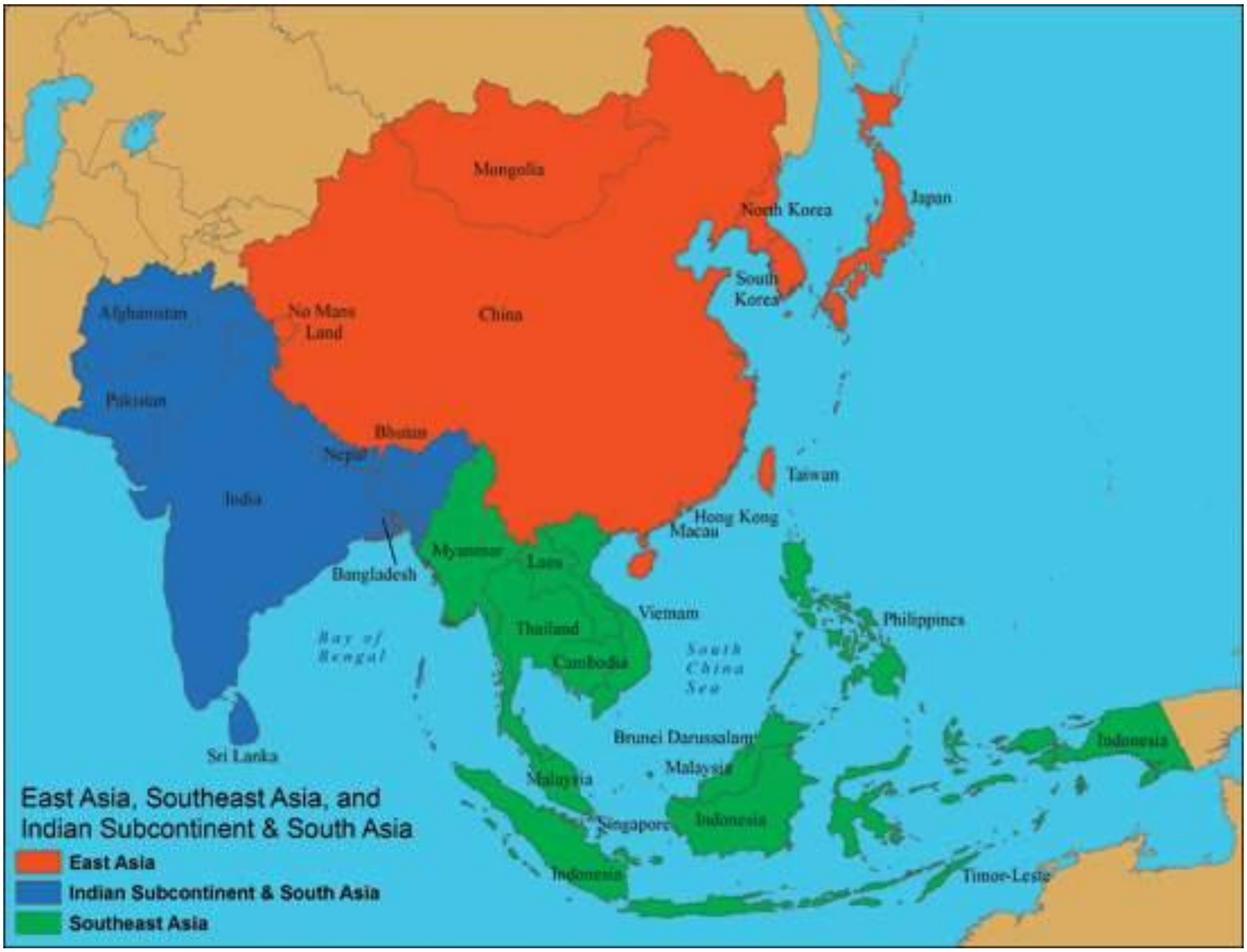
Regional
Disease Vector Ecology Profile

Southeast Asia



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I. **PREFACE**

Disease Vector Ecology Profiles (DVEPs) summarize unclassified literature on medically important arthropods, vertebrates and plants that may adversely affect troops in specific countries or regions of the world. Primary emphasis is on the epidemiology of arthropod-borne diseases and the bionomics and control of disease vectors. DVEPs have proven to be of significant value to commanders, medical planners, preventive medicine personnel, and particularly medical entomologists. These people use the information condensed in DVEPs to help plan and implement prevention and control measures to protect deployed forces from disease, injury, and annoyance caused by vectors and pests. Because the DVEP target audience is also responsible for protecting troops from venomous animals and poisonous plants, as well as zoonotic diseases for which arthropod vectors are unknown, limited material is provided on poisonous snakes, noxious plants, and rodent-borne diseases such as leptospirosis.

In this document vector-borne diseases are presented in two groups: those with immediate impact on military operations (incubation period <15 days) and those with delayed impact on military operations (incubation period >15 days). For each disease, information is presented on military importance, transmission cycle, vector profiles, and vector surveillance and suppression. Some Tables and Appendices in this DEVP include three-letter abbreviations for the 11 included countries, listed in alphabetic order, as follows: Bru = Brunei-Darussalam, Cam = Cambodia, Ind = Indonesia, Lao = Laos, Mal = Malaysia, Mya = Myanmar, Phi = the Philippines, Sin = Singapore, Tha = Thailand, Tim = Timor-Leste, and Vie = Vietnam. Additional information on venomous vertebrates and noxious plants is available in the National Center for Medical Intelligence (NCMI), formerly the Armed Forces Medical Intelligence Center (AFMIC); Medical, Environmental, Disease Intelligence, and Countermeasures (MEDIC) CD-ROM. That CD-ROM is updated several time per year and it can be downloaded by anyone accessing it from a website which ends in -.mil or -.gov. The link to access the MEDIC and related documents on the NCMI website is "https://www.intelink.gov/ncmi/medic_downloadable.php". Further information may be found on publicly accessible websites like www.who.org , or www.cdc.gov.

Contingency Operations Assistance: The Armed Forces Pest Management Board (AFPMB) has a Contingency Liaison Officer (CLO), who can help identify appropriate DoD personnel, equipment, and supplies needed for vector surveillance or control during contingencies. Contact the CLO at Tel: (301) 295-8312, DSN: 295-8312, or Fax: (301) 295-7473.

Information Services Division (ISD) Services: Besides DVEPs, the ISD publishes Technical Guides (TGs) and develops other information aids which are posted on the AFPMB website: www.afpmb.org . ISD can provide online literature searches of databases on pest management, medical entomology, pest identification, pesticide toxicology, venomous snakes, poisonous plants and other biomedical topics. Contact ISD at Tel: (301) 295-7476, DSN: 295-7476, or Fax: (301) 295-7473. This DVEP is available to be downloaded as a PDF file on the AFPMB website.

Other Sources of Information: The epidemiologies of arthropod-borne diseases are constantly changing, especially in developing countries undergoing rapid growth, ecological change, and/or large migrations of refugee populations resulting from civil strife. In addition, diseases are underreported in developing countries with poor public health infrastructures. Therefore, DVEPs should be supplemented with the most current information on public health and geographic medicine. Users may obtain current disease risk assessments, additional information on parasitic and infectious diseases, and other aspects of medical intelligence from the NCMI, Fort Detrick, Frederick, MD 21701, Tel: (301) 619-7574, DSN: 343-7574.

Information is also available from the Navy and Marine Corps Public Health Center (NMCPHC) at Tel: (757) 762-5500, after hours at (757) 621-1967, DSN: 253-5500, or Fax: (757) 444-3672, or from the Defense Environmental Network and Information Exchange (DENIX). Their homepage address is: <http://denix.army.mil/denix/denix.html>.

Specimen Identification Services: Specimen identification services and taxonomic keys for mosquitoes and certain other vectors can be obtained from the Walter Reed Biosystematics Unit (WRBU), Museum Support Center, MRC-534, Smithsonian Institution, Washington, DC 20560 USA; Tel: (301) 238-1077; Fax: (301) 238-3168; e-mail: <mailto:wrbu@wrbu.si.edu>; homepage: <http://wrbu.si.edu/>.

Emergency Procurement of Insect Repellents, Pesticides and Equipment: Deploying forces often need pesticides and equipment on short notice. The Defense Logistics Agency (DLA) has established an Emergency Supply Operations Center (ESOC) to provide equipment and supplies to deploying forces with urgent requirements and in a timely manner.

For insect repellents, pesticides, pesticide application equipment, personal protection equipment (bednets, head nets, *etc*.) and respirators:

Contact the DLA Customer Interaction Center, DLA Contact Center, at Tel: 1-877-352-2255 or DSN: 661-7766. They are open 24/7 365 days a year for all customer inquiries and submittal of requisitions. Email and related info is listed below:

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Every effort is made to ensure the accuracy of the information contained in DVEPs. Individuals having additional information, corrections, or suggestions, are encouraged to provide them to the Chief, ISD, AFPMB, Fort Detrick / Forest Glen Annex, Walter Reed Army Medical Center, Washington, **DC** 20307-5001, Tel: (301) 295-7476, DSN: 295-7476, or Fax: (301) 295-7473.

