, because of the recent trend toward intensive agriculture leading to larger pig farms comprising several hundreds of piglets and distant from houses, this vector behavior may have changed.

More studies are needed at local scale involving the relationship between the vectors and the hosts and, at different spatial scales regarding the types of environment allowing higher incidence.

3.3.2. Population vulnerability: Current Situation of Japanese encephalitis infection in Thailand

JE is affecting children and responsible of severe neurological manifestations (25% of clinical cases) and often neuropsychiatric sequelea (half of the patients) and sometimes death.

Also, JE appears as a major childhood disease in Thailand. In Thailand 39,987 VE cases have been clinically diagnosed from 1971 to 2001 with a peak incidence in 1980. Among them 25% are likely to be due to Japanese Encephalitis (JE). Meanwhile JE reported cases might represent only a fraction of JEV human infections, given that more than 90% of individuals infected with JE may be asymptomatic. Dengue and scrub typhus representing one fifth of the etiologies of neuronal syndromes of infectious origin, The rate of confirmed JE infection in northern Thailand was estimated at more than 65% in the 1980s, as compared to lower confirmation rate (mean = 40%) in the southern and central regions, it is likely that a higher percentage of non-JE pathogens were responsible for hospitalized cases of encephalitis in these areas. The confirmation of JE for reported cases is therefore representative of a nationwide incidence and is inclusive of regional etiologic variations. Although, after ruling out bacterial or parasitic infections they do not make up a large portion of clinically reported encephalitic disease, non-arboviral pathogen do not express the same epidemiological dynamics as JE and, may account for the lack of disease seasonality observed in central and southern Thailand. Therefore, it is likely that most cases of clinically diagnosed encephalitis in Thailand with unknown etiology are of viral origin and, JE vaccination and mosquito control programs will not completely eliminate the presence of VE in Thailand.

3.3.3. The Spread and dynamics of the disease (endemic and epidemics): Japanese encephalitis Emergence history in South East Asia

JE appears as an emerging and expending viral disease for the SEA region. Viremic humans or animals, especially birds, infected mosquitoes or their eggs can be efficient mean of transportation of JEV over important distances. Moreover, JE occurs all over the Asian continent form Pakistan to Siberia including SEA and his archipelagoes. One can distinguish two main path for the extension of JE : 1/ from North East Asia to South East and toward the Indian continent and, 2/ to the South crossing the Wallace’s line and reaching the tip of Australian Cape York. The first JEV isolation in Thailand occurred in 1958 during a Dengue fever epidemic.

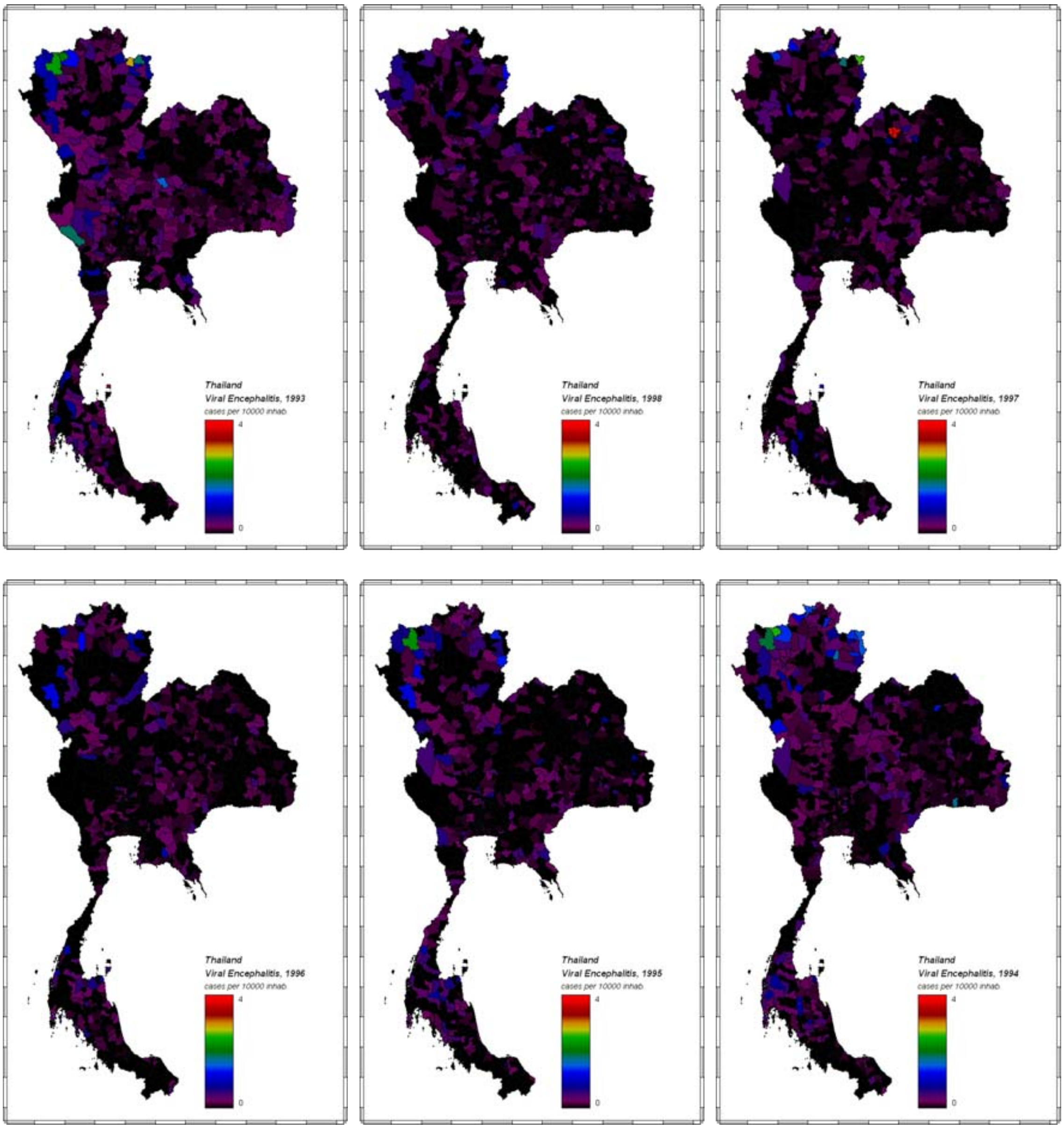
JE is one of the leading causes of VE in Asia, while in Thailand great spatial and temporal variations of JE incidence are observed. Research studies from the mid to late 1980’s have indicated that JE virus has been hyperendemic in the northern and northeastern regions of Thailand, with more than 65% of the population showing séroprevalence. In 1998, serologic testing for JE viral antibodies was done by the MOPH on reported cases of VE in Thailand among 4,643 sera tested, 25% were positive for JEV. Also, in central plain of Thailand, of 57 samples collected in 1997, 50.9% tested positive for JE and, in 1998, among 201 samples, 55.5% tested positive. Moreover, in the first half of 2001, clinical information was collected from six VE pediatric patients from Ratchaburi Hospital in central plain of Thailand two of three tested positive for a recent JE infection. Today JEV appears to be hypoendemic in the northern region of Thailand, and in contrast, relatively more present in southern Thailand, with low antibody prevalence in humans.

3.3.4. The Spatial correlation between disease extension and a water-related changing environment

Geographical Information System (GIS) studies have been used successively in similar analyses of vector borne pathogens to understand the spatial and temporal dynamics of complex disease and, to build predictive models. GIS is a powerful tool that enables environmental information to be integrated into disease occurrence analysis and some preliminary studies have been implemented using GIS as an alternative method for the analysis of VE trends and etiologic variation in Thailand. We present an analysis of environmental patterns of reported VE (clinically diagnosed) and JE (biologically confirmed) in Thailand using a GIS to investigate on temporal and spatial differences of disease incidence.

Characteristics of the Study site. Thailand is comprised of 76 provinces that are commonly divided into four geographic regions: the northern (17 provinces), northeastern (19 provinces), central (26 provinces), and southern (14 provinces). The present analysis concern the JE and VE incidence reported to the MOPH for the period of time of 1993 to 1998 and, data were kindly supplied by the MOPH and other national agencies of Thailand. The 921 district of Thailand have been taken as unit and data aggregated in consequence.

VE and JE spatial incidence. For the study period, 206 cases have been reported with a JE incidence of 0 to 53 pour 100,000 inhabitant (mean: 0.41); 777 districts did not report any JE case. Although the cumulative JE incidence for the six years show higher concentration of the cases in the northern part of Thailand and, an important dispersion is observed which suggest a random phenomenon.



Viral Encephalitis incidence1993-1998, by district, in number of cases per 10000 inhabitants (IRD/MOPH)

Agricultural ground. Agricultural statistics were available at the provincial level for the all country. Domestic pig population is spread between large pig farm (mean size of 500+-250 piglets) with a total of 7,423,10 of pigs in 1999 (more than 8M in 2001). The percentage of rice field surface regarding the total surface of the province was estimated in percentage. The spatial distribution of JE incidence did not correlate with pig or rice field, values were not conclusive regarding the limited number of JE cases and also the small provincial study scale which was probably hiding the JE phenomenon more likely acting at the district/sub-district scale. Also VE incidence did not correlate with rice (r = 0.1) neither with pig number (r = 0.04).

Physical environment. Geographic analysis of elevation and land-use can provide insight into the regional variations of VE in Thailand. The elevation has a direct consequence on the climate, the density of forest cover and any potential vector or host. Elevation correlates strongly with forested area (r = 0.8), however elevation and forest cover did not correlate consistently with VE (r = 0.4). Nevertheless, when one study the residual correlation of each analysis it shows a spatial disparity regarding elevation but an homogenous distribution regarding the forest. Conclusively the forest appears more important in term of VE virus transmission than elevation and needs to be investigated.

Climate. JE incidence has also been observed as following climate variations. In the Northern part of Thailand the rainy season along with an average temperature over 25°C favors arbovirus transmission while vector breeding sites (rice fields and open pools) are filled with rain water and the extrinsic cycle duration is relatively short due to temperature. Dry and cold season, reduce the vector population and its potential to be infected by the low average temperature: in mountainous districts, the average minimum during the night can be under 10°C. In the Central Plain and in the South of Thailand, climatic variations are less marked and, VE and JE virus transmission appear to exhibit a lesser degree of seasonality. The same geographical pattern, much more contrasted in the Northern part of the country is also demonstrated for Dengue virus transmission.

Conclusively, the use of spatial sciences for defining environmental risk indicator appears to give insight on VE and JE virus transmission even in the absence of known etiology. However a precise analysis needs to define a proper scale of data collection and record and the analysis taking into account the variability of all factors.

3.3.5. Control and prevention: The Thai Japanese Encephalitis Immunization Campaign

Control of JE was based until 1990 on vector control, outbreak control, health education. The control of virus transmission by pig immunization is made difficult by the rapid turnover (a new generation every 6 months) in the reared pig population.

From 1984 to 1987 several efficacy and feasibility vaccine pilot studies were carried out in the Northern and Central provinces. The stepwise Immunization Campaign (IC) was launched by the Thai Ministry of Public Health (MOPH) in 1990 within the height northern hyperendemic provinces, then extended in 1991 to all 17 northern provinces and, in 1994, to the 34 provinces with a VE incidence greater than 1 per 100,000 inh.. Since then the JE vaccination has been part of the Expanded Program of Immunization and a school-based catch-up vaccination has been developed from 10 to 28 provinces in 1997. A direct impact of the IC on JE incidence was a decrease in serological confirmation. Also the total incidence of VE proportionally increases. The Immunization campaign appears to have induce a 75% decrease in JE incidence with an estimated to 50 JE cases/year. If a consistent decrease in VE was observed in the early 90s a leveling of disease incidence now appears along with an increase of JE confirmation, and it is a cause of concern regarding the efficacy of the vaccine, the campaign, or the case reporting system.

3.4. Leptospirosis

Leptospirosis is considered to be the most widespread zoonosis in the world. It is mostly present under temperate or tropical climates, which help the existence of the etiologic agent, leptospires. Thailand has recorded important epidemics since 1999, which have raised the awareness on the danger of potential proximity with rodents.

3.4.1. The Natural cycle(s) of the disease

Leptospires (*Leptospira interrogans*) are long, and motile spirochetes. There are more than 200 known serotypes of 23 serogroups, that make difficult their identification. In tropical countries leptospires can move in fresh water, soil and mud and survive there for months.