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EXECUTIVE SUMMARY

Southeast Asia Profile.

Geography. Southeast Asia encompasses almost 4.38 million sq km of land. Its topography includes rugged high mountains (over 4,000 m elevation) in far northern Myanmar, throughout most of northern Laos, and ranges of lower but still fairly rugged mountains and their foothills running roughly north and south in eastern Myanmar and western Thailand, from China down most of the length of western Vietnam and adjacent Laos and Cambodia, plus ranges or single volcanic peaks at over 2,500 m elevation on the larger islands of Indonesia (especially Irian Jaya, in Kalimantan on Borneo, Java, and Sumatra), Malaysia, and the Philippines. There are high plateaus in north-central Myanmar, eastern Thailand, northern and central Laos, eastern Cambodia and south-central Vietnam. Several major rivers drain the mainland countries of Southeast Asia, including the Irrawaddy and Salween in Myanmar; the Mekong in Laos, Thailand, Cambodia and southern Vietnam; and the Red River in northern Vietnam. These and numerous smaller rivers run through rich valleys or flood plains which support most of the region's agriculture. Low coastal plains up to 200 m elevation occupy about 15% of the total land area.

The highest point in the region is 5881 m at Hkakabo Razi in far northern Myanmar near the Chinese border; and the lowest point is 0 m elevation (mean sea level) at any given location along the extensive sea shores of nearly all the countries in the region (only Laos is landlocked). The two largest archipelagic nations in the world are in Southeast Asia. Indonesia includes >18,000 islands and the Philippines include >7,000. Many of the mountains and hilly areas are quite rugged and forested; and valleys and rivers are often narrow and winding throughout the region; while roads are often limited, unpaved and not well maintained, making transportation and travel difficult.

Most of the countries in Southeast Asia have an economy that is currently based on, or is progressing toward, a capitalistic system. Even Vietnam's classic communist-style government has recently significantly liberalized its economic policies and, since 1995, it has officially encouraged tourism. All Southeast Asian countries have relatively old civilizations with well-established and in some countries very diverse, cultural, religious (mainly Buddhist, Muslim, or Christian), ethnic (*e.g.*, Chinese, Malayo-Indian, Khmer, Austronesian), and family or tribal customs, ceremonies, beliefs, and practices.

All of the larger countries in this region have significant natural resources (mainly oil, natural gas, timber, or metal or mineral ores) but, these vary by country and often have not yet been very well developed. Labor is relatively cheap throughout most of the region, and several of these countries depend on production and export of labor-intensive or light industrial products, such as electronics, textiles, handicrafts, processed food and toys. Many of these countries must import most of their power, fuel, food, water, industrial raw materials, machinery, and manufactured goods (*e.g.*, Brunei, Cambodia, Laos, Singapore and Timor-Leste). Large numbers of people live in areas where they are exposed to tropical high temperatures and rainfall fluctuations, severe storms (often associated with monsoons or typhoons), earthquakes, landslides, occasional droughts, and flooding. Coastal areas are occasionally devastated by tsunamis.

Climate. The generally tropical climate of Southeast Asia varies from temperate to moderately cold in the northern regions, and on the highest mountains, to nearly constant, very warm, wet monsoons within 15 degrees latitude both north and south of the equator, which runs nearly through the middle of Indonesia. Most of the region has average daily temperatures of 18-30^{o} C all year (higher elevations are often 5-10^{o} C cooler). Some countries have distinct wet and dry seasons, but most have two rainy seasons a year, with different prevailing wind directions (*e.g.*, a northeastern and a later southwestern monsoon), and nearly all have at least some rain every month. Average total annual precipitation can vary from no more than 25 cm of rainfall (or equivalent) in higher elevations of northern Myanmar, Laos and Vietnam, to occasional totals of 500 cm a year in the Irrawaddy delta and on the western side of the Malay Peninsula. Monsoons periodically bring severe storms and flooding, causing many flood-related deaths every year in low coastal plains or in flood plains or deltas of large rivers in Cambodia, Indonesia, Malaysia, Myanmar, Thailand and Vietnam. Intense cyclonic storms can cause severe damage and loss of life, especially in coastal areas (*e.g.*, Cyclone Nargis, which struck Myanmar May 2, 2008). Sometimes, local or regional droughts caused by unusual weather patterns have caused serious famine or collapse of local agriculture, and rarely abandonment of remote villages in parts of Indonesia, Laos, Malaysia, northern Myanmar, Thailand, and Vietnam.

Population and Culture. Southeast Asia is home to almost 575 million people, mostly concentrated in major cities and along the fertile river valleys and coastal plains. Population density for the whole region averages 130.7 persons per sq km, but ranges from only 53 persons per sq km in Timor-Leste to 7,049 persons per sq km in Singapore. Several countries in this region have been occupied by humans for >100,000 years (*e.g.*, the Indonesian island of Java, and northern coastal Vietnam). The main current ethnic groups of most of these countries can trace their origins back many centuries: over 1,500 years for some Chinese and Malayo-Indians, over 2,800 years for the Khmer, at least 3,000 years for the Austronesians, and nearly 500 years for even the Dutch and Portugese. Multiple pulses of immigration into this region by various foreign populations have occurred over long periods of time, and many have left identifiable traces in the countries' current populations and cultures.

Southeast Asia's principal religions currently are: Buddhism, Taoism, Christianity (mainly Roman Catholic), Islam (Muslims), and animism (several local variations). Although Buddhism may marginally be the preference for the population of the region as a whole, each nation often has its own prevailing religion (and language). For example, Brunei and Indonesia both have a large majority of Muslims, Myanmar is overwhelmingly Buddhist, and both the Philippines and Timor-Leste are predominantly Roman Catholic. In most of the region, traditional religious, ethnic, and long-established family practices and customs strongly influence most people's daily lives, beliefs, and actions, especially in remote and rural sites. Most countries in the region are < 50% urbanized, but that ranges from 8% in Timor-Leste to 100% in Singapore. Literacy levels are difficult to determine, and may change rather quickly, but probably average higher than 70% for Southeast Asia, overall; and they vary a lot by country, currently from 59% in Timor-Leste to 93% in the Philippines and Singapore.

Sanitation and Living Conditions. Water is mainly drawn from surface sources such as shallow wells, catchments, streams or other raw water sources throughout most of Southeast Asia, especially rural sites. Supplies of potable water in many places are inadequate, are not adequately treated and are often contaminated via poorly maintained, inadequate or leaking public distribution systems. Waste disposal and sewage treatment are non-existent or grossly inadequate in most remote or rural sites, and even in some parts of major cities. In many countries, surface water sources, agricultural lands, and some ground waters and lines are routinely contaminated by organic or industrial wastes. This is especially true in rural, remote and some suburban sites in large cities like Bangkok or Rangoon. Effective distribution is often available in modern dwelling units in large cities, but mainly only to the rich, or government-associated families (*e.g.*, high-ranked military in Cambodia, Indonesia, or Myanmar).

These conditions are ideal for the maintenance and rapid distribution of a wide variety of water-borne pathogens and parasites of humans and domestic animals, and offer excellent breeding sites for a range of disease vectors. Municipal sewage systems exist only in major urban areas, and only a very small percentage of the total sewage is treated by such systems. Many untreated domestic wastes, garbage, industrial wastes, and mine tailings are dumped into open ditches and waterways or onto the ground. Pit latrines and septic tanks are found in some urban areas, but the most common method of excrement disposal in rural areas is still bucket or cart collection, usually followed by disposal into flooded rice paddies. These practices also ensure the attraction and maintenance of large populations of various parasites and disease vectors into places where people live.

Health care systems vary from country to country, but overall, high quality care and adequate modern facilities, equipment, and personnel are usually only available in larger cities. Rural or remote places in many countries may have few care givers, with limited training, supplies and facilities. Often, only traditional medicines, practices, and facilities are available or affordable, and care must be provided by a tribal shaman or a volunteer with no more than first aid level training. Current life expectancy at birth ranges from about 56 years in Laos to about 82 years in Singapore, and is at least 70 years in six other countries.

Education systems vary widely in this region, but all countries provide the majority of children with some amount of primary education. Secondary education is available to a majority of the children in only a few countries, and tertiary education is far less available in most countries. The curriculum content and the language in which classes are taught are sometimes rigidly controlled by the individual nation's government (*e.g*., Indonesia, Myanmar). In some countries certain ethnic groups are actively discriminated for or against. For examples, in Brunei, all Chinese persons are considered "classless" and are denied access to public schooling; and in Malaysia, a quota system specifically and officially favors Malays for all levels of government-supported schooling. Private schools or private funding for students or schools are important elements of the education system (*e.g.,* the Philippines and Vietnam, respectively).