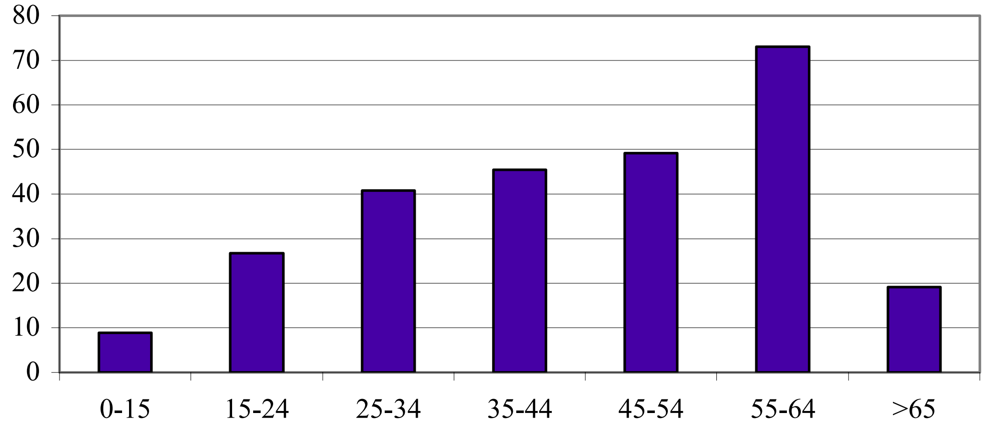
Leptospira organisms are either free-living or associated with animal hosts, such as rodents, pigs, cattle, horses, dogs or other wild animals. Vectors may become sick but sometimes have no symptoms while infesting by leptospires.

The transmission of leptospirosis to human could be either direct from these infected animals or indirect through contact with soil, water or food, containing urine from them. This may happen by swallowing contaminated food or water or through skin contact, especially with mucosal surfaces or with broken skin. Leptospirosis is not known to be spread from person to person.

3.4.2. The Population vulnerability

Leptospirosis is hazardous to those in contact with infected animals or contaminated soil or water. Vulnerable people are mainly men (about 75% according to the epidemiological data, MOPH) and farmers (also 75%), working in rice fields especially. Other workers who spend time in fields are also exposed to high risk of contacting leptospirosis: people working in fisheries for example. Then the incidence is very high for the working age classes: till 73.0 (/100,000 inhabitants) for the people from 55 and 64 years old (see Figure 1).

Figure 1: Incidence (/100,000 inhabitants) of leptospirosis per age in the region 6 in 2002 (Source: Ministry of Public Health).



Then there is a need of activity from the populations to be infected by getting in contact with pathogens, disseminated by water.

A study of the risk factors associated with leptospirosis infection tried to identified the causative activities (Tangkanakul, 1998). These activities if realized within the two weeks prior to illness are walking through water, applying fertilizer, plowing or pulling out rice plants sprouts in wet fields for more than 6 hours a day.

People hunting and eating wild animals as well as animal caretakers and veterinarians are highly vulnerable to get the disease because of the direct contact with potentially infected animals.

Travellers involved in recreational activities in freshwater such as rafting, kayaking, and swimming are also exposed to high risk of transmission.

At last everybody who can handle contaminated objects becomes vulnerable. It is especially the case of drinks in cans that can have been stored in places visited by rodents.

3.4.3. The Spread and dynamics of the disease (endemic and epidemics)

Leptospirosis was first reported in Thailand in 1943 (WHO). The National Disease Surveillance, which started in the seventies, recorded annually from 10 to 20 cases. Then from 1982 to 1995 leptospirosis cases were reported at much higher level, up to 272 in 1988, with an incidence around 0.3 (/100,000 inhabitants). Since 1995 Thailand has reported a rapid increase in incidence (see Figure 2), which conducted to the highest incidences in 2000 (14287 cases, incidence of 21.9 (/100,000) and 362 deaths) and 2001 (10114 cases, incidence of 16.2 (/100,000) and 168 deaths). Enhanced awareness and diagnostic efforts should have also contributed to the increase of reported cases.

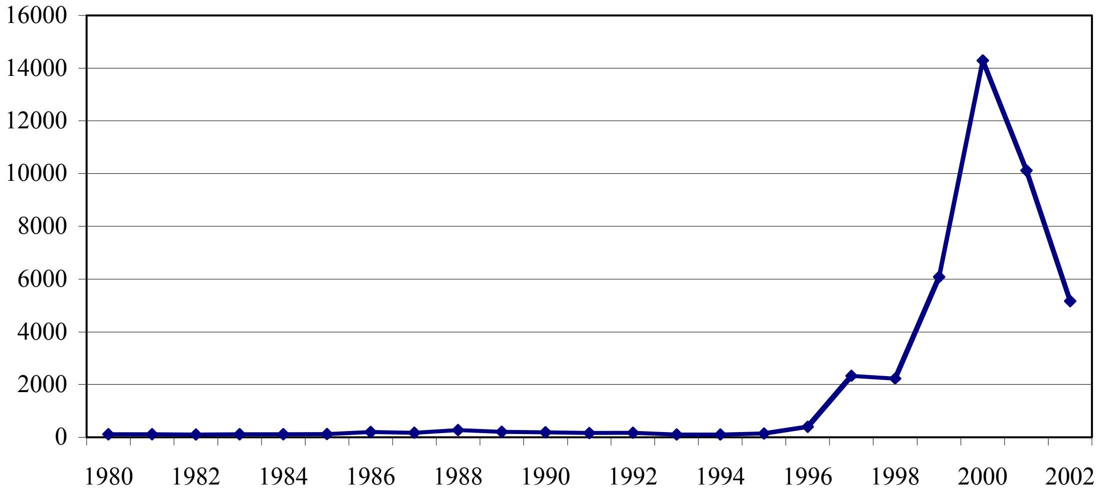


Figure 2: Reported cases of leptospirosis from 1980 to 2002 in Thailand (Source: Ministry of Public ***Health).***

In 2002 the incidence significantly decreased to 9.5. Some factors, mentioned by the MOPH, are a development of immunity within northeastern populations, some bacterial changes of the pathogen Leptospira and a better prevention of vulnerable populations by wearing protective equipment.

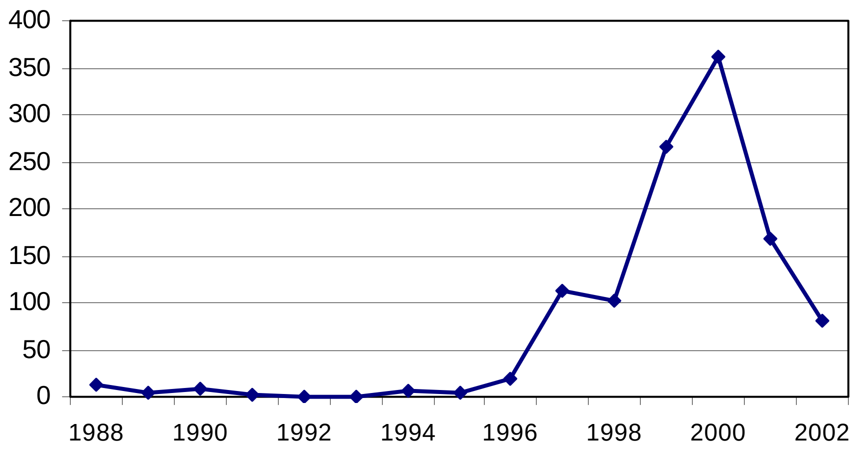


Figure 3: Reported deaths of leptospirosis from 1988 to 2002 in Thailand (Source: Ministry of Public Health).

Most of the contaminations occurred in the Northeast region of Thailand where the incidence is from 2 to 4 times higher (*4.4 in 2002) than for the whole country (see Figure 4). Within the Northeast region, a group of 7 provinces (Nong Bua Lamphu, Khon Kaen, Udon Thani, Loei, Nong Khai, Kalasin and Sakhon Nakhon) get a higher incidence in 2002 (31.1 which is 1.3 times higher than the Northeast incidence and 3.2 times the one of the country).

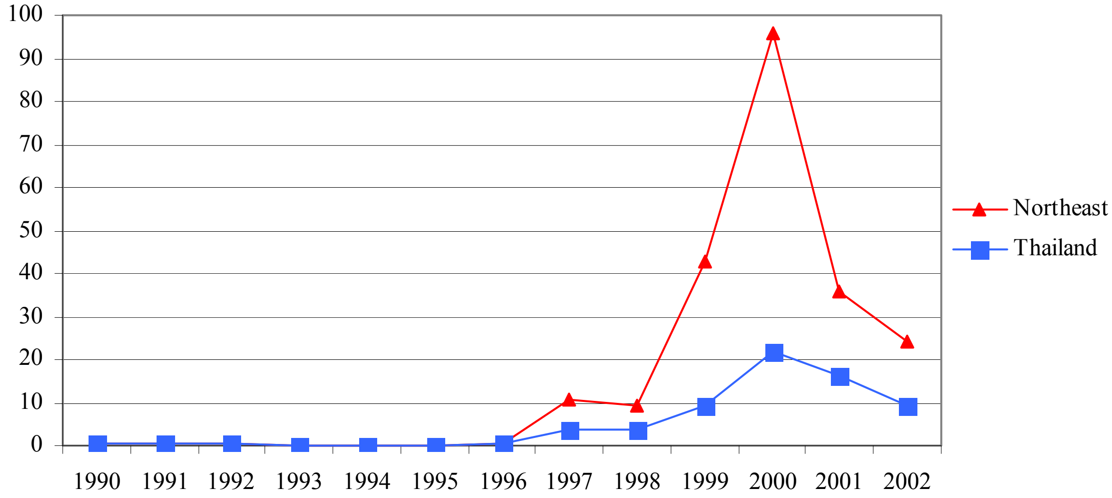
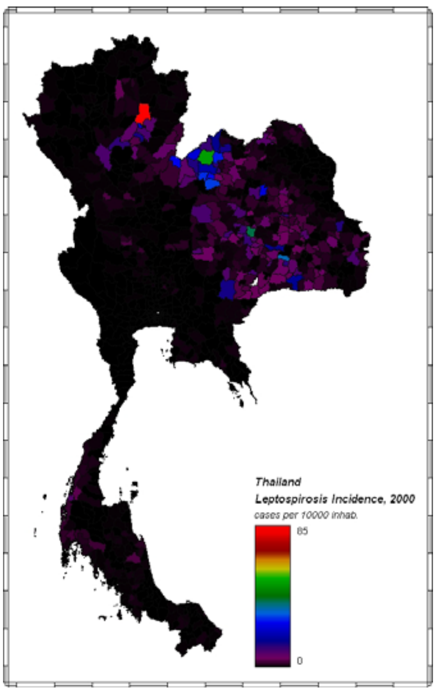


Figure 4: Incidence (/100,000 inhabitants) of leptospirosis in Thailand and in the Northeast region, from 1990 to 2002 (Source: Ministry of Public Health).

Anyway some other provinces can have high incidence of leptospirosis, such as Phrae in the Northern part of Thailand. « Leptospirosis has shown to be epidemic in Phrae province by its high morbidity rate – 58.6/100,000 population in 1999. » (Tanjatham et al., 2003). The morbidity rate was 9.6, i.e. 6 times lower, in Thailand in 1999. Consequently Phrae provincial health center conducted some researches on leptospirosis in 2002, using sera from different mammals (rodents, cattle, pigs).

The symptoms of leptospirosis are very close to other fevers, such as dengue or malaria, and the diagnosis is hardly determined on a clinical basis. In 2002 most of the health centers have started to perform a parallel screening test to validate the diagnosis. As a result the incidence recorded in 2002 should be close to the reality whereas the ones of 2000 and 2001 should have been over evaluated.



Leptospirosis incidence 2000, by district, in number of cases per 10000 inhabitants (IRD/MOPH)

3.4.4. The Spatial correlation between disease extension and a water-related changing environment

Like other water-related diseases, it peak period of transmission occurs in the monsoon months. Some annual climate variation may occur in modifying the extent of flooding and then the importance of leptospirosis epidemics. Extensive precipitations in October 2002 caused late epidemics with numerous cases till November.

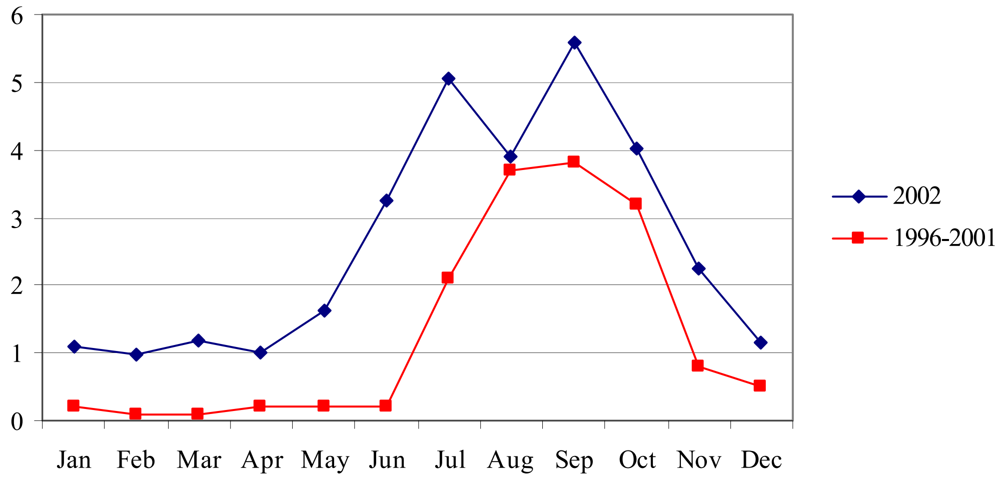


Figure 5: Incidence (/100,000 inhabitants) of leptospirosis per month in 7 Northeastern provinces in 2002, compared with the median calculated between 1996 and 2001 (Source: Ministry of Public Health).