Plastics, packaging materials, and potentially toxic substances are increasing components of the waste stream in most countries in this region. In suburban areas, unprocessed industrial waste and garbage are often piled up. In rural areas, refuse is often burned or disposed of indiscriminately. In industrialized areas, surface waters are also contaminated with chemical wastes, including high levels of potentially toxic metals, complex organic chemicals, and petroleum products. These contaminants pose a threat of both acute and chronic poisoning to humans and domestic animals.

Things that pollute water may include automobiles, manufacturing plants, power plants, and petroleum processing, chemical, or mining facilities. Ground water contaminants may include fertilizers, pesticides, or mining and industrial wastes. Major rivers in Southeast Asia often carry heavy silt loads due to deforestation and related soil erosion, causing a risk of silt-induced flood damage, especially in such places as the delta regions of the Mekong, Irrawaddy, and Red rivers. Coastal waters are sometimes polluted by raw sewage, oil, or industrial waste discharges from rivers or ocean-going ships moored or passing nearby. These materials may poison humans directly and kill many non-target organisms (*e.g.,* fish, waterfowl, aquatic plants).

Large "blooms" of certain marine organisms, called "red tides," that usually kill massive numbers of fish, may be associated with agricultural runoff and sometimes appear along coastlines (*e.g.,* in the Gulf of Thailand, or along the Vietnamese coast). Air pollution levels near and in some large industrialized cities (*e.g*., Bangkok, Jakarta) are high by U.S. standards. Large, uncontrolled forest fires in parts of Indonesia and Malaysia often put so much smoke and particulate matter into the air that they pose a health hazard to people in countries a long way down wind from them (*e.g*., Brunei, Singapore). These pollutant concentrations often exceed the World Health Organization (WHO) guidelines (230 $\mu g/m^3$ daily maximum).

Food sanitation practices in homes and commercial establishments throughout Southeast Asia are frequently inadequate by Western standards. These conditions and practices all combine to help ensure that a variety of food-borne and vector-borne pathogens are maintained and spread to humans and domestic animals. A large part of the human population of this region still lives in rural or remote locations, which may help minimize their exposure to industrial wastes, but reduces their potential to get quality modern health care in a timely manner. Because rural living conditions are fairly primitive in many areas, the people are more likely to be directly exposed to such new pathogens as the H5N1 Avian Influenza (bird flu), most often harbored and carried by wild and domestic birds.

Civil unrest, potential terrorist activities, frequent but unpredictable volcanic activity, deforestation, soil erosion, drug production and trafficking, sex tourism, and illegal trade in endangered species are additional concerns in Indonesia, Malaysia, Myanmar, the Philippines and Thailand. Occasionally, manmade problems can significantly impact large numbers of people or areas of a country. An industrial accident (during drilling of an exploratory well for natural gas) on May 28, 2006, near the town of Sidoarjo, in eastern Java, led to eruption of a mud volcano which is still spewing loose mud (Luci) at a rate of about 100,000 m^3 /day. This incident has reportedly killed 13 people, destroyed a town, and inundated >4 sq. mi. (>10 sq. km.), so far.

DIARRHEAL DISEASE

Gastrointestinal infections are highly endemic throughout Southeast Asia and are the principal disease threats to military personnel deployed to the region. Bacillary dysentery has profoundly impacted military operations throughout history. Fecal-oral transmission from person-to-person is common, but most infections are acquired from consuming contaminated food, water or ice. Filth flies can mechanically transmit pathogens to food, food contact surfaces and utensils. Fly populations sometimes grow very large during warm weather in areas with poor sanitation. Good sanitation and fly control can significantly reduce the risk of such gastrointestinal infections. Cockroaches can also mechanically transmit such pathogens.

Pathogens that can cause diarrheal disease include: *Staphylococcus aureus*, *Clostridium perfringens*, *Bacillus cereus*, *Vibrio parahaemolyticus*, many serotypes of *Salmonella*, *Shigella* spp., *Campylobacter*, pathogenic strains of *Escherichia coli*, hepatitis A and E, rotaviruses, *etc*. Infection with pathogenic protozoa, such as *Entamoeba histolytica*, *Giardia lamblia* and *Cryptosporidium* spp., is common, though bacterial pathogens cause most cases of diarrheal disease. Onset of symptoms is usually acute and may result in subclinical infections or severe gastroenteritis. *Shigella* infections can produce significant mortality even in hospitalized cases. Resistance of enteric pathogens to commonly used antibiotics can complicate treatment. Such resistance is common in many parts of Southeast Asia, including modern cities like Bangkok or Jakarta, and bacterial populations with resistance to multiple antibiotics have been reported.

MOSQUITO-BORNE DISEASE

Malaria transmission is endemic throughout the region, and transmission occurs nearly year round in most areas except at higher elevations (>500 m) and in the most northerly parts of Myanmar, Thailand, Laos and Vietnam. Vector mosquito activity and related intensity of transmission increase and decrease based on rainfall timing and patterns. These vary with the particular vector species, but are usually most intense during or shortly after peaks of rainfall in warm months. Strains of *Plasmodium falciparium* and *P*. *vivax* resistant to chemoprophylactic drugs have been reported to be fairly common and widespread in several countries, especially in parts of Laos, Cambodia, Vietnam, and along both sides of the northern half of the border between Myanmar and Thailand. At least 40 species of *Anopheles* mosquitoes transmit malaria in Southeast Asia. Many of these are species complexes and are still not well studied. Insecticide resistance is not regularly monitored, nor well reported, but historically there has been rather widespread resistance or tolerance by several species of vector mosquitoes to commonly used insecticides in this region. Anyone going into this region should do a search beforehand on websites of the WHO (www.who.org), the U.S. CDC (www.cdc.gov), or similar travellers' health sites, for the latest reported status and currently suggested chemoprophylactic drugs (and respective doses). Appropriate personal protective techniques should be used routinely to help prevent infection by any vectorborne disease(s) while in Southeast Asia. Malaria is definitely a significant threat to either short or long term military operations in this region.

Dengue virus (**DEN**) is widespread and essentially endemic throughout most of Southeast Asia. Periodic outbreaks of all four strains (serotypes) occur and tend to go through poorly defined cycles of transmission at roughly 10-15 year intervals. Both **dengue hemorrhagic fever (DHF)** and **dengue shock syndrome (DSS)** have been reported currently or very recently from every country in the region. Populations of the primary vector, *Aedes aegypti*, have greatly increased due partly to rapid and uncontrolled urbanization in much of Southeast Asia. *Aedes albopictus* is an important vector in more rural areas of the region. Dengue is a debilitating disease that would be a significant threat to military forces operating in the region.

Japanese encephalitis (JE) is a serious neurological disease that causes high morbidity and mortality throughout Asia. Periodic outbreaks of JE have occurred in rural and peri-urban areas in every country of Southeast Asia. The expansion of irrigation and rice growing in many areas has greatly increased populations of the primary mosquito vector, *Culex tritaeniorhynchus*, as well as other *Culex* vectors. The incidence of JE has decreased in most countries of the region due to extensive vaccination programs, but it remains highly enzootic in many parts of the region and is a threat to non-immune military personnel. Effective vaccines could limit the impact of this disease on military personnel operating in endemic areas.

Sporadic outbreaks of **chikungunya fever (CHIKV)** have been reported recently in Timor-Leste, Thailand, Myanmar, and the Philippines; and there has been a recent significant increase of cases in several sites in Indonesia. This disease is transmitted mainly by *Ae*. *aegypti* and related species. This virus can incapacitate large numbers of people in a short time. Due to its historically limited prevalence in Southeast Asia, chikungunya fever is currently less of a threat than dengue. A few cases of suspected **Sindbis virus** have been reported recently in Thailand, Cambodia, and Indonesia, but its enzootic status is unclear, and it would represent little threat to military personnel due to its mild symptoms and its apparently low prevalence in the region.