The intensification of agriculture and increase of artificial spaces have contributed to the scope of floodable areas by lowering the capacity of soil to absorb water and raising the speed of flooding. Then leptospirosis presents an important spatial variability showing in some close provinces high and low incidences: in 2002 Loei recorded the highest incidence (88.7 /100,000 inhabitants) and Sakhon Nakhon a low one (5.3). These figures are those of two provinces located at the same latitude and about 200 kilometers apart.

3.4.5. Control and prevention

Control of leptospirosis by controlling its vectors, especially rodents, is not really possible. Most efforts are prevention campaigns. They have been conducted (on TV, in newspapers, as news, advertising or even a song for the youngest) to make everybody sensitive to the potential possibilities to get the disease. Then all over the country most people know leptospirosis as the rat urine disease.

Travellers can reduce the risk by not swimming or wading in water that might be contaminated with animal urine.

Protective clothing and boots should be wore by those exposed to contaminated water or soil. In practice this goal is difficult to be achieved, especially wearing boots in inundated fields during cultivation. We could hope that the progress of agriculture (living conditions for farmers and mechanization of work) will contribute to protect them from getting leptospirosis at work.

References:

Tanjatham S., Khaungaew W., Boonyod D. 2003. Serological survey on Leptospira in animals and patients, Prae province. *In Journal of Health Science.* Bangkok. Vol. 12, Nb. 2: 265-272.

Tangkanakul W., Tharmaphornpil P., Plikaytis B. D. et al. 2000. Risk factors associated with leptospirosis in northeastern Thailand, 1998. In *The American Journal of Tropical Medicine and Hygiene.* Vol. 63. No 3-4. pp. 204-208.

Sarkar U., Nascimento S.F., Barbosa R., Martins R., Nuevo H., Kalafanos I., Grunstein I., Flannery B., Dias J., Riley L.W., Reis M.G., Ko A.I., 05/2002. Population-based case-control investigation of risk factors for leptospirosis during an urban epidemic. In *The American Journal of Tropical Medicine and Hygiene.* Vol. 66. No 5. pp. 605-610.

Chapter 4

Water borne infectious diseases having an intermediate host: Helminthiases

4.1. Introduction

Data provided from scientific journals and from the department of Disease Control of the Ministry of Public Health show that numerous helminths species belonging to different taxonomic classification, Trematodes, Cestodes, Nematodes, are present in Thailand (table 1). These parasites have a medical (mortality, morbidity) importance and an economic impact.

NEMATODA		TREMATODA		
Ascariasis	Ascaris lumbricoides (roundworm)		Opisthorchiasis	Opistorchis viverrini (liver flukes)
Ancylostomiasis (Hookworm infection)	*Necator americanus* *Ancylostoma duodenale*		Fasciolopsiasis	Fasciolopsis buski (intestinal flukes)
Strongyloidiasis	Strongyloides stercoralis		Paragonimiasis	Paragonimus heterotremus (lung flukes)
Enterobiasis	Enterobius vermicularis (Threadworm-pinworm)	FILARIASIS	Bancroftiasis	*Wuchereria bancrofti* Brugia malayi
Trichuriasis	Trichuris trichiura (Whipworm)	CESTODA	Taeniasis	Taenia saginata
Gnathostomiasis	Gnathostoma spinigerum		Echinococcosis	Echinococcus granulosus

Table 1: Medical importance of some helminths in Thailand

The different species have complex life cycle involving one or more required intermediate host (mainly mosquitoes, snails, crustacean, and fishes). The parasites have different stages, egg, miracidium, sporocyst, redia, cercaria, metacercaria, adult (trematodes) or eggs, five instars larvae with molts, adults (filariasis). The definitive hosts are mainly animal but human can get parasite through different ways (Markell & Voge, 1976).

In some species, the parasite must penetrate directly through the skin of the vertebrate hosts (Ancylostoma sp., Necator sp., Strongyloides sp., Schistosoma sp.). In other it is transmitted from human to human through the biting of vectors (mosquitoes/bancroftiasis). In still others it must attach to vegetation and secrete a resistant cyst, waiting to be eaten by the final host (ascaridiasis). Human habits like eating raw meat (crabs shrimps, fishes...), or insufficiently cooked, are very common source of contamination (opisthorchiasis, paragonimiasis, gnathosomiasis). Others activities and habits (water contact and faecal behaviour) of the inhabitants can often increase the infestation.

Most of these parasites are water dependant according to the development of the life cycle of the intermediary hosts (snail, crab, fish), or the vectors (larval stages of mosquitoes).

The diagnostic differs for searching parasites, (i) in faecal matters (Opisthorchis sp., Trichuris sp., Taenia sp, Ascaris sp., Echinostoma sp., Enterobius sp., Stongyloides sp.) (ii) sputum and faeces (Paragonimus sp.), blood (Wuchereria bancrofti) (iii) clinical diagnosis as larva migrants, eruption (Ancylostoma sp; Gnathostoma sp.).

Distribution of heminths is not homogenous throughout the country. It varies from one region to another. For only intestinal helminthiasis (with eggs in the faeces) the prevalence rate, (17025 stools were examined within 30 clusters sampling was carried in each 12 health regions in 2001) is 22,5% (figure 1). The Chao Phraya basin covers 6 of 12 regions and concerns 43,5% of general intestinal infection (table 2).

Several diseases can often occur in the same area in Thailand and is a considerable burden for the population. For examples Opisthorchis viverrini, Strongyloides stercoralis, hookworm, Echinostoma spp, minute intestinal flukes (1.54%), Taenia species (1.37%), Enterobius vermicularis (0.68%) (Waree et al., 2001) can appear in the same village. 13% of patient has more than one parasite (MOPH, 2002, figure 2).

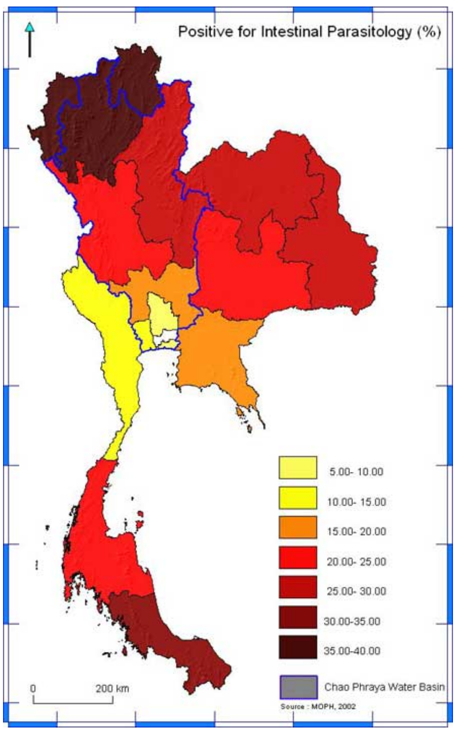


Figure 1

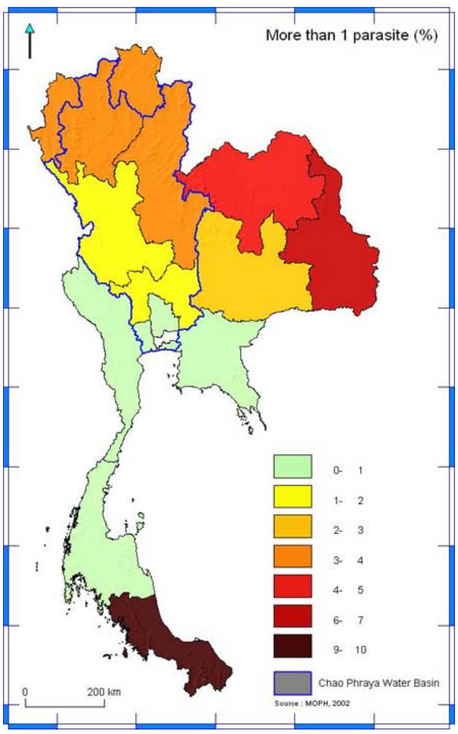


Figure 2

Since decade the Ministry of health has been involved to control these diseases and several national program have been implemented combined diagnosis, health education, treatment, sanitary measures. A general decreasing of prevalence rate is observed since 1957 (Jongsuksantikul et al., 1992) (figure 3).

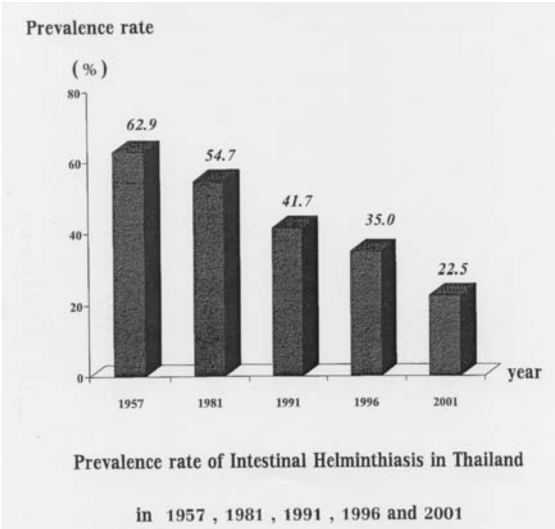


Figure 3

Each parasitosis present in the area of the basin of Chao Phraya will be described by mentioning recalls of the biological cycle of the parasite, the symptoms, the distribution in Thailand, the epidemiology of the disease. The current data on the strategies of prevention and control implemented by the national programs will be mentioned. Finally, the factors of evolution of these diseases in the zone of the basin of Chao Phraya will be the subject of a particular development.

4.2. OPISTHORCHIASIS (liver fluke)

Opisthorchiasis caused by *Opisthorchis* trematode has been recognized in Thailand as the major local public health problem. Its high prevalence with chronic infection contributes to a development of liver cirrhosis and a prevalence of cholangiocarcinoma which causes a considerable morbidity and mortality among the rural human population (Jongsukuntigul & Imsomboon, 1998). The habit of eating raw fish is the cause of infection. *Opistorchiasis* are one of the most important food-borne parasitic zoonoses found in the north, northeast and central regions of Thailand (Khamboonruang, 1991). The potential economic losses that would result from banning the export of fish production from endemic areas need to be taken into account.

4.2.1. Parasite life cycle & clinical symptoms

In Thailand *Opisthorchis viverrini* is the only parasite of *Opisthorchiasis*. Harinasuta & Vajrasthira, (1961) and Wykoff (1965) had demonstrated a complete life cycle of *O. viverrini*.

Opisthorchiasis viverrini trematode definitive hosts other than human are cat, dog and other fish eating animals. The first intermediate hosts are snails *Bithynia*. *Bithynia (Digoniostoma) funiculata*, B.(D.) *siamensis siamensis*, B.(D.) *s. goniomphalos* and *Melanoides tuberculata* have been reported to mediate the human parasitic disease of *Opisthorchiasis viverrini* in Thailand, (Lohachit, 1998).

The second intermediate hosts are numerous species of *cyprinidae* fishes. The egg hatches when ingested by a snail. The *cercariae* leave the snail in about 2 months encysted in the fresh of *cyprinidae* species fish and become infective *metacercariae*. When ingested by a definitive host, the excyst go in the duodenum and pass to the distal bile ducts, where they reach maturity in 3-4 weeks (Jongsukuntigul, & Imsomboon, 1998) (figure 4).

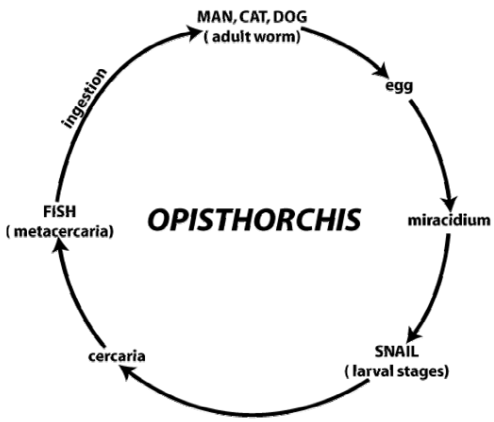


FIGURE 4

Clinical features of opisthorchiasis vary from mild to severe manifestations. Most cases are symptomsless, or present with mild symptoms of pain in the right costal margin and epigastrum, lassitude anorexia and flatulence. Severe manifestation associated with portal cirrhosis ascending cholangitis and bilary obstruction are seen in some cases The most critical one is cholangiocarcinoma which is believed to be the end result of a prolonged accumulation of liver fluke infection. Liver fluke infection has an effect on health as well as nutritional status. (Pungpak et al., 1985).

4.2.2. Present status of opisthorchiasis in Thailand: distribution & Epidemiology

Thailand is recognized as having a high prevalence of human liver fluke , Opisthorchiasis viverrini, infection (Jongsukuntigul & Insomboon, 1997). The first case of Opisthorchiasis was reported in 1911 by Leiper from the autopsy of corpse in Chiangmai.