Bancroftian filariasis, caused by ***Wuchereria bancrofti***, and **Brugian filariasis**, caused by ***Brugia malayi***, are now lumped by the WHO as "**Lymphatic Filariasis**" (**LF**). According to the WHO in 2007, LF is currently endemic and widespread, and poses serious public health problems in Indonesia, Myanmar, the Philippines, Thailand, and Timor-Leste. It is also endemic in Cambodia, Malaysia, and Vietnam, but mapping of the populations at risk and pursuant programs of mass drug administration (MDA), using oral dosing with diethylcarbamazine citrate (DEC), are in progress in these countries, and seem to be reducing the levels of LF morbidity therein. Laos currently has only limited areas of endemic LF. The main vectors of Bancroftian filariasis, *Culex pallens* and *Cx. quinquefasciatus*, have become more abundant as breeding sites have been expanded due to increased urbanization and poor sanitation. Nocturnally periodic forms of *B. malayi* and *W. bancrofti* are also currently endemic in parts of the region. At least 14 different species of mosquitoes found in Southeast Asia are reported vectors of filariases (LF), including several *Anopheles* spp. A third species of filarial parasite, ***Brugia timori***, seems to be limited mainly to Timor, plus a few nearby islands in the Lesser Sundas. Its epidemiology, main vector mosquito species, human health impact, and observed responses to MDA are similar to those for *B. malayi*, but it may cause less severe symptoms.

TICK-BORNE DISEASE

Q fever is an acute, febrile rickettsial disease contracted mainly by inhaling airborne dust which includes the pathogen, *Coxiella burnettii*, or by direct contact with secretions of infected domestic animals. Certain tick species have been reported to be natural reservoirs of the pathogen. Transmission by ticks to humans is possible but apparently rarely occurs. Serological surveys indicate that Q fever is widespread throughout Southeast Asia and infects a wide variety of wild and domestic animals, especially sheep and goats. Even though most human cases are mild and self-limited, military personnel operating in this region should avoid exposure to sheep, goats, cattle and other domestic animals and should not sleep or rest in animal shelters.

Rare sporadic cases of **tick-borne relapsing fever**, caused by *Borrelia recurrentis*, have been reported from this region. The disease is enzootic in rocky, rural areas where livestock are tended and effective vector soft ticks, *Carios* spp., are present. The incidence of *B. recurrentis* is low and effective vector ticks are rare. Therefore, the military threat due to this disease is minimal.

MITE-BORNE DISEASE

Scrub typhus, caused by the rickettsia *Orientia tsutsugamushi*, is focally distributed throughout the region from coastal lowlands to over 1,500 m in the Himalayan foothills near the northern end of the Myanmar and Thailand border. The disease is transmitted by chigger mites of the genus *Leptotrombidium*, subgenus *Leptotrombidium*, that are mainly associated with rodents of the genus *Rattus*. Scrub typhus is prevalent in disturbed habitat characterized by secondary scrub vegetation and grasses. During World War II, it was a leading cause of morbidity in military personnel in the Asia-Pacific area. Although the overall incidence of human scrub typhus infection in Southeast Asia is hard to determine, it is enzootic in all countries of the region and is a significant threat to military forces in the field, especially in parts of Indonesia, Malaysia, and Thailand.

LOUSE-BORNE DISEASE

Epidemic typhus may still be endemic among poor people and tribes living in more remote rural areas and higher elevations of northern Myanmar, Thailand, Laos and Vietnam. Declining sanitary and living conditions caused by natural disasters, civil unrest, and illegal drug operations have increased the likelihood in such places that this, and other vector-borne diseases, may reemerge and be maintained there. Body lice are not uncommon in colder mountainous sites and in slums of large cities in Southeast Asia. Sporadic cases of **louse-borne relapsing fever** have also been reported from the region, which, like epidemic typhus, it is mainly a winter disease.

FLEA-BORNE DISEASE

Murine typhus is a rickettsial disease similar to louse-borne typhus but milder. It is enzootic at low levels at some places in this region in domestic rats and mice and possibly other small mammals. Infected rat fleas, mainly *Xenopsylla cheopis*, defecate infective rickettsiae while sucking blood, and airborne infections may occur. Fairly rare human cases have been reported throughout Southeast Asia. Enzootic **plague** is widespread and endemic in rural areas of Laos, Myanmar, and Vietnam. Most recent outbreaks in humans have resulted from hunting or handling infected small mammals or rodents and contacting their associated fleas. An important reservoir of the disease, *X. cheopis* is fairly common in Southeast Asia, especially associated with ports and urban areas. At least 2 other flea species common in the region are known to be competent plague vectors. A large number of other flea species and small mammals are involved in the complex cycle of wild rodent plague.

SAND FLY-BORNE DISEASE

Visceral leishmaniasis (VL) in humans is relatively rare in this region, but may be caused by two different parasites, *Leishmania donovani* and *Le. infantum*. It is a severe systemic disease and a threat to military personnel. In Southeast Asia, the most often reported species causing VL has been *Le. donovani* which is most likely spread by the anthropophilic sand fly species *Phlebotomus argentipes.* Recent cases have been reported from northwestern Myanmar, near its border with Bangladesh; 2 recent locally acquired (autochthonous) cases have occurred in Thailand. The suspected wild reservoir hosts include canids and related mammals. Transmission of leishmaniasis usually occurs in warmer months of the year, when the vectors are most active. The distribution of sand flies and the diseases they carry is often very focal because of the specialized habitats required by their larvae and the limited flight range of adults.

VERTEBRATE-BORNE DISEASE

Leptospirosis should be considered enzootic in most countries of Southeast Asia. The spirochete is transmitted when abraded skin or mucous membranes are contacted by water contaminated with urine of infected domestic and wild animals, especially rats. Military personnel would be at high risk of infection from this disease. Troops should never handle rodents and should not sleep or rest near rodent burrows or swim or bathe in stagnant pools or sluggish streams, or go into rice paddies unnecessarily.

Hantaviral diseases are an emerging public and military health threat in parts of Asia, but in this region, they are not very well documented, not routinely surveyed for, and apparently of lower incidence and importance than many other diseases (*e.g.*, malaria, dengue). Field rodents are reservoirs for several closely related viruses that can be transmitted to humans exposed to airborne pathogens from dried rodent urine or feces, through direct contact with those materials or on virus-contaminated eating utensils. Serological evidence of hantaviral infection has been detected in humans or wild animals in several countries in this region, including Indonesia, Malaysia, Thailand, and Vietnam. At least one mild form, referred to as hemorrhagic fever with renal syndrome (HFRS), caused by Hantaan virus and closely related viruses, is associated with wild rodents in open fields, rice paddies, or unforested habitats. At least one serotype reported from this region infects *Rattus norvegicus* and can cause clinical disease in humans.

. A few cases of **Nipah virus** have been reported recently from Malaysia, Indonesia and Singapore, but it is rather uncommon. This virus has been found at low incidence levels in a wide range of wild and domestic animals, from water buffalo to dogs, and is most commonly associated with either bats or swine. Transmission is reported to be mainly by direct contact of a susceptible animal (or human) with an infected animal. The epidemiology of Nipah virus would make it unlikely to have significant impact on military operations in this region.

Avian Flu virus (influenza A, H5N1) occurs naturally and is widespread in many and very diverse taxa of birds around the world. Some highly pathogenic strains of this virus emerged in Asia in 2003, and have since caused several epizootic outbreaks in wild and domestic birds, and have infected humans, too. Based on case reports since 2003, once humans develop a suite of serious symptoms due to H5N1, more than half of them die. Transmission is primarily via direct contact with an infected bird, or its excretions or secretions. So far, direct secondary transmission from human to human has not been carefully documented, but a few reports have strongly implied that may have happened. This virus, like many influenza A viruses, seems to change its genetic and behavioral characteristics and rapidly adapts to different hosts. If its transmissibility to and between humans increases, it could lead to a pandemic. Earliest symptoms of human cases usually include respiratory symptoms, fever, headache, myalgia, and coughing. A number of recent H5N1 outbreaks have occurred in Southeast Asia, with human cases and deaths in several countries including: Indonesia in 2006, and 2008; Thailand in 2004; and Vietnam in 2004, 2005, 2006, and 2009. For current information on avian flu and outbreak updates, go to: www.cdc.gov or www.who.org , and then search by appropriate topic or links.

SNAIL-BORNE DISEASE

Schistsomiasis. Worldwide, there are over 100 million people at risk of infection within schistosomiasis-endemic areas. There are two species of these parasitic bloodworms (schistosomes) which frequently cause serious human illness in Southeast Asia. They are: the *Schistosoma japonicum* complex, which still poses a major public health threat in large areas of Indonesia (especially Sulawesi) and the Philippines; and *Schistosoma mekongi*, which is indigenous to the main Mekong River system. It causes many human cases annually, but is life-threatening mainly to heavily infested young children, 5 years old or younger. Cases of *S. japonicum* have been reported sporadically from other nearby countries, but quite a few of those may have been imported cases in expatriate travelers. *Schistosoma mekongi* is highly endemic in Laos, Cambodia, and parts of Thailand and Vietnam. Good habitat for suitable host (vector) snail species is essential to maintaining the natural cycle of a given schistosome species. The main snails supporting *S. japonicum* are members of the genus *Oncomelania*, and those mainly supporting *S. mekongi* are certain members of the genera *Neotricula* and *Tricula*. Control or reduction of schistosomiasis must include treatment of human hosts and physical elimination, modification, or treatment of their main host snails' habitat.