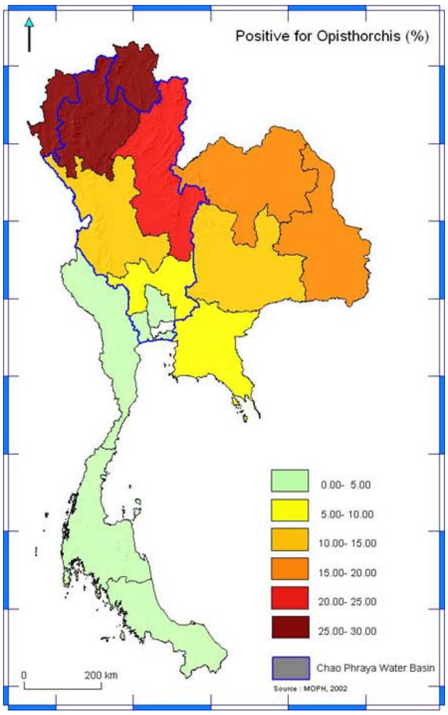


Figure 5: Positive for Opistorchis

Distribution of opisthorchiasis is not homogenous throughout the country. It varies from one region to region. (Figure 5). In 1996 the highest prevalence (32,6%) was in the northern region while the central region had its prevalence rate of 16,7%. The lowest was 15,3% of the Northeastern region. Comparing with figures of 1981 and 1991 there are considerable increase in the Central and Northern regions while Northeastern region has significant decrease (Jongsukuntigul & Insomboon, 1998).

In 2001, 55% of liver fluke infection occurs in the area of Chao Phraya basin. The highest prevalence is in region 10, 9, 8 (Table 2).

The habit of eating raw fish or improperly cooked fish among the rural is the source of infection community contributed to high prevalence of the liver fluke infection. The prevalence among rural dwellers is higher than urban dewellers (Kurathong et al., 1987). The prevalence of intensity of the infection increased with age, reaching a plateau in young adults (Jongsukuntigul & Insomboon, 1998) .Studies on the distribution of cyprinoid fish and their susceptibility to the infection were performed in different places. Investigations on the infection rate of Opisthorchis viverrini metacercaria in fish had been conducted in wide scale, 62208 cyprinoid fish in 17 northern provinces (Wongsaroj et al., 1999) and a small scale, Sukhothai and Phichit Provinces only, (Waikagul et al., 1998). At least 15 species of cyprinoid fish were widely distributed in the natural water reservoir throughout the northern region of Thailand. They included fishes such as Cirrhinus jullieni, Cyclocheilichihys apogon, C. enoplos, Hampala macrolepidota, Henicorrhyncus siamensis, Mystacoleucus marginatus, Labiobarbus burmanicus, Osteocheilus hasselti, Poropuntius deauratus, Puntioplite proctozysron, Puntius brevis, P. gonionotus, P. leiacanthus, P. orphoides and P. spilopterus.

4.2.3. Control programme

History of Opisthorchiasis control has dated back to 1950 as a small scale helminthiasis control program in some high risk areas. Since 1988, national control programme of opisthorchiasis using large scale chemotherapy to treat infected individuals with praziquantel (40 mg/kg body weight) has been launched since 1988. In 1992, the program has its coverage up to 42 provinces (Jongsukuntigul, & Imsomboon, 1998).

The main strategies for liver fluke control are comprised of 3 interrelated approaches, namely (i) stool examination and treatment of positive cases with praziquantel for eliminating human host reservoir; (ii) health education for a promotion of cooked fish consumption for preventing of infection: and (iii) the improvement of hygienic defecation for transmission interruption.

In 1992, the program has its coverage up to 42 provinces in some central provinces, and all northeastern and northern provinces of Thailand. After a control programme, the prevalence of opisthorchiasis in Northeastern Thailand has continuously declined from 34,6% in 1984 to 24,01% in 1991 (Jongsuksantikul et al., 1992). In 1991, the prevalence of opisthorchiasis in the North was 22,9 %. In 1998 the infection is lower than the previous report 5 years ago (11,6 vs 22,88).Decreasing may possibly be attributed ton many facteurs including better education about consuming raw food %) (Radomyos et *al.* 1998).

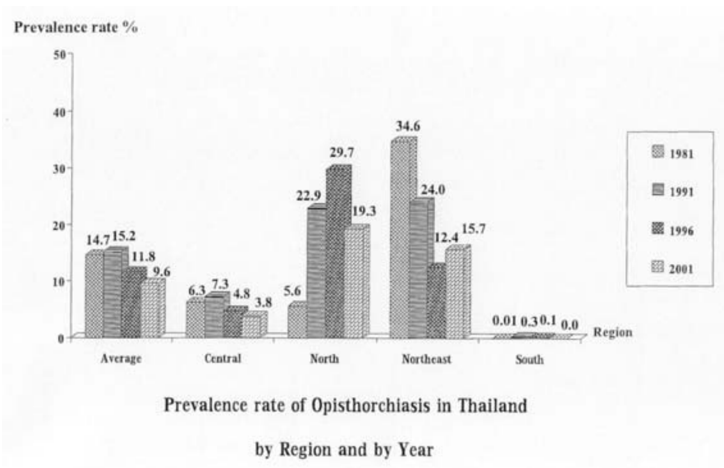


figure 6

Comparing with figures of 1981 and 1991, there are considerable increase in the central and northern regions, while the northeastern region has significant decrease.

4.2.4. Further development

The prevention of fish becoming infected with O. Viverrini depends on environmental control of surface waters where fish is caught or harvested (cultured fish) and the control of the first intermediate hosts (snails). There are many potential difficulties in the implementation of these measures. For example, monitoring and control large bodies of surface waters (rivers, lakes, reservoirs) may be impracticable in Thailand. However, the improvement of aquaculture pratices, widely spread in Thailand to exclude O. Viverrini may be possible with the cooperation and participation of the people involved. Prevention and control could be reinforced by food safety procedures. This involved a complete new strategy based on the comprehensive coverage of the origin of the fish up to its consumption (Khamboonruang et al.,1997).

4.3. GNATHOSTOMIASIS

Human gnathostomiasis is endemic in South-east Asia and most frequently caused by *Gnathostoma spinigerum* and it is a public health problem in Thailand. The normal route of infection is ingestion of infected second intermediate or paratenic hosts such as fishes, amphibians, and eels. Man is an accidental host, infected by eating raw fresh-water fish, freshwater crab, frog snake or chicken. Cutaneous symptoms and eyes complication may occur. The patient pay dies from brain damage when the larvae move into the brain (Daengsvang, 1980).

4.3.1. Parasite Life cycle & clinical symptoms

There are five species of Gnathostoma that cause disease in man. *Gnathostoma spinigerum* is the most common infection in Thailand. The others are *G. hispidum, G. vietnamicum, G. Doloresi ang G. Malasiae*.

In the dry season, the feces and gnathostoma eggs remain on the surface soil and can not continue the life cycle. When the rainy season comes, the water flow flushes the gnathostoma eggs to the surface reservoirs and the eggs then hatch into first stage larvae. The larvae are then ingested by *Cyclops spp* and develop into the second-stage larvae. Eels, fishes, frogs which have eaten these infective *Cyclops sp* will be infected and larvae can be found in flesh and liver. The development of *G. Spinigerium* from ova in cats or dogs feces to the encysted form of third stage larvae in eel livers requires about 1-2 months.

There are several species of freshwater fish serving as second intermediate hosts of *Gnathostoma* (Daengsvang, 1981, Rojekittikhun et al. 1989). Among all these species the highest infection is found in swamp eels Fluta alba might be important in transmitting the infection either among human and reservoir animals. Cat and dogs are the natural definitive hosts. In gnathostomiasis man becomes an accidental host by eating infected under-cooked fresh water fish. Ingested by man, the larvae do not mature but migrate throughout the body

As judged by its prevalence and mortality, central nervous system disease caused by G. Spinigerum is the most important parasitic disease of the central nervous system in Thailand Because of its high motility, may cause widespread damage in the spinal cord and brain stem (Vejjajiva, 1978). Encephalitis, myelitis, radiculitis and subarachnoid haemorrhage, formed the majority of clinical syndromes, Schmutzhard & Chusattayanond, 1988), Involvement off the eye is a rare complication of gnathosomiasis (Rhitibaed & Daengsvang, 1937).

4.3.2. Present status of gnathosomiasis in Thailand: distribution & Epidemiology

The infection rate has increased every year because of the popularity of eating raw fish and raw meat. Most of the cases (figure 7) are from the central region (Nuamtanong et al., 1998, Rojekittikhun et al., 2002). The swamp eels, Fluta alba have been reported to be one of the most heavely infected natural intermediate hosts of G. Spinigerum at various localities (Nuamtanong et al., 1998; Setasuban & Nuamtanong, 1991).

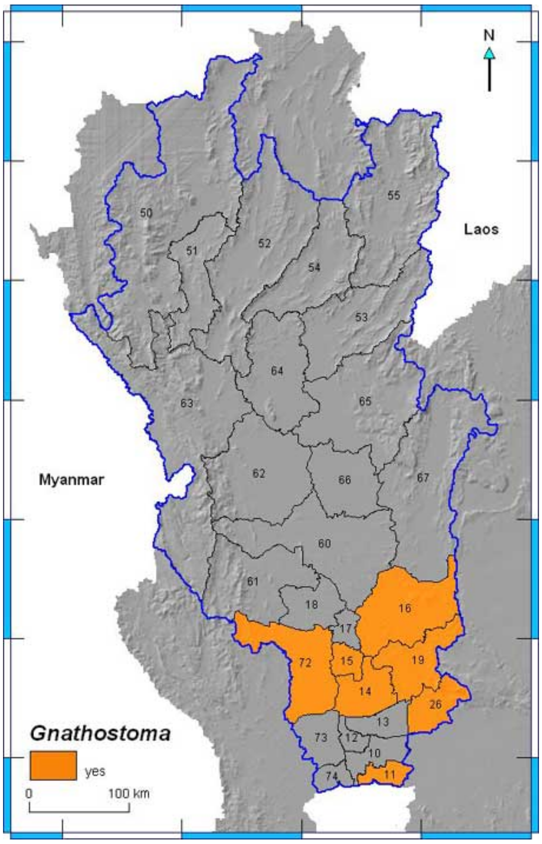


Figure 7: Cases of Gnathostomiasis from only references in scientific journals

Seasonal variation can be followed by:

(i) Studies the prevalence and intensity of canine *Gnathosoma spinigerum* infection in northeastern Thailand. 4,1% (2940 dogs) were infected. The prevalence and worm burden exhibited a seasonal fluctuation. The parasite were more abundant in the rainy season and the early winter (August –december) than in summer (april-March) seasonal fluctuation in 4,1% (2940 dogs).

(ii) collected fishs, swamp eels (*Fluta alba, Monopterus alba*) from local market (Rojekittikhun & Pubampen, 1998, Saksirisampant & Kukaew 2002) indicate that the prevalence of the infection varied with season, being generally high during the rainy season (September, 38%) and whereas the lowest was in April and they start to rise.

4.3.3. Control programme

No special control program for Gnathostomiasis, except individual treatment and health education are included in intestinal helminthiasis control program. Following dataes from the hospital of tropical Medecine of Mahidol University, the number of annual cases has decreased since 5 years from 800 to 100 (Dr Jitra Waigakull, pers.comm). Albendazol and Ivermectine (80% of cure with administration of200mg/kg) are used.

4.4. PARAGONIMIASIS (lung fluke)

Paragonimiasis is an endemic disease in many Asian countries (Thailand, Korea, China, philippines, Lao DR and india). Fourteen species of Paragonimus are known to infect humans. *Paragonimus westermani* infection is the most common elsewhere while *P. Heterotremus* is the etiologic agent of *paragonimiasis* in Thailand (Waree et al., 2001).

4.4.1. Parasite Life cycle & clinical symptoms

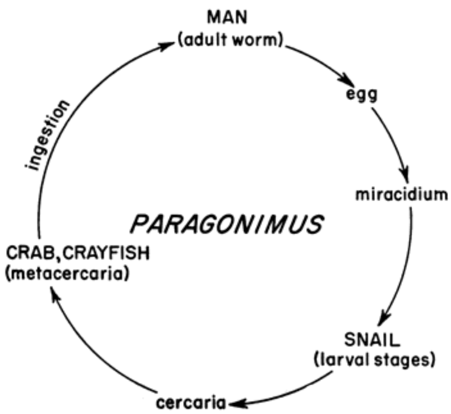


Figure 8 : Life cycle of Paragonimus sp

The freshwater crab, family *Potamidae* is an intermediate host of lung fluke, *Paragonimus heterotremus*, there are 4 species: *Larnaudia beusekomae, L. Jamaudii, Potamon lipkei* and *Potamon* spp.; (Naiyanetr,1998) (figure 8).

No recognizable symptoms attend the migration of the parasites. As they grow in the lungs, there is an inflammatory reaction which may sufficient to produce fever. When the cysts rupture, a cough develops, and there may be increased production of sputum, frequently bolled tinged. Severity and progression of symptom will depend upon the number of parasites present. Bronchiectasis may result.

4.4.2. Current status of paragonimiasis in Thailand & Epidemiology

The first case of human paragonimiasis in Thailand was reported in Petchabun Province (Prommas, 1928). After that many cases reported in Saraburi, Nakhon Nayok, Chiang Rai, Nan and Pitsanulok provinces (Daengsvang *et al.*, 1964, Pannarunothai *et al.*, 1988). Recently, Waree *et al.*, 2001 carried out a cross-sectional survey and evaluation of paragonimiasis situation from endemic area in Phitsanulok Province was studied. *P. heterotremus* eggs were detected. The prevalent rate of *paragonimiasis* in this endemic area in Phitsanulok Province has decreased during the past decade.