CONJUNCTIVITIS

Bacterial and viral conjunctivitis is common in Southeast Asia and has epidemic potential. Enteroviruses have been implicated in some outbreaks. Trachoma is endemic in many coastal plain areas of Southeast Asia and is often spread mechanically by certain species of small flies or eye gnats (*e.g*., *Hippelates* spp.). Transmission is normally through contact with secretions of infected persons or contaminated articles. Several species of eye-frequenting moths, primarily in the family Noctuidae, are known from Southeast Asia which feed on the lacrimal secretions of wild or domestic animals as well as humans. Some species may actually actively take up blood from open wounds (maybe even physically helping to re-open recently formed soft scabs). These may also play a role in the transmission of ocular pathogens besides causing serious irritation.

VENOMOUS ANIMALS

More than 50 species of venomous terrestrial snakes and 19 species of venomous sea snakes representing four families are found in the Southeast Asian region. Some, such as the king cobra which can reach 18 feet in length, can be very intimidating and possess highly lethal venoms. The Okinawan habu, *Trimeresurus flavoviridis,* some cobra species, and the Brown Tree Snake sometimes enter houses. Snakebite and envenomation are serious risks in the region. Military personnel should be thoroughly briefed on the risk and prevention of snakebite, as well as the steps to take immediately after snakebite. Some effective snake antivenins are available.

Scorpions, centipedes and **widow spiders (*Latrodectus* spp.)** are common in many parts of Southeast Asia. *Scolopendra* species of centipedes can attain a length of over 20 cm and inflict a very painful bite if handled or stepped on. *Mesobuthus extremus* and *Mesobuthus martinsii* are the only notably toxic scorpions of 66 species reported in the region. The latter species may cause a variety of painful symptoms in adults, including neurological involvement. Death is usually limited to small children and persons who are already ill from another cause or are elderly. Scorpion stings rarely require hospitalization, although envenomation by widow spiders, especially *Latrodectus hasselti*, can be life threatening. Antivenins are available. Troops should be warned to not tease or play with snakes or scorpions.

> **A properly worn military uniform (*e.g.*, the Army Combat Uniform, or ACU) or work uniform, properly impregnated with permethrin, combined with use of extended duration DEET on exposed skin, has been demonstrated to provide nearly 100% protection against most blood-sucking arthropods. This combined use of highly effective repellents on the skin and clothing is termed the "DoD arthropod repellent system." It is the most important single method of protecting individuals against arthropod-borne diseases. Permethrin can also be applied to bednets, tents and screens to help prevent disease transmission by insects. The proper use of repellents is discussed in TG 36, Personal Protective Techniques Against Insects and Other Arthropods of Military Significance**.

Regional Map of Southeast Asia

Map of Brunei-Darussalam

Map of Cambodia

Map of Indonesia

Map of Lao Democratic People's Republic

Map of Malaysia

Map of Myanmar

Base 802499 (B01313) 8-96

Map of the Philippines

Base 801703 (R00150) 10-93

Map of Singapore

Map of Thailand

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Map of Timor-Leste

Map of Vietnam

VI. Country Profiles.

A. Brunei-Darussalam.

1. Geography. The Sultanate of Brunei, also called Brunei Darussalam, or Negara Brunei Darussalam, is slightly smaller than the U.S. state of Delaware, with land area of 5,270 sq km, including 500 sq km of inland water surface. It is divided into two unequal segments by a narrow strip of land, and is embedded within the Malaysian state of Sarawak on the northwestern coast of Borneo, 480 km north of the equator. The capital, Bandar Seri Begawan, lies on an inlet of Brunei Bay, near the northern tip of the larger western segment of the country. The flat coastal plain rises to mountains in the east and hilly lowlands in the west. Most of the country is at less than 200 m, but it ranges from 0 m (mean sea level) along 161 km of coastline on the South China Sea to 1,850 m, its highest point, on Bukit Pagon, near the farthest southeastern tip of the eastern segment of the country. There is very little arable land (about 2%), some permanent crops (about 1%) and a very small amount of irrigated land (about 10 sq km). Brunei is close to major sea transport lanes of the Indian and Pacific Oceans. It currently has large reserves of petroleum, natural gas and timber (rainforest covers about 80% of the country).

2. Climate. The climate is tropical, hot, humid and rainy. Daily ambient temperatures at Bandar Seri Begawan are fairly constant all year, ranging from about 24^{o}C in October to about 32^{o}C in April and May. Rainfall is frequent and usually ranges from about 12 cm per month in January and February to about 46 cm per month in October and November. The country has a long annual rainy season, with extremely high humidity from March through December. Typhoons, earthquakes, and serious flooding occur, but are rare. There are occasional seasonal problems with smoke or haze from forest fires at upwind sites in neighboring Indonesia or Malaysia. The UK currently maintains a small military presence (<1,000 persons) in Brunei, mainly to run a military jungle survival training school there.

3. Population and Culture. Brunei is one of the richest nations in the world, with a Gross Domestic Product (GDP) per capita of approximately (U.S.) $24,000 in 2005. Its current wealth is based mainly on its foreign investments and its petroleum and natural gas production. It has a population of about 382,000 which is about 73% urbanized and 92% literate. Their ethnic origins are 67% Malay, 15% Chinese, 6% indigenous, and 12% other. Major religions include 67% Islam (the official national religion), 13% Buddhist, 10% Christian, and 10% other (including indigenous beliefs). Brunei has been ruled by sultans from the same family for more than six centuries. It became a British protectorate in 1888 and was granted independence in 1984. Although the government has been officially patterned after the British system, most of the real authority and power are retained by the sultan, his close associates, and his family members. Political parties are banned. The official language is Malay, but English and Chinese are widely spoken. Roughly 61% of the labor force is involved in industry (mainly petroleum and natural gas), 36% in services, and 3% in agriculture (rice, vegetables, fruits, chickens and other livestock).

4. Sanitation and Living Conditions. Most Bruneians have a high standard of living, with usually well-maintained and modern potable water and waste disposal systems in urban areas. A wide variety of goods and high-tech electronics and convenience items are commonly available, and most of the people are active consumers. Health care is free, but major surgical or very specialized procedures are often sought in Singapore or other foreign countries. Average life expectancy at birth is currently 75.5 years. The country has modern communications and transportation systems, and encourages tourism, promoting itself as the “gateway to Borneo.” Education is free through the university level if desired, except for the stateless Chinese (who officially do not qualify). Nearly all food, manufactured items, machinery, and consumer goods must be imported. The government practices official positive discrimination in favor of Malays (and certain other indigenous ethnic groups) especially in job opportunities and social mobility. Under current Brunei laws, drug trafficking and illegal importing (as usually evidenced by possession) of controlled substances carry a mandatory death sentence.

B. **Cambodia**.

1. **Geography**. Cambodia is slightly smaller than the U.S. state of Oklahoma, with land area of 176,520 sq km, and includes 4,520 sq km of inland water surface. The Great Lake (Tônlé Sap), just west of the center of the country, is a prominent geographic feature. It drains into the Mekong River. Cambodia is bordered on the west and north by Thailand and Laos, on the east and southeast by Vietnam, and on the southwest by a 443 km coastline on the Gulf of Thailand. The capital, Phnom Penh, is located on the Mekong River in the southern part of the country. Most of Cambodia is low, flat plains less than 200 m elevation, but there are mountains in the far northeast near the Laotian and Vietnamese borders, and in the southwest. Overall elevation ranges from mean sea level (0 m) along the coastline to the highest point (1771 m) on Phnum Aôral in the southwestern mountains. Land use includes about 20% arable land, mainly in the central plains around the Tônlé Sap and its drainage; 1% permanent crops; and 79% other uses, including 2,700 sq km of irrigated land. More than 75% of the country is forested, and most of the coast is lined with mangroves. Cultivated crops are limited to paddies or forest clearings.

2. **Climate**. The climate is tropical, rainy with annual monsoon season from May-November, and a dry season from December-April. Lowland areas usually have moderate rainfall and fairly consistent temperatures. Daily ambient temperatures at Phnom Penh range from 21-22^{o}C during December-February to 34-35^{o}C during March-May. Average monthly rainfall in Phnom Penh varies from about 1 cm in January, steadily increasing to a maximum of about 26 cm in late October, then declining rapidly to less than 4 cm by late December. Monsoons vary in intensity, sometimes causing severe flooding, and droughts occur but are not frequent. Winds are usually northeasterly during May-September, then southeasterly during October-April.