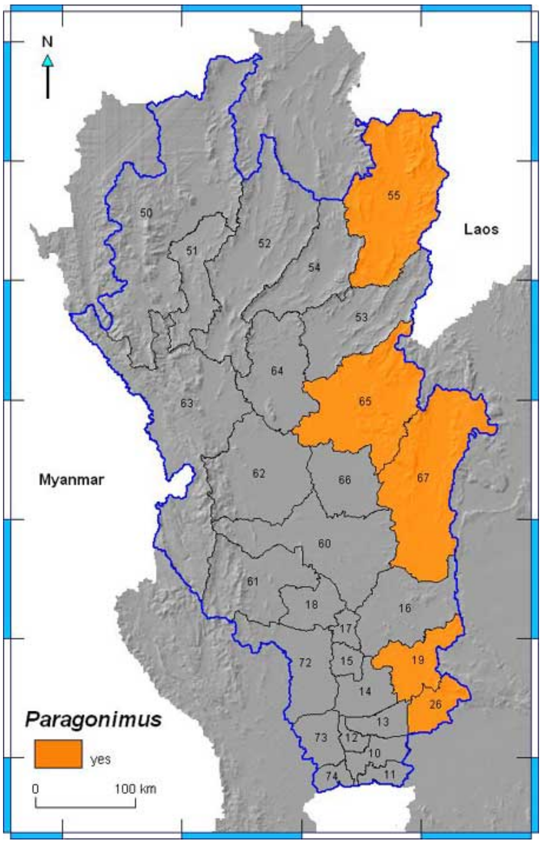


Figure 9: Cases of Paragonimus sp. from only references in scientific journals

4.4.3. Control program

Decreasing prevalence may be due to the control programs of the Ministry of Public health for paragonimiasis and Health education on not consuming raw crabs. Praziquantel at dose of 75 mg/kg, three times daily for thre days give good results. For cutaneous gnathostomiasis, albendazole at a dosage of 400 mg twice daily for 14 days has given (Inkatanuvat, S., Suntharasamai et al., 1998).

4.5. ANGIOSTRONGYLIASIS

Angiostrongylus cantonensis is recognized in many aspects of host surveys in Thailand especially in the NE.

The transmission of this helminth to man is by consumption of infected animal with infective larvae (third stage larvae), i.e; intermediate hosts: fresh water snails, land snail (*Achatina sp*) and slugs, fresh water shrimp fresh water crabs, amphibians and monitor. When the third-stage larvae are ingested, they penetrate thre blood vessels in the intestinal tract and are carried to the meninges, where soon die (Radomyos, Tungtrongchitr, 1994; Chotmongkol et Sawanyawisuth, 2002).

It occurs in Thai people of lower socio-economic groups who acquire the parasite by eating infected raw *Pila* snails, *Ampullarium canaliculatus* (Tsai, Liu, *et al*., 2001).

A. cantonensis is the most common cause of eosinophilic meningitis or meningoencephalitis. Almost all cases are self-limiting (fever, headache, orbital pain, gastrointestinal upset, hyperesthesia, muscle weakness, skin rash) and are diagnosed by cerebrospinal fluid eosinophilia and enzyme-linked immunosorbent assay; pathology reports are restricted to postmortem samples from lethal cases. (Tsai, Liu, *et al*., 2001; Petjom *et al*., 2002). Patients die by acute coma (Chotmongkol & Sawanyawisuth, 2002)

There is no specific treatment and there have been only a few reports of antihelminthic therapy in humans.

4.6. BANCROFTIAN FILARIASIS (filariasis)

In Thailand, two main filarial species are reported, *W. Bancrofti* found in the northern and western parts and *B. Malayi*, in the southern region of the country. Filariasis are still the public health problems in Thailand

4.6.1. Parasite life cycle & Clinical symptoms

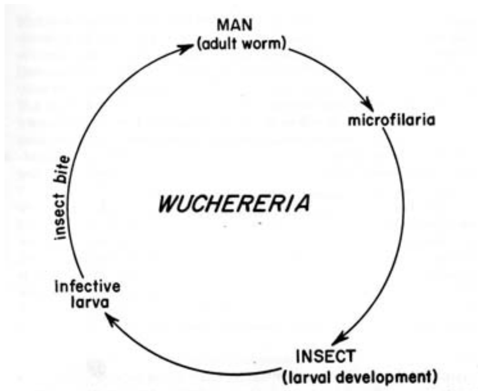


FIGURE 127. Schematic representation of life cycle of the human filarial worms.

Figure 10: Life cycle of Wuchereria sp.

The adult worms live in lymphatic vessels in the human body and produce embryos called microfilaria, which circulate in the bloodstream and are picked up by biting mosquitos. After developing for several days in the mosquito, infective larvae enter the skin when the mosquito feeds, migrate to the lymph nodes and develop into adult worm in lymp vessels? The adult worms can live for many years.Transmission via the bite of blood-feeding female mosquitoes which transmit immature larval forms of the parasitic worms from human to human.

Infective larvae develop into adult worms (known as macrofilariae) in the afferent lymphatic vessels, causing severe distortion of the lymphatic system. Adult Wuchereria are often lodged in the lymphatics of the spermatic cord, causing scrotal damage and swelling. Elephantiasis - painful, disfiguring swelling of the limbs - is a classic sign of late-stage disease.

There are three basic disease stages: (1). asymptomatic: patients have hidden damage to the lymphatic system and kidneys (2). Acute: attacks of ‘filarial fever’ (pain and inflammation of lymph nodes and ducts, often accompanied by fever, nausea and vomiting) increase with severity of chronic disease. (3). chronic: may cause elephantiasis and hydrocoele (swelling of the scrotum) in males or enlarged breasts in females.

4.6.2. Current status of Bancroftiasis: Distribution & Epidemiology

The annual report of the division of filariasis, Department of Communicable Diseases Control, Ministry of Public health in 1998 stated the microfilaremic rates of *B. Malayi* and *W. bancrofti* were 0,09-1,76% and 11-18 % respectively (Ryong *et al*. 2000).

The endemic area is distributed throughout the Thai-Myanmar border, i.e. Ratchaburi, Kanchanaburi, Tak and Mae Hong Song. The area is rural, hilly, and semi-forest and all of the cases were Thai-Karens.

Several studies confirm that *W. Bancrofti* was brought to Thailand by exodus of Myanmar laborers at the border, Tak province (Triteeraprapab & Songtrus, 1999) but also farther in Central area (Lamphun Province, Chiang Mai province) (Khamnoonruang *et al*., 1989, Jitpakdi *et al*., 1998. The microfilarial rate in 654 Myanmar migrants working in Mae Sot, Tak province, was 4.4 per cent.

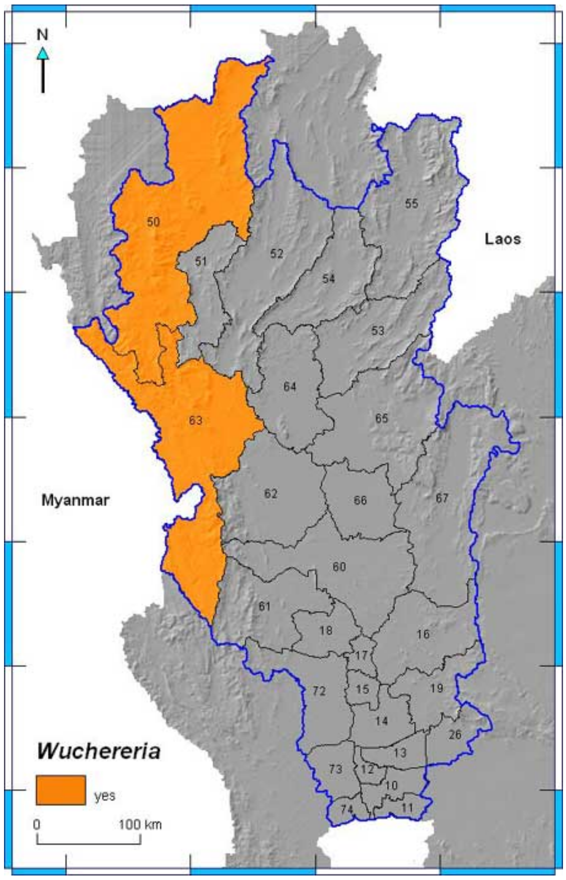


Figure 11: Cases of Wuchereria sp. from only references in scientific journals

The highest microfilarial rate was found in males aged 21-30 years (6.8%). The majority of Myanmar migrants (55.5%) have been staying in Thailand 1-6 years; most (82.0%) have never been back to Myanmar. A preliminary survey for Bancroftian filariasis in villagers of Ban Prabat Heuy Tom, Tambol Na-Sai, Amphoe Li, was performed between in 1986 and 1987. A total of 1,435 villagers comprising 668 females and 767 males were examined for microfilaraemia in peripheral blood. Microfilariae were found in five males of which two cases were found to have developed hydrocele at a lesser degree and all of them had formerly resided in an endemic area of Tak Province. Microfilarial periodicity was studied in two cases, and it was shown to be nocturnally subperiodic. (Khamboonruang *et al.*, 1989)

Studies carried out on migratory Myanmar and local Karen inhabitants suggest that transmission in the village may have occurred in recent years (Bhumiratana *et al*., 2002). Recently, another type of nocturnally periodic *W. Bancrofti* transmitted by *Culex quinquefasciatus* was brought to Thailand by exodus of Myanmar laborers. This filarial type has been questionned up to this time, whether active transmission occurs in the thai population (Jitpakdi *et al*., 1998)

The periodicity behaviour is nocturnally subperiodic type with a peak microfilaremia at 18- 20:00 hours. (Khamboonruang *et al*., 1987, 1989).

4.6.3. Control Programme

The World Health Organization has aimed to eliminate the disease globally by the year 2020.The strategy is based on a) mass administration of drugs to at-risk populations with once-a-year, one-day treatment (to interrupt transmission) b) promotion of rigorous, simple hygiene, techniques for lymphoedema (to alleviate and prevent suffering affected individuals). The treatment strategy is now based on annual dose of DEC+albendazole.

4.6.4. Further development

Although the prevalence of lymphatic filariasis in the Thai population is low, migration of Myanmar labor into Thailand may increase the incidence of bancroftian filariasis. Since these migrants carry the parasite with high infected rate and the mosquito vector *Culex quinquefasciatus* is also prevalent in Thailand, Thai people are at high risk of acquiring this disease if good control and prevention strategies are not implemented.

Control programmes have reduced the prevalence of Bancroftian filariasis in Thailand to low levels. Recently, there has been an influx of more than one million Myanmar immigrants into urban centres of Thailand. The prevalence of patent *Wuchereria bancrofti* infection in these immigrants (2-5%) has prompted concern in the public health community that the potential now exists for a re-emergence of Bancroftian filariasis in Thailand. It is possible that an urban cycle of transmission could become established. The Myanmar immigrants are infected with the nocturnal periodic (urban) type *W. bancrofti* for which *Culex quinquefasciatus* serves as the main vector. The Thai strains of *Cx. quinquefasciatus* have never been reported to transmit Bancroftian filariasis. Artificial feeding experiments demonstrated that the Thai *Cx. quinquefasciatus* are permissive for the development of Myanmar *W. bancrofti* to infective third-stage larvae thus establishing the potential for establishing an urban cycle of transmission in Thailand. (Triteeraprapab, Kanjanopas *et al.,* 2000)

4.7. SCHISTOSOMIASIS (blood flukes)

In South East Asia *Schistosoma japonicum* is prevalent in southern Philippines and Central Sulawesi, Indonesia whereas *S. mekongi* is endemic in the mekong Delta, in limited areas of the lower Mekong basin in Laos and Cambodia.

4.7.1. Parasite life cycle & Clinical symptoms

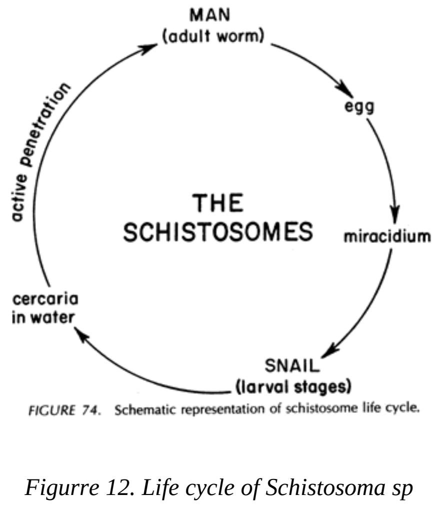


FIGURE 74. Schematic representation of schistosome life cycle.

Figurre 12. Life cycle of Schistosoma sp

People are infected by contact with water where infected snails *Neotricula aperta* live. Larval forms of the parasites (known as cercariae), released by the snails, penetrate the skin of people in the water. The snails themselves become infected by another larval stage of the parasite, known as miracidium, which develops from eggs passed out the faeces of infected people.

Adult male and female schistosomes *S. mekongi* pair and live together in human blood vessels. The females release eggs, some of which are passed out in stools but some eggs are trapped in body tissues.

Severe disease is associated with advanced infection status. Signs and symptoms of portal hypertension dominate the clinical situation, and death is usually due to bleeding from ruptured esophageal varices (Urbani, Sinoun *et al*., 2002)

4.7.2. Current status of schistosomiasis & Epidemiology

In Laos and Cambodia, transmission of *S. mekongi* occurs in rocky banks of the river according to a seasonal cycle. In Kratie province, the transmission period of *S. mekongi* is the hot dry season, when the Mekong river is low and slow-moving (Stich *et al*., 1999) These conditions favor the development of the intermediate host snails, *Neotricula aperta*, which adhere to the rocks and stones that lie on the bottom of the mekong river. Recent studies confirm the role of the dogs as a parasite reservoir (Iijima *et.al*., 1971, Martsumoto *et al*., 2002). Common daily activities of villagers living in the endemic areas constitute the risk factors for infection (Urbani, Sinoun *et al.,* 2002). Children are especially vulnerable to infection, which develops into chronic disease if not treated.

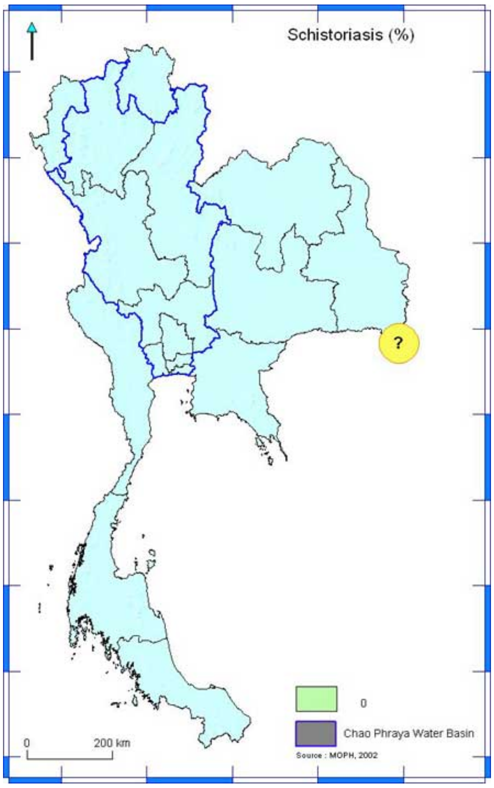


Figure 13 : schistosomiasis

In Thailand no human infections have been reported**.** Since the first case of *Schistosoma mekongi* infection was reported in Laos and Cambodia, respectively in 1957 and 1968, surveys have been carried out on the Mekong tributaries and some reservoirs in Thailand **especially** in Mun River. Studies on the Pakmoon Hydroelectric Power Dam, located in an area where the risk of transmission of *Schistosomiasis mekongi* is possible were carried out.

The results of conventional stool examination in cattle, buffalo, dog and cat including forest and rice field rats by using M.I.F. technique, found various kinds of parasitic eggs but not those of *S. mekongi*.

Egg hatching technique failed to demonstrate miracidia of *Schistosoma* spp from the fecal specimens of cattle and water buffalo. Similarly, the results of perfusion and pressing techniques also failed to reveal the presence either of adult worms or their eggs in the liver and intestines of the rats.

Although, the evidence of the transmission of *S. mekongi* could not be demonstrated in Thailand, the presence of the potential snail intermediate host, *Neotricula aperta* β race and the natural animal reservoir hosts such as domestic dogs in some area in the east of Thailand provides significant potential to support future spreading of this public health and economically important parasite if it is introduced from nearby endemic foci in Lao PDR and Cambodia. (Wongsaroj *et al*., 1999).

All the three strains of *Neotricula aperta* (Gastropoda: pomatiopsidae) sampled from populations in Northeast thailand were found to be compatible with a *Schistosoma mekongi* isolate from Kratie District, eastern Cambodia. The infection rates were : 3% alpha-strain, 6% beta-strain, and 20,5% gamma-strain. **(**Attwood & Kitikoon *et al*., 1997)

4.7.3. Prevention and control

Schistosomiasis control in both Laos and Cambodia was based on universal treatment campaigns (single dose of praziquentel at 40 mg/kg body weight) and resulted in a dramatic fall in prevalence of the infection and in morbidity control. Morbidity control through an integrated approach: (i) diagnosis faecal smear techniques (ii) drug treatment with praziquantel: effective in a single dose against all species (iii)Snail control through focal mollusciciding (iv) Provision of safe, adequate water supply and sanitation (v) Health education

4.7.4. Further development

The presence of susceptible strain of *Neotricula aperta* to *S. mekongi* from Laos and Cambodia in some place in Thailand require appropriate surveillance and/or prevention. Program in order to control its introduction to northeast Thailand from the neighbouring countries, Cambodia and Laos.

There is concern that water resource development in the Lower Mekong Basin could lead to an outbreak of Schistosomiasis in Northeast Thailand and others areas that are not known to be affected by this disease at present (Attwood, 1994). It is necessary to mitigate this adverse health impact by adopting appropriate surveillance and/or prevention program against spread of *Schistosoma mekongi* and establish the surveillance of animal reservoir hosts.

4.8. Others intestinal helminths

These heminthiasis are not directly water dependant. Human behaviour, sanitary conditions are the main causes of infection and transmission. These helminths are transmitted directly by fingers from infected soil (Trichuriasis, Taneniasis) or by the patients theirselves (Oxyuriasis). For others (hookworms, Strongyloidiasis) transmission by skin penetration occurs. Dampshaded soil near water reservoir or lake are suitable place for transmission

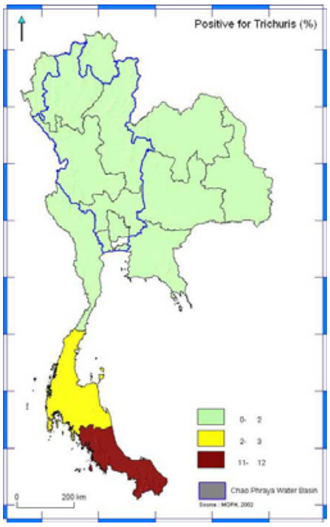
From data provided by MOPH, the infection rate within Chao Phraya basin differs among helminths :

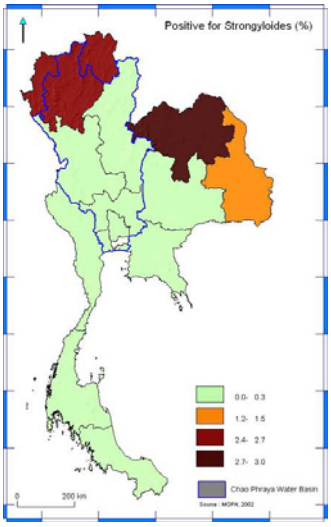
Necator americanus, Ancylostoma duodenale (Hookworm) are the major human hookworm in Thailand (37,5%, figure 17) mainly in the south (20-25%) and less (10-15%) within the chao phraya basin. Since 1981, the rates are decreasing in all regions. Anemia is the main symptom. Albendazole is recommanded for the treatment.

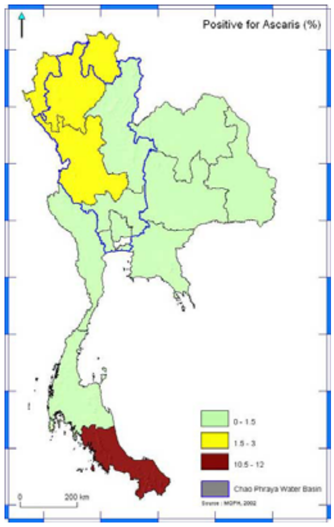
E. vermicularis (pinworm) (40%) (Nithikathkul et al.,2001 a, b), The infection rate was significantly higher in agricultural areas and areas farthest from urban Bangkok. Industrial and urban areas had the lower rates of infection.

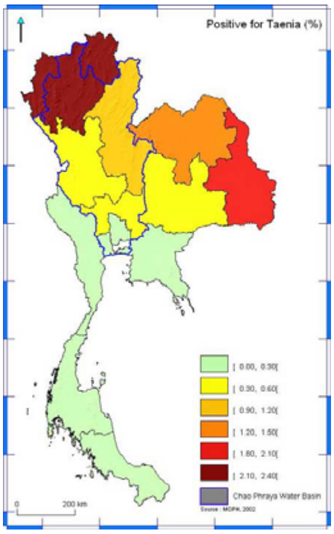
Others play less importance (Ascaris sp, Trichuris sp, echinostome sp., figure 18 et 19, Taenia sp (52%, figure 15), S. stercoralis (35%; figure 16).

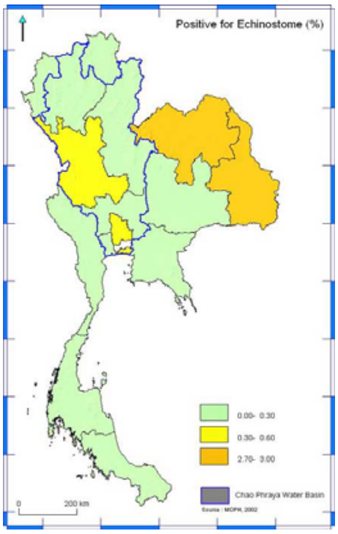
Minute flukes have been identified in particular after a treatment by anti heminthic, *Phaneropsolus bonnei, plagiochid fluke, Prosthodendrium molenkampi, Stellanchasmus falcatus* (Radomyos et al., 1998), *Fasciolopsis buski* (Wiwanitkit et al., MedGenMed), sparganosis (Settakorn et al., 2002) *Centrocestus caninus* (Waigakul *et al*., 1998).











4.9. Conclusions

Numerous helminths species are present in Thailand. In 2001, 43,5% of general intestinal infection still occurs in the Chao Phraya basin.

Previous studies have provided a better understanding of the life-cycle and the epidemiology in order to identify the risk factors to a new development of these diseases in Thaïland. Several factors can enhance the spread of parasites:

- Water resources development: most of theses diseases are water-dependent: building water body (dam for electricity supply, for natural water reservoir, lakes, fish farming, market-gardens, irrigation and rice cultivation) can allow the development of the intermediate and definitive hosts in better condition and enhance the risk of an increase of these diseases.

- Human migration: construction of reservoir, dam, hiring of seasonal workers in rice field is a very great concern to spread parasite. Increasing tourism, movement of population and the influx of refugees from Southeast Asia demand a greater awareness.

Wiwanitkit, V., Suwandaksri el, (2002) mention *Fasciolopsis buski* can be carried by number of immigrants from various regions of Thailand over the past few years, possibly explaining the migration of the fluke parasite setting in Northeast Thailand.

Although the prevalence of lymphatic filariasis in the Thai population is low, migration of Myanmar labor into Thailand may increase the incidence of bancroftian filariasis. Thai people are at high risk of acquiring this disease if good control and prevention strategies are not implemented.

There is concern that water resource development in the Lower Mekong Basin could lead to an outbreak of Schistosomiasis in Northeast Thailand and others areas that are not known to be affected by this disease at present (Attwood, 1994). It is necessary to mitigate this adverse health impact by adopting appropriate surveillance and/or prevention program against spread of Schistosoma mekongi and establish the surveillance of animal reservoir hosts.

Eating Behaviour

Human habits like eating raw meat (crabs shrimps, fishs...) or insuffisently coocked are a very common source of contamination (opisthorchiasis, paragonimiasis, gnathosomiasis). Health education must be integrated within the prevention and control activities.

Trade & Food surveillance

Food control measures (especially products sold within the national market) are particularly important in the struggle to control diseases related to fish or other products being eaten raw or undercooked. The involvement of aquaculturists and fish inspectors, side by side with medical public health is crucial (Khambooruang et al.). The potential economic losses that would result from banning the export of fish products from endemic areas need to be taken in account.

Overall helminthiasis diseases are on the drecreasing trends since 1957 probably in relation with the implementation of control programme by the Ministry of public health. The strategies combine diagnosis, treatment, education, water supplies and sanitary latrine construction. For most of the parasite efficacy drugs are available: praziquantel is effective for opisthorciasis, schistosomiasis.DEC has been identified in Thailand for bancroftiasis. Albendazole can treat intestinal helminths (geohelminthiasis). This effort must be continued to maintain the results at this level.

References

Introduction

Markell, E.K. & Voge, M. –1976 Medical Parasitology. Fourth Edition W.B. Saunders Company, 391 pp.

Jongsuksantikul P, Chaeychomsri W., Techamontrikul, P. *et al.*, 1992. Study on prevalence and intensity of intestinal helminthiasis and opisthorchiasis, *J. Trop. Med. Parasitol.* 15 , 80-95.