3. **Population and Culture**. Cambodia is a constitutional monarchy. It is currently a relatively poor country, with a GDP per capita of about (U.S.) $300 per year. It has suffered several decades of fluctuating levels violence from the 1950s to 2003, due to wars, civil unrest, extreme political turmoil and invasion and manipulation by foreign powers. Historically, it was the center of the Khmer empire which ruled most of Southeast Asia from 800 to 1400 of the Current Era (CE). The capital of that empire was Angkor, near the current city of Siĕmréap, north of the western tip of Tônlé Sap. The ruin of Angkor Wat, a once magnificent Buddhist temple, still stands near there and is an important archeological site and a popular tourist attraction. Cambodia has a population of nearly 14 million, which is about 18% urbanized and 74% literate. Because of the years of violence at many levels, wars, starvation and executions, especially during the extreme period when Pol Pot’s Khmer Rouge was in power, more than 50% of the current population is <20 years old, and there are proportionately more orphans and widows than in most other nations in the world. Cambodians’ ethnic origins are 90% Khmer, 4% Vietnamese, 1% Chinese, and 5% other. The official language is Khmer, but French, Chinese, Vietnamese and Cham are commonly spoken locally. Major religions include 93% Buddhist, 6% Islam (Muslim), and 1% Christian. Khmers and Vietnamese, both as nations and ethnicities, have a long history of hostility toward each other. Vietnam's invasion and takeover of Cambodia in 1979 and its control of that country until 1989 increased those animosities.

4. **Sanitation and Living Conditions**. The wars and turmoil since 1953 destroyed most of the country's infrastructure in transportation, health care, education, and economics. Recovery is underway in all these areas, but it has required much external aid and is slow. There is very limited reliable water treatment or waste disposal in the main cities, and none outside them. Most of the population does not have access to potable water. Medical care is very limited throughout Cambodia, and people often cannot afford treatments or drugs they need. Average life expectancy at birth is currently 61.3 years. People in rural areas live in the worst poverty, essentially at a subsistence level.

Even in the cities, travel is still mainly by bicycle (some motorized) or rickshaw, and boats on principal waterways. Walking is the main mode of personal travel throughout most of the country outside cities. Electronic, broadcast, and printed communications are improving but are still limited in coverage, quality and reliability. Cambodia has reached the point of producing enough rice for domestic needs, but many other foods and most manufactured goods must be imported. Timber is its most prominent natural resource, but poorly planned harvesting, difficulty moving logs to market, and local deforestation (causing significant local soil erosion) are problems. Financial problems at the national level, government corruption, land ownership disputes, and heavy dependence on foreign aid make recent economic reforms ineffective.

The government tries to provide an education system through the college level, and six years of primary school (for ages 6-12 years) is required, but developing the infrastructure and training adequate teachers have only begun. The country's main exports include textiles, certain chemical products, rubber, and some metals and precious gems. Tourism has been increasing slowly, but transportation and related services are limited. Several very serious tropical diseases are endemic and some are widespread in Cambodia, including: food and water-borne diarrheas, typhoid fever, and hepatitis A; mosquito-borne dengue fever, malaria, and Japanese encephalitis; and the H5N1 strain of avian influenza (found in some wild birds).

C. **Indonesia**.

1. **Geography**. Indonesia is a large archipelago of 18,108 islands (6,000 inhabited) stretching about 5,000 km from the middle of New Guinea to the northwestern tip of Sumatra. The capital, Jakarta, is on the northern side of the island of Java, near its western end. Indonesia lies between the Pacific and Indian Oceans astride or beside major sea lanes. The country includes parts of three different time zones. It straddles the equator with nearly all its land area between 5 degrees north and 10 degrees south latitude. Indonesia includes 1,826,440 sq km of land and 93,000 sq km of inland water surface. That is about three times the size of Texas.

Land use is comprised of about 11 % arable land; 7 % permanent crops; and 82% other uses, including 45,000 sq km of irrigated land. Most of the area is coastal lowlands <500 m elevation, but many islands contain volcanic mountains, and some volcanoes have recently been, or are currently, active. The lowest point is 0 m elevation anywhere along the 54,716 km of coastline. The highest point is 5,030 m elevation, on Puncak Jaya in the central mountain range of Papua New Guinea. Indonesia's natural resources include petroleum products, mineral ores, coal, and timber. It is the world's largest exporter of liquefied natural gas (LNG). Tourism is a growing industry. Natural hazards that are locally, and often regionally, severe include floods, droughts, tsunamis, earthquakes, volcanic eruptions, and forest fires.

2. **Climate**. The climate is generally tropical, hot and humid, with more moderate temperatures at higher elevations. Rain falls year round, but there is usually a relatively dry season from June-September, and the wettest months are usually December-March. Daily temperatures at Jakarta range from a low of 23^{o}C in December-February, to a high of 32^{o}C in April-May, and September-October. Average monthly rainfall at Jakarta is usually highest in January (31 cm) and lowest in August (4 cm). These averages vary a lot with location and altitude; for example, the Moluccas (the Maluku Island group), just northwest of Papua New Guinea, get most of their rain in June-September.

3. **Population and Culture**. Indonesia was colonized by the Dutch in the 17th century (hence the name Dutch East Indies), was occupied by the Japanese in 1942-1945, and declared its independence August 17, 1945, the day Japan surrendered. The population of about 235 million is approximately 90% literate and 43% urbanized. Based on a 2000 census, Indonesians' ethnic origins include 41% Javanese, 15% Sundanese, 3% Madurese, 3% Minangkabau, 2% Betawi, 2% Bugis, 2% Banten, 2% Banjar, and 30% other. Their main religious affiliations include 86% Islam (Muslim, mainly Sunni), 6% Protestant Christian, 3% Roman Catholic, 2% Hindu, and 3% other. Indonesia is a multi-party democracy, but historic concentration of power and wealth in the hands of a very few persons has caused it to function very much like a dictatorship for the past several decades. It has the largest Muslim population of any country in the world. The official language is Bahasa Indonesia, but more than 250 other languages or dialects are spoken.

4. Sanitation and Living Conditions. Living conditions, surface roads, health care and average incomes are all rather good on Java, Sumatra and some nearby smaller islands but on most islands east of Bali, including Kalimantan (Borneo), Papua and Sulawesi, travel is mainly by air, river or walking. Most rural people live in poverty. The current inflation rate is about 13% and unemployment is persistently high. Most of the country's machinery, chemicals, fuels and foods must be imported.

The health care system is good and generally accessible with an extensive network of hospitals and clinics down to the village level. However, there is a growing shortage of doctors with only one per 6,560 people. Average life expectancy at birth is currently about 70 years. Primary education is compulsory, but only about 58% of the population receives a secondary education. Higher education is very limited in most rural areas, and university students are mainly from richer families. Satellite-based international telephone systems were introduced by the government in 1976, and other electronic communications are usually available and effective but physical travel and transport are difficult on most islands.

Women have equal rights under law and are very active at many levels in business, politics and government. The country's physical and political stability are threatened by historically serious government corruption, burdensome bureaucracy, harsh government suppression of any dissent, often brutal ethnic and religious violence, especially in poor or less developed places, and significant widespread piracy. Unemployment is high (12.5% overall in 2006), especially in major urban and heavily populated areas. Civil tension often runs high or hostilities may flare locally, often due to human rights violations, and extreme disparities of economics and standards of living between the rich and powerful and the rural poor.

Water treatment and distribution and waste treatment are very limited or not available outside urban areas (mainly on Java and Sumatra). Malnutrition and pollution-related health problems are prevalent in many rural populations and have even been noted by the International Monetary Fund (IMF). Excess cutting of timber is causing soil erosion and stream pollution. Uncontrolled forest fires and improper mining and chemical processing practices routinely release volumes of pollutants which can cause serious human health threats.

Recent events causing large upheavals in the population and infrastructure of Indonesia have included: fighting over the reassertion of its independence by Timor-Leste (the former East

Timor) in 1999; the bombing of a night club on Bali by Muslim terrorists in 2002; a December 2004 tsunami that nearly destroyed Aceh and nearby areas; a big earthquake in central Java in 2006; and a mud volcano which was caused by an industrial accident on May 28, 2006, near Sidoarjo, on eastern Java. It is still spewing loose mud (called Luci). Public websites addressing the last-named crisis include: http://en.wikipedia.org/wiki/Sidoarjo_mud_flow , and http://news.nationalgeographic.com/news/2007/01/070125-mud-volcano.html. In 2007, there was also a tsunami in South Java; and major flooding in Jakarta.

D. **Laos**.

1. **Geography**. Laos, also called the Lao People's Democratic Republic, and Sathalanalat Paxathipatai Paxaxon Lao, is officially a Communist state. It is slightly larger than the state of Utah, with about 230,800 sq km of land and about 6,000 sq km of inland water surface. Most of this landlocked country is rugged and fairly heavily forested mountains, with about 40% at or higher than 1,000 m elevation, along with a few areas of plains, plateaus and river valleys. The lowest point in Laos is 70 m elevation, where the Mekong River flows across the southernmost border into Cambodia near the city of Muang Khóng; and the highest point is 2,817 m elevation on Phou Bia, near the center of the country.