Opisthorchiasis

Kurathong et al., 1987

Jongsukuntigul, & Imsomboon, T. 1998 Epidemiology of opisthorchiasis and national control program in Thailand, *Southeast Asian J. Trop. Med. Public Health, 29 (2) : 327-332*

Khamboonruang, P, 1991 On emerging problems in food –borne parasitic zoonosis : impact on agriculture and public health. *Southeast Asian J. Trop. Med. Public Health,* 22 (suppl.) : 1-7

Radomyos, B., Wongsaroj, T., Wilairatana, P., Radomyos, P., Praevanich R., Meesomboon, V. & Jonguksuntikul, P., 1998 Opisthorchiasis and intestinal fluke infections in Northern Thailand, *Southeast Asian J. Trop. Med. Public Health, 29 N°1 123-127*

Pungpak S., Riganti, M., Bunnang D. & Harinasuta, T., 1985, clinical features in severe *Opisthorchiasis viverrini****,*** *Southeast Asian J. Trop. Med. Public Health,* 16 (3) 405-409

Jongsuksantikul P, Chaeychomsri W., Techamontrikul, P. *et al*., 1992. Study on prevalence and intensity of intestinal helminthiasis and opisthorchiasis*, J. Trop. Med. Parasitol*. 15 , 80-95

Ramasoota T, 1991 Current status of food-borne parasitic zoon,oses in Thailand *Southeast Asian J. Trop. Med. Public Health, 22 (suppl.) 23-6*

Wongsaroj, T., Jongsuksuntigul, Meesomboon, V., Kitikon, V. 1999 Opisthorchiosis control program in the Northern part of Thailand.: 1. Study on natural infection of opisthorchis viverrini and small intestinal flukes (Heterophyyidae) in cyprinoid fish in the Northern part of thailand in 1997, Joint international tropical Medicine Meeting 1999

Meesomboon & Jongsuksuntigul, PM. 1997 Situation in Thailand at the end of 7th National public Health Development plan. Report of the division of general communicable Diseases Control, 1997

Harinasuta, C. & Vajjrasthira S., 1991 Opisthorchiasis in Thailand. *Ann.trop. Med. Parasitol*., 54 : 100-5

Wykoff, D.E., Harinasuta, C., Juttijudata, P. & Winn, M.M., 1965 Opisthorcis viverrini in Thailand. The life cycle and comparison with O. felineus. *J. Parasitol*, 51 : 207-214

Lohachit, C. Snails mediated opisthorchiasis viverrini,

Waigakull J., 1998-Opisthorchiasis viverrini metacercaria in thai freshwater fish *Southeast Asian J. Trop. Med. Public Health, 29* : 324-6

Changbumrang, S., Migasena, P., Supawan, V. Et al., Impact of opisthorchiasis to health and nutritional status Joint International tropical Medecine Meeting,

Sukontason, K.L., Sukontason, K., Piangjai, S., Pungpak, S. & Radomyos, P., 2001 Prevalence of Opisthorchis viverrini infection among villagers harboring opisthorchis-like eggs *Southeast Asian J. Trop. Med. Public Health, 32 (suppl.2) 23-26*

Khamboonruang, C., Keawvichit, R., Wongworapat, K., Suwanrangsi S., Hongpromyart, M., Sukhawat, K., Tonguthai, K. & Lima dos Santos, CAM, Application of Hazard analyzis critical control point (HACCP) as a possible control measure for Opistorchis viverrini infection in cultured carp (*Puntius gonionotus*) *Southeast Asian J. Trop. Med. Public Health,* 28 (1) : 65-72

Gnathosomiasis

Daengsvang S., 1980 Monograph on the genus *Gnathostoma* and Gnathostomiasis in Thailand Tokyo: *Southeast Asian Medical information Center, 4-53*

P, Nuamtanong S, Rojanakittikoon V, Yaemput S, Dekumyoy P, Akahane H, Kojima S. 1.Gnathostomiasis in Thailand: a survey on intermediate hosts of Gnathostoma spp. with special reference to a new type of larvae found in Fluta alba

Vejjajiva A, 1978 Parasitic diseases of the nervous system in Thailand. *Clin. Exp. Neurol.,* 15 : 92-7

Schmutzhard, E. & Boogird, P *et al* -1988 eosinophilic meningitis and radiculomyelitis in Thailand caused by CNS invasion of *Gnathostoma spinigerum* and *Angiostrongylus cantonensis J. Neurol. Neurosurg Pscychiatry, 51 (1) : 80-7*

Rojekittikhun, W, Pubampen, S., *et al.,* 1998 Seasonal variation in the intensity of Gnathostoma larvae in swamp eels (*Fluta alba*) sold in a local market in Bangkok , *Southeast Asian J. Trop. Med. Public Health* 29 (1) 148 153

Daengsvang S., 1981- Gnathostomiasis in Southeast Asia : *Southeast Asian J. Trop. Med. Public Health*, 12 : 319-332

Rojekittikhun W, Pubampen, S., Hiranyachattada., P. Chiamratana, B., Setasuban PM., A survey of the infective larvae of Gnathostoma spinigerum in fresh-water-fish sold in the local markeyts of Bangkok*. J. Trop Med. Parasito*l, 12 : 7-12

Rojekittikhun, Chaiyasith, T., Nuamtanong, S., Pubampen, S., Maipanich W., Tungtrongchitr, R., 2002 Gnathostoma infection in Nakhon Nayok and Prachin Buri, Central Thailand. *Southeast Asian J. Trop. Med. Public Health*, 33 (3) 474-484

Nuamtanong, S., Waikagul, J., Anantaphruti, M.T., 1998 Gnathostome infection in swamp eels, Fluta alba, in Central thailand, *Southeast Asian J. Trop. Med. Public Health*, 29 (1) :144-147

Setasuban, P., Nuamtanong, S., Rojanakittikoon, V., Yaemput, S., Dekumyoy, P., Akahanz, H., Kojima, S , 1991 Gnathostoma in Thailand a survey on intermediate hosts of Gnathostoma spp. With special reference to a new type of larvae found in *Fluta alba Southeast Asian J. Trop. Med. Public Health, 22 suppl. 220-4*

Rhittibaed, C. & Daengsvang, S. 1937 A case of blindness caused by Gnathostoma spinigerum. *J. Med. Assoc Thai*, 19 : 84O

Saksirisampant, W. & Kukaew, K. *et al*. 2002 A survey of the infective larvae of *Gnathostoma spinigerum* in swamp eels bought in a local market in Bangkok, Thailand, *Ann. Trop. Med. Parasitol*., 96 (2) 191-195

Paragonimiasis

Daengsvang, S., Papasarathorn, T., Tongkoom, B. 1964 Paragonimus westermani (Kerbert, 1878) in Thai leopards. *Ann. Trop. Med. Parasitol*

Inkatanuvat, S., Suntharasamai et al;, 1998- Changes of liver finctions after albendazole treatment in human gnathostomiasis J. Med. Assoc. Thai, 81 (10) : 735-40

Naiyanetr, P 1998 Medical importance crabs in Thailand, *Joint international Tropical Medicine Meeting*

Pannarunothai S, Sukmuang, U., Tiloklert, M. *et.al*. 1988 Paragonimiasiasis at Nernmaprang district, Phitsanulok province, Thailand region six *Med. J*. 2 1-8

Prommas C., 1928 Paragonimiasis, opisthorchiasis and madura foot, *J. Med. Assoc. Thai*, 11 : 67-71

Waree, P., Polseela, P., Pannarunothai S., Piptgool, V., 2001 The present situation of paragonimiasis in endemic area in Phitsanulok, *Southeast Asian J. Trop. Med. Public Health,* 32 suppl. 2 : 51-54

Bancroftiasis

Bhumiratana, A., Wattananakull, B., Koyadun, S., Suvannadabba, S., Rojanapremsuk, J., Tantiwattanasup, W., 2002 Relationship between Male hydrocele and infection prevalences in clustered communities with uncertain transmission of *Wuchereria bancrofti* on the Thailand-Myanmar border, *Southeast Asian J. Trop. Med. Public Health,* 33 (1): 7-17

Jitpakdi A., Choochote, W., Panart, P., Tookyang, B., Panart, K. & Prajakwong S., 1998 Possible transmission off two types of Wuchereria bancrofti in Muang District, Chiang Mai, Northern Thailand, *Southeast Asian J. Trop. Med. Public Health, 29 (1) : 141_143*

Khamboonruang C, Sukhavat K, Pan-In S, Choochote W, Somboon P, Keha P, Muangyimpong Y 1989 Bancroftian filariasis in Tambol Na-Sai, Amphoe Li, Lamphun Province: a preliminary survey for microfilaraemia.. *J. Med. Assoc thai*, 72 (6) : 321-4

Khamboonruang C, Thitasut P, Pan-In S, Morakote N, Choochote W, Somboon P, Keha P, 1987 Filariasis in Tak Province, northwest Thailand: the presence of subperiodic variant Wuchereria bancrofti , *Southeast Asian J. Trop. Med. Public Health, 18 (2) : 218-222*

Riyong, D., Choochote, W., Jitpakdi, A., Suvannadabba, S., Leemingsawat & Chaithong , U.-2000 Autogenous Aedes togoi sub colony (Chanthaburi) in Thailand strain), an efficient laboratory vector in study of filariasis, *Southeast Asian J. Trop. Med. Public Health,* 31 (2) : 246-251

Suvannadabba S. 1993 Current status of filariasis in Thailand *Southeast Asian J. Trop. Med. Public Health 24 suppl.2 : 5-*

Triteeraprapab, S. & Songtrus, J., 1999 high Prevalence of Bancroftian filariasis in Myanmar-migrant workers : a study in Mae Sot district, Tak Province, Thailand *J. Med Assoc. Thai* **82** (7) 735-9

Triteeraprapab, S. & Nuchprayoon, K. 2001 High prevalence of Wuchereria bancrofti infection among Myanmar migrants *Ann. Trop. Med. Parasitol*, , 95 (5) : 535-8

Triteeraprapab S., Karnjanopas K. *et al*., 2000 Transmission of the nocturnal periodic strain of *Wuchereria bancrofti* by *Culex quinquefasciatus* : establishing the potential for urban filariasis in Thailand *Epidemiol.infect,* 125 (1) : 207-212

Triteeraprapab, S. & Nuchprayoon, K. 2001 High prevalence of Wuchereria bancrofti infection among Myanmar migrants *Ann. Trop. Med. Parasitol*, 95 (5) : 535-8

Schistosomiasis

Attwood, S.W., 1994 Rates of recruitment among populations of the freshwater snail *Neotricula aperta* (Temcharoen) in North East Thailand*. J. Moll. Stud*., 60 : 197-200

Attwood, S.W., 1996 Changes in Neotricula beta-aperta population density following construction of the Pak Mun dam in northeast Thailand, with implications for the transmission of schistosomiasis *Southeast Asian J. Trop. Med. Public Health,* 27 (1) 24-8

Attwood , S.W. & Kitikon, V. *et al*., 1997 Infectivity of a Cambodian isolate of Schistosoma mekongi to *Neotricula aperta* from northeast Thailand *J. Helminthology*, 71 (3) : 183-7

Iijima, T., Lo CT, Ito, Y. , 1971 Studies on schistosomiasis in the Mekong Basin. 1. Morphological observation of the schistosomes and detection of their reservoir hosts*. Jpn. J. Parasitol.* : 20 : 24-33

Matsumoto, J., Muth, S., Socheat D. & Matsuda H., 2002 The first reported cases of Canine *Schistosomiasis mekongi* in Cambodia. *Southeast Asian J. Trop. Med. Public Health,* 33 (3) : 458-461

Stich, A.H.R., Byas, S. Odermatt, P. et al., 1999, Foci of *Schistosomiasis mekongi*, Northern Cambodia : II. Distribution of infection and morbidity. *Trop. Med Intl Health*., 4 674-85

Urbani, C., Sinoun M. *et al*., 2002 Epidemiology and control of mekongi schistosomiasis *Acta trop*., 82 (2) : 157-168

Wongsaroj, T., Meesomboon, V. Phatihatakorn, W. Kitikoon V. 1999 Surveillance and prevention of Schistosomiasis program in the vicinity of pakmoon dam community and its related areas ubon Ratchattani Province thailand: 1. The study and survey of animal reservoir hosts of *Schistosomiasis mekongi* in 1997 *Joint international Tropical Medecine Meeting*

Others intestinal helminths

Preuksaraj, S., Jeradit, C., Sathiyathai, A., Kijvannee, S., Sudonrusmi, T., 1982 Studies on prevalence and intensity of intestinal helminthic infection in the rural population of Thailand. *Commun. Dis. J*. 8 : 244-68

Enterobius vermicularis (pinworm)

Nithikathkul, C., Changsap, B., Wannapinyosheep, Poister, C. & Boontan, 2001 a- The prevalence of *Enterobius vermicularis* among primary school students in Samut prakan province, thailand, . *Southeast Asian J. Trop. Med. Public Health, 32 (suppl.2) :* 133-137

Nithikathkul, C., Changsap, B., *et al.,* 2001 b- the prevalence of enterobiasis in children attending mobile health clinic of Huachiew Chalermprakiet University, *Southeast Asian J. Trop. Med. Public Health*, 32 (Suppl.2) : 138-142

Angiostrongyliasis

Chotmongkol & Sawanyawisuth, 2002 Clinical manifestations and outcome of patients with severe eosinophilic meningoencephalitis presumably caused by *Angiostrongylus cantonensis, Southeast Asian J. Trop. Med. Public Health, 33 (2) :* 231-234

Ancylostomiasis

Anantaphruti, M., Maipanich, W., Muennoo, C., , Pubampen, S., Sanguankiat, S., 2002- Hookworm infections of schoochildren in southern Thailand, *Southeast Asian J. Trop. Med. Public Health,* 33 (3) : 468-473