Laos' main exports include timber, hydropower, textiles, gypsum, tin, gold and gemstones. Land use includes 4% arable land, <0.5% permanent crops, and nearly 96% other uses (including about 1,750 sq km of irrigated land). The capital, Vientiane, is on the Mekong River, at the country's west-central border with Thailand. Laos is bordered on the east by Vietnam, on the north by China and Myanmar, and on the west by Thailand. The Mekong River constitutes a large portion of the 1,754 km long western border.

2. **Climate**. Laos has a tropical monsoon climate, with a rainy season (May-November) which sometimes has very heavy rainfall in southerly monsoons, and a dry season (December-April) each year. Serious floods and droughts occasionally occur. Daily temperatures at Vientiane (<500 m elevation) range from about 14^{o}C in January to 34^{o}C in April, and September-October. Temperatures may be much colder at higher elevations. Average monthly rainfall at Vientiane is usually highest (31 cm) in June, and again in September, and lowest (2 cm) in December-January.

3. **Population and Culture**. The population of Laos is about 6,522,000 (estimate of July 2007) and is about 69% literate and 20% urbanized. There are more than 60 different ethnic groups which often makes it hard to reach any consensus. The society can be broadly divided by elevation: about 68% are Lowland Laotians (Lao Loum); 22% are Upland Laotians (Lao Theung); 9% are Highland Laotians (Lao Soung); and 1% are Vietnamese and Chinese. Religious preferences are 65% Buddhist, 33% animist, >1% Christian, and <1% other. The official language is Lao, which is spoken by about 67% of the people, but French and English are widely spoken, and tribal dialects are routinely used locally. Laos is an ancient country, and the 14th century Lao kingdom of Lan Xang ruled all or most of the current countries of Cambodia, Laos, and Thailand. It came under the control of Siam (now Thailand) in the 18th century, and then became part of French Indochina in the late 19th century. The Communist Pathet Lao took control in 1975 and still rules under the newer name of the Lao People's Revolutionary Party (LPRP), currently the only legal political party.

4. **Sanitation and Living Conditions**. Most of the population has no access to potable water. Some other major concerns include unexploded ordinance (from earlier wars), deforestation and related soil erosion, and transportation limitations. The Mekong River is still a major travel route for goods and people, but surface roads have been improved a lot in recent years. About 80% of the work force is employed in agriculture, and nearly 31% live in poverty. More than 40% of the annual gross domestic product is based on subsistence farming. Most manufactured items, fuel, machinery, vehicles and consumer goods must be imported. Market-oriented economic reforms have been progressing since 1975, but political power is still centralized and government corruption is occasionally exposed.

Tourism is developing slowly, but is still mainly limited to areas near the capital. Laos is one of the least developed countries in the world. Some highland tribes, including the Hmong, Yao and Man, have been resisting the government's efforts to get them to stop growing opium poppies (a high value cash crop) and raise other crops instead. Education, to at least age 10, and health care have been improving overall for the past few years. Average life expectancy at birth is currently about 56 years. Laos is the main recipient of foreign aid in the region. Telephone and electronic communications are improving but are still not readily available to most of the people.

E. **Malaysia**.

1. **Geography**. The Federation of Malaysia is slightly larger than the state of New Mexico with total land area of 328,550 sq km and 1,200 sq km of inland water surface. It consists of the southern portion of the Malay Peninsula plus Sarawak and Sabah, which together occupy about the northern one-third of the island of Borneo. The whole country lies between one degree and eight degrees north latitude, south of Vietnam and Thailand. It is bordered by the South China Sea, the Strait of Malacca, and the Indian Ocean. Most of the land is coastal plains rising to hills and mountains. Central mountains separate coastal lowlands of the Malay Peninsula. The lowest point is 0 m elevation at mean sea level at any point along Malaysia's >4,600 km coastline. The highest point is at 4,100 m elevation on Gunung Kinabalu in northern Sabah.

The capital, Kuala Lumpur, is near the middle of the western slope of peninsular Malaysia. A new high-technology administrative center, Putrajaya, lies just south of Kuala Lumpur. Land use is about 5% arable, 17.5% permanent crops, and 77% other uses (including 3,650 sq km of irrigated land). Malaysia is the world's largest producer of palm oil. Crude oil, gas, refined petroleum products, tin and timber are its greatest natural resources. It is a major tourist destination because of the excellent beaches, hiking in the Cameron Highlands, and rain forest treks in East Malaysia. The international convention trade is also increasing.

2. **Climate**. Malaysia's climate is tropical with annual southwest (April-October) and northeast (October-February) monsoons. Despite having two distinct rainy seasons, almost all of Malaysia is nearly always very hot and humid, with some rain falling during 150-200 days each year. Daily temperatures at Kuala Lumpur (near 500 m elevation) range from about 21^{o}C in December to 33^{o}C in February-March. Temperatures may be slightly cooler at higher elevations. Average monthly rainfall at Kuala Lumpur is usually highest in April (29 cm), and again in November (27 cm), and lowest in June (9 cm).

3. **Population and Culture**. Malaysia was formed when former British-ruled territories on the Malay Peninsula became independent in 1957 and joined with Sabah, Sarawak and Singapore in 1963. Singapore seceded in 1965. Malaysia has a population of more than 24,820,000 (2007 est.), who are currently about 89% literate and 59% urbanized. Ethnic origins include about 50% Malay, 24% Chinese, 11% indigenous people, 7% Indian and 8% other. There are also an estimated 1 million immigrants in the country, mainly from the Philippines, Indonesia and Vietnam, but numbers and proportions vary. Religious preferences include about 60% Islam (Muslim), 19% Buddhist, 9% Christian, 6% Hindu, 3% traditional Chinese religions (Confusianism, Taoism, etc.), and 2% others or none.

The official language is Bahasa Malaysia, but English, Chinese (Cantonese, Mandarin, Hokkien, Hakka, Hainan, and Foochow), Tamil, Telugu, Malayalam, Punjabi, and Thai are also spoken; and in East Malaysia Iban, Kadazan, and several indigenous languages are common. Malaysia is a constitutional monarchy, with a paramount ruler (monarch), a bicameral Parliament, and a Prime Minister. Nine peninsular states have hereditary rulers, and the states of Melaka, Pulau Pinang (Penang), Sabah and Sarawak have federally appointed governors.

4. **Sanitation and Living Conditions**. Potable water is not readily available to many in the rural population, and sewage treatment is very limited even in many cities. Life expectancy at birth is currently about 73 years. Health care is improving overall, but there is a big disparity between modern facilities and care available in cities and conditions in rural areas, where traditional and herbal medicines are more typical.

About 95% of the population attends primary school, 70% receive secondary education, and 26% go on to collegeot technical schools. A government quota system for higher education (especially at the college level) favors Malays. The Chinese have their own schools, and many students, especially Chinese, go abroad for tertiary education. Schools are integrated racially and ethnically, but teaching is often in different languages. Since 2002, university students and staff have been required to swear allegiance to the state.

Transportation by road and rail is well developed on peninsular Malaysia. Roads are fairly good in Sabah but not well maintained in Sarawak. Long-distance transportation in East Malaysia is mainly by airplane or boat, with local travel mainly on foot or by boat. News media are largely controlled by the government, but electronic communications systems and devices, including radios, phones, microwave radio relays, satellite communications and the internet, are relatively available to most of the population.

Malaysia's problems include historically serious debt and budget problems, incipient corruption at multiple levels of government, and too little skilled labor. Migrants are often mistreated, whipped or detained for minor infractions. The government has practiced positive discrimination favoring Malays since the 1980s. Excessive logging denudes large areas each year, leads to serious erosion, and threatens to exterminate some already endangered tree species. Periodic regional forest fires can cause great loss of timber, produce dramatic smog clouds that sometimes cover whole countries, and can cause serious human health problems in large areas downwind, even in neighboring countries. Grandiose modernization schemes, like the proposed Bakun Dam project, threaten traditional lifestyles, especially among rural minorities.

F. **Myanmar**.

1. **Geography**. The Union of Myanmar, also called Burma, is slightly smaller than Texas, with total land area of 657,740 sq km and 20,760 sq km of inland water surface. It is divided into 7 divisions and 7 states. It is bordered on the north and west by India and Bangladesh, on the northeast and east by China, Laos and Thailand, and on the southwest and south by the Bay of Bengal and the Andaman Sea. It is strategically close to major Indian Ocean shipping lanes.