Chotmongkol, V. & Sawanyawisuth, K. –2002 Clinical manifestations and outcome of patients with severe eosinophilic meningoencephalitizes presumably caused by *Angiostrongylus cantonensis Southeast Asian J. Trop. Med. Public Health, 33 (2) : 231-4*

Radomyos, Tungtrongchitr, 1994, Occurence of the infective stage of *Angiostrongylus cantonensis* in the yellow tree monitor (*Varanus bengalensis*, in five Provinces of Thailand *Southeast Asian J. Trop. Med. Public Health, 25 (3) : 498-500*

Tsai, T.H., Liu, Y.C *et al*., 2001- an outbreak of meningitis caused by Angiostrongylus cantonensis in Kaohsiung. *J. Microbiol. Immuno Infect* 34 (1) : 50-6

Petjom, S., Chaiwun, B. *et al*., 2002 Angistrongylus cantonensis infection mimicking a spinal cord tumor *Ann. Neurol*., 52 (1) : 99-101

Waikagul, J., Krudsood, S., Radomyos, P¨., Radomyos, B., Chalemrut, K., Jonsuksuntigul, Kojima, S., Looareesuwan, S., Thaineau, W. , 2002 A cross-sectional study of intestinal parasitic infections among children in Nan province, Northern Thailand, *Southeast Asian J. Trop. Med. Public Health,* 33 : 218-223

Haplorchis taichui (Heterophyidae)

Radomyos, B., Wongsaroj, T., Wilairatana, P., Radomyos, P., Praevanich R., Meesomboon, V. & Jonguksuntikul, P., 1998 Opisthorchiasis and intestinal fluke infections in Northern Thailand, Southeast Asian J. Trop. Med. Public Health, 29 N°1 123-127

Sukontason, K.L. & Sukontason et al;, 2001 Intensity of trematode metacercaria in Ciprinoid fish in Chiang Mai *Southeast Asian J. Trop. Med. Public Health, 32 (2) :* 214-217

Strongyloidiasis

Anantaphruti, M.T. , Nuamtanong, S. et al., 2000 *Strongyloides stercoralis* infection and chronological changes of other soil-transmitted helminthiasis in an endemic area of Southern Thailand *Southeast Asian J. Trop. Med. Public Health, 31 (2) :* 378-382

Trichuriasis

Trichuris trichiura (Anantaphruti, Nuamtanong, et al., 2000)

Minute flukes

Waigakul, J., Wongsaroj, T., Radomyos, P. et al., 1998- human infection of Centrocestus caninus in Thailand. Southeast Asian J. Trop. Med. Public Health, 28 : 831-5

Table 2: Public Health Region within Chao Phraya Basin

Public Health Region	Province	Public Health Region	Province
1	1. Nonthaburi	8	1. Nakhon Sawan
	2. Pathum Thani		2. U-Thai Thani
	3. Ayuthaya		3. Tak
	4. Ang Thong		4. Sukhothai
	5. Samut Prakan		5. Kampaeng Phet
2	1. Saraburi	9	1. Phitsanulok
	2. Lop Buri		2. Phichit
	3. Sing Buri		3. Phetchabun
	4. Chainat		4. Phrae
	5. Nakhon Nayok		5. Nan
	6. Suphan Buri		6. Uttaradit
3	1. Chon Buri	10	1. Chiang Mai
	2. Chachoengsao		2. Lampang
	3. Prachin Buri		3. Chian Rai
	4. Sra Kaeo		4. Phayao
	5. Trat		5. Lamphun
	6. Chanthaburi		6. Mae Hong Son
	7. Rayong	11	1. Nakhon Si Thammarat
4	1. Ratchaburi		2. Surat Thani
	2. Nakhon Pathom		3. Chumphon
	3. Kanchanaburi		4. Ranong
	4. Phetchaburi		5. Phang Nga
	5. Prachoap Khiri Khan		6. Phuket
	6. Samut Sakhon		7. Krabi
	7. Samut Songkhram	12	1. Songkhla
5	1. Nakhon Ratchasima		2. Phatthalung
	2. Chaiyaphum		3. Trang
	3. Buri Ram		4. Satun
	4. Surin		5. Yala
	5. Maha Sarakham		6. Pattani
6	1. Khon Kaen		7. Narathiwat
	2. Loei		
	3. Nongkhai		
	4. Udon Thani		
	5. Nong Bua Lamphu		
	6. Sakon Nakhon		
	7. Kalasin		
7	1. Ubon Ratchathani		
	2. Amnat Charoen		
	3. Nakhon Phanom		
	4. Mukdahan		
	5. Roi Et		
	6. Si Sa Ket		

	7. Yasothon		

Chapter 5

Directly transmitted WBID and enteric diseases

5.1. Introduction

Such diseases are dependent of water mostly for their transmission and spread because the pathogens can survive on water and consequently water appears as a reservoir or passive vector of the pathogens.

Some Water Borne Enteric illnesses

Type of pathogen	Disease	Agent	Water Borne	Present in Thailand
Parasite	Amebiasis	Entamoeba hystolitica	Drinking water of contaminated food	
	Blastocystoses	Blastocystis hominis		
	Giardiasis	Giardia	Drinking water	
	Campylobacteriosis	Campilobacter jejuni		
Bacteria	Cholera	Vibrio cholerae		
	Cryptosporidiosis	Cryptosporidium	Drinking water	
Bacteria	Colibacillosis	*Escherichia coli* 0157:H7	Drinking water	
Bacteria		Helicobacter pilory		
Bacteria	Listeriosis	Listeria monocytogenes		
Virus		Norwalk virus		
Virus		Rotavirus		
Bacteria	Salmonellosis	*Salmonella enteritidis*		
Bacteria	Shigellosis	Shigella		
Bacteria	Typhoid	Salmonella typhi		

5.2. Cholera

Cholera is an acute intestinal infection caused by the bacterium *Vibrio cholerae*. It has a short incubation period, from less than one day to five days, and produces an enterotoxin that causes a watery diarrhoea that can quickly lead to severe dehydration due to loss of fluid and salts through profuse diarrhea and, to a lesser extent, through vomiting and death if treatment is not promptly given. Most infected persons have no symptoms or only mild diarrhea. Cholera occurs in many of the developing countries of Africa and Asia, where sanitary conditions are less than optimal. The organism that causes the illness is named Vibrio cholerae type O:1 or O:139. During epidemics, it is spread by ingestion of food or water contaminated directly or indirectly by feces or vomit from infected persons. Diagnosis is made by culturing the bacteria from the stool of a patient and confirming that the organism produces toxin.

5.2.1. The Natural cycle of the disease

Cholera is spread by contaminated water and food. Sudden large outbreaks are usually caused by a contaminated water supply. Only rarely is cholera transmitted by direct person-to-person contact. In highly endemic areas, it is mainly a disease of young children, although breastfeeding infants are rarely affected. Vibrio cholerae is often found in the aquatic environment and is part of the normal flora of brackish water and estuaries. It is often associated with algal blooms (plankton), which are influenced by the temperature of the water. Human beings are also one of the reservoirs of the pathogenic form of Vibrio cholerae.

5.1.2. Population vulnerability

The Spread and dynamics of the disease (endemic and epidemics) The vibrio responsible for the seventh pandemic, now in progress, is known as V. cholerae O1, biotype El Tor. The current seventh pandemic began in 1961 when the vibrio first appeared as a cause of epidemic cholera in Celebes (Sulawesi), Indonesia. The disease then spread rapidly to other countries of eastern Asia and reached Bangladesh in 1963, India in 1964, and the USSR, Iran and Iraq in 1965-1966.

In 1970 cholera invaded West Africa and in 1991 Latin America, where after been absent for more than a century.

Until 1992, only V. cholerae serogroup O1 caused epidemic cholera. Some other serogroups could cause sporadic cases of diarrhoea, but not epidemic cholera. Late that year, however, large outbreaks of cholera began in India and Bangladesh that were caused by a previously unrecognized serogroup of V. cholerae, designated O139, synonym Bengal. Isolation of this vibrio has now been reported from 11 countries in South-East Asia. It is still unclear whether V. cholerae O139 will extend to other regions, and careful epidemiological monitoring of the situation is being maintained.

5.2.3. Control and prevention

The best protection is to avoid consuming food or water that may be contaminated with feces or vomit from infected persons. The organism can grow well in some foods, such as rice, but it will not grow or survive in very acidic foods, including carbonated beverages, and is killed by heat. Most persons infected with V. cholerae do not become ill, although the bacterium is present in their faeces for 7-14 days. When illness does occur, more than 90% of episodes are of mild or moderate severity and are difficult to distinguish clinically from other types of acute diarrhoea. Less than 10% of ill persons develop typical cholera with signs of moderate or severe dehydration.

At the present time, the manufacture and sale of the only licensed cholera vaccine in the United States (Wyeth-Ayerst) has been discontinued. It has not been recommended for travellers because of the brief and incomplete immunity if offers. No cholera vaccination requirements exist for entry or exit in any country.

Two recently developed vaccines for cholera are licensed and available in other countries (Dukoral®, Biotec AB and Mutacol®, Berna). Both vaccines appear to provide a somewhat better immunity and fewer side-effects than the previously available vaccine

5.3. Enteric Diseases

Enteric disease encompasses a range of syndromes including diarrheal diseases, enteric fevers (Typhoid and paratyphoid), and intestinal parasitic infections. Eating, drinking or swallowing food or water contaminated with a pathogen germ contracts enteric diseases.

Escherichia coli

O157:H7: Detected in 1982, this bacterium is typically transmitted through contaminated food and has caused outbreaks of haemolytic uraemic syndrome in North America, Europe and Japan. A widespread outbreak in Japan in 1996 caused over 6 000 cases among school children, among whom two died. During a single outbreak in Scotland in 1996, 496 people fell ill, of whom 16 died.

Borrelia burgdorferi:

Detected in the USA in 1982 and identified as the cause of Lyme disease, this bacterium is now known to be endemic in North America and Europe and is transmitted to humans by ticks. Vibrio cholerae

O139: First detected in 1992 in India, this bacterium has since been reported in 7 countries in Asia. The emergence of a new serotype permits the organism to continue to spread and cause disease even in populations protected by antibodies generated in response to previous exposure to other serotypes of the same organism.

Rotavirus

Rotavirus is the most common cause of severe diarrhoeal disease in infants and young children all over the world, and is an important public health problem, particularly in developing countries.

Thyphoid fever

Typhoid fever is contracted when people eat food or drink water that has been infected with Salmonella typhi. It is recognized by the sudden onset of sustained fever, severe headache, nausea and severe loss of appetite. It is sometimes accompanied by hoarse cough and constipation or diarrhoea. Case-fatality rates of 10% can be reduced to less than 1% with appropriate antibiotic therapy. Paratyphoid fever shows similar symptoms, but tends to be milder and the case-fatality rate is much lower.

Salmonella

It was in 1885 that Daniel E. Salmon, U.S. veterinary surgeon, discovered the first strain of Salmonella. Today, there are 2213 known strains and the book is not closed. Over the years, antibiotic resistant strains have developed that are difficult to control and there is a body of evidence in the scientific literature suggesting the possibility that some of these strains may have emerged due to use of antibiotics in intensive animal husbandry. Recent years saw a dramatic rise both in terms of incidence and severity of cases of human salmonellosis; compared to 1980 some countries in Europe witnessed a staggering 20-fold increase in incidence in the last 10 - 15 years. Where the epidemic has been further studied, the majority of cases has been caused by strains or, more correctly, serotypes of Salmonellosis enteritidis and Salmonellosis typhimurium. The bad news is that since the beginning of the 1990s, strains of S. typhimurium, which are resistant to a range of antibiotics, have emerged and are threatening to become a serious public health problem. This is part of a general trend. The incidence of bacterial resistance has increased at an alarming pace in recent years and is expected to continue rising at a similar or even greater rate in the future as antimicrobial agents or antibiotics lose their effectiveness.

SALMONELLOSIS

Transmission: Salmonellosis in humans is contracted mainly through the consumption of raw or undercooked contaminated food of animal origin (mainly meat, poultry, eggs and milk) , although many other foods have been implicated in its transmission. The causative organisms pass through the food chain from primary production or through cross-contamination from food products in households or food-service establishments and institutions such as hospitals. In developed countries human to human transmission is uncommon but can occur, notably in institutions, for instance special-care baby units and residential homes for the elderly. Little is known about the epidemiology in developing countries but spread within hospitals and health centres has been reported.

A total of 2213 different salmonella strains have been identified. Epidemiologically, they can be classified according to their adaptation to human and animal hosts:

Group 1, e.g. Salmonella typhi and Salmonella paratyphi, causes enteric fever only in humans and in higher primates.

Group 2 causes disease in certain animals: Salmonella dublin in cattle, Salmonella cholerae-suis in pigs, but only infrequently in humans. However, when these strains do cause disease in humans, it is often invasive and can be life-threatening.

Group 3 includes the remaining strains. Typically, such strains cause gastroenteritis which is often mild and self-limiting but can be severe in the young, the elderly, and patients with weakened resistance against infectious diseases. This group features Salmonella enteriditis and Salmonella typhimurium, the two most important strains for salmonellosis (transmitted from animals to humans).