Mountains higher than 1,000 m elevation occupy about 20% of the land area, mainly in the northern and eastern parts, but most of the country is occupied by the central Irrawaddy (or Ayeyarwady) River basin, at <500 m elevation. The lowest point is 0 m elevation anywhere along the 2,000 km of coastline, and the highest point is 5,881 m on Hkakabo Razi near the extreme northern tip of the country, where it borders India and China. The capital, Rangoon (Yangon), is on the easternmost mouth of the Irrawaddy River near the Andaman Sea at <200 m elevation. Most of the country is forested. Land use is about: 15% arable land, 1% permanent crops, and 84% other (including 18,700 sq km of irrigated land).

The economy is based mainly on agriculture, but Myanmar is the world's largest exporter of teak, and has large offshore reserves of oil and natural gas. Fish, mined metal ores (*e.g.*, zinc, tungsten), gems (*e.g.*, pearls, rubies), and textiles are also important exports. The country has a wealth of historic Buddhist temples and monuments. Tourism has been expanding slowly, with official government encouragement; but there are numerous international economic sanctions and related travel restrictions due to human rights violations. Earthquakes and landslides often cause serious destruction and human fatalities. Myanmar's economy is troubled. The country has a large, longstanding external debt, an official inflation rate of about 50%, persistent unemployment of at least 5%, and a severe shortage of skilled workers.

Most consumer goods must be imported. Most key industries are military-run state enterprises, business and government corruption are common, and there is a thriving black market in every aspect of the economy. The northeastern border states annually produce and export more than 50% of the worlds heroine.

2. **Climate**. Myanmar has a tropical climate, typically with annual southwest (June-September) and northeast (December-April) monsoons. Most of the country has very warm to hot summers, with high humidity and heavy rainfall, and winters with mild temperatures, lower humidity and much less rain. Elevations above 1,000 m usually have lower temperatures and less rain year round. Daily temperatures at Rangoon (<200 m elevation) range from about 18^{o}C in January to 36^{o}C in March-April. Average monthly rainfall at Rangoon usually reaches a peak in mid-July (about 58 cm), and is lowest in January-February (1-2 cm). Annual rainfall in the southern peninsular Tenasserim region and in the Irrawaddy delta occasionally totals 500 cm (197 in.). Climate-related natural threats include typhoons (*e.g.*, Cyclone Nargis), flooding, and periodic droughts.

3. **Population and Culture**. Myanmar has been ruled at various times since the 11th century by three separate Tibeto-Burman dynasties, Mongols and Mons. It became a province of British India in 1886 as a result of the Anglo-Burmese wars, and was given its independence in January 1948. Since a coup in 1962, the country has remained a military dictatorship. It has a population of about 47,374,000 (June 2007 est.), which is about 90% literate and 29% urbanized. Ethnic origins include 68% Burman, 9% Shan, 7% Karen, 4% Rakhine, 3% Chinese, 2% Indian, 2% Mon and 5% other. Religious preferences include 89% Buddhist, 4% Christian (3% Baptist, 1% Roman Catholic), 4% Islam (Muslim), 1% animist and 2% others. The official language is Burmese (Myanmar), but many indigenous ethnic groups (>100) routinely speak some 100 local languages and dialects.

Most of the population works in subsistence agriculture, followed by extraction of oil and natural gas, logging, and mining (metal ores). Most communities are rural, relatively poor, and have traditional lifestyles based on the extended family. Women have significant routine roles in daily work, family life and business. The military government has strong ties with China, which has so far provided it with arms worth more than (U.S.) $1 billion, and is a major trading partner for other goods.

4. **Sanitation and Living Conditions**.

(**a**) Overall. Historically, potable water has almost never been readily available to most of the rural population, and to some parts of even the two main cities, Mandalay and Rangoon. Adequate sewage treatment is nonexistent or very limited in rural sites, in most small cites, and even in some parts of the major cities. Both these conditions, along with industrial pollution of air, water and soil, contribute to significant levels of several human diseases. Dissidents forced out of their jobs and people of the rural hill tribes have the worst living conditions. Officially, about 23% of the population lives in poverty, but that is a gross underestimate.

The country must import most of its food, fuel, machinery, vehicles and other manufactured goods. Only the military elite and their supporters live comfortably, and socioeconomic progression depends mainly on loyalty to the military. Average life expectancy at birth is currently about 62.5 years. Health care is variable, with some very good facilities and personnel, but a big disparity between the availability of care and facilities in larger cities versus rural areas, where traditional and herbal medical practice may be all that is readily available or affordable.

About 90% of the population receives mandatory primary education (5 years), 39% receive secondary schooling, and 11% go on to college or technical schools. Most universities were closed in the 1990s, some reopened in 2000, but the government has limited the scope and "sanitized" the content of many courses. Transportation and communications networks are somewhat limited, with most roads unpaved and railroads connecting mainly the two major cities. The rivers are arteries for boat transport, and the state-run domestic air carriers connect most of the divisions and states.

Political dissent and political parties have been banned, and there is a longstanding and often-cited law prohibiting any gathering of more than five people in one place. Since 1962, the repressive military dictatorship has savagely put down many protests by ethnic minorities, students, and Buddhist monks. The National League for Democracy (NLD) won free elections by a landslide in 1990, but no members of the NLD have ever been allowed to take office. The NLD leader, Aung San Suu Kyi, was awarded the Nobel Peace Prize in 1991. She has been imprisoned or under house arrest almost continuously since 1991 and was not allowed to leave the country to visit her husband who was dying of cancer in the UK.

(**b**) Recent Natural Disaster. Cyclone Nargis struck the Ayeryarwady River delta and the capital city, Yangon (Rangoon), on May 2, 2008. It passed northeastward across Myanmar and had diminished significantly by the time it entered northern Thailand. Its strong winds (up to200 km/hr) and associated storm surge and flooding destroyed the infrastructure of most of the transportation, communications and health care systems of most states and divisions in its path.

As of 21 July, 75% of all health care facilities in the country had suffered some storm damage, and about 20% were totally destroyed. Replacement cost was estimated at > (U.S.) $2 billion. By 1 August, 2008, WHO reported at least 140,000 people dead or missing, and an estimated 2.4 million more seriously affected. In addition, at least 14% of all villages in the storm's path now have refugee camps that are totally dependent on outside support. Actual refugee numbers have not been estimated, beyond saying there are many, and their numbers are still fluctuating in most camps. A 1 July estimate, stated that >100,000 people had been displaced by the storm.

Among the most serious continuing problems are contamination of drinking water, malnutrition, and endemic, directly communicable (mainly diarrheal) and vector-borne diseases (especially malaria and dengue). A WHO Flash Appeal on 10 July (extended until April 2009) estimated the support needed to be >(U.S.) $12,800,000, of which roughly $8 million has already been received (or pledged). A large part of the country's agricultural industry has been destroyed or disrupted and about 60% of farmers have no seed to plant for next year. This will likely have a lingering impact on most of the people and the whole country (source: WHO Myanmar Donor Update, 21 July 2008; at: http://www.who.int/disasters).

The military government's refusal to allow more than a very few volunteer relief workers and donated supplies to be brought in has made matters much worse, could greatly increase the overall death toll and morbidity, and will greatly delay full recovery. For more details, go to: http://www.who.int/hac/crises/mmr/en/, and search for specific topics or maps. Another public website that includes many details is: http://en.wikipedia.org/wiki/Cyclone_Nargis/.

G. The Philippines.

1. Geography. The Republic of the Philippines is the second largest archipelagic nation in the world, with 7,107 separate islands of which 4,600 are named and 1,000 are inhabited. It is slightly larger than the U. S. state of Arizona, with about 298,000 sq km of total land area and 1,800 sq km of inland surface waters. It is located by major bodies of water and marine trade routes on the western edge of the Pacific, north of Indonesia, and east of Vietnam. The islands are grouped in a roughly triangular pattern, bordered by the South China Sea to the northwest, the Celebes Sea to the south and the Pacific Ocean to the northeast.

Most of the terrain is mountainous, with the extent of coastal lowlands varying markedly from one island (or portion of an island) to the next. The lowest point is 0 m elevation anywhere along the coastlines (about 36,200 km total), and the highest point is 2,954 m on Mt. Apo, near the southeastern Pacific coast of the island of Mindanao. Land use includes about 19% arable land, 17% permanent crops, and 64% other (including 15,500 sq km of irrigated land). The republic has 79 provinces and 117 chartered cities.

The economy has been growing at a fairly good but fluctuating pace, agricultural production and exports are increasing, and emigrant workers routinely send significant funds back home, amounting to more than (U.S.) $7 billion in 2003. Unemployment is currently about 11%. Tourism is an important source of revenue, but it has been hurt by recent high-profile kidnappings of tourists by Muslim secessionists. The image of sex tourism has also had a negative impact due to international pressures to end such abusive practices. Physical travel and communications infrastructure are limited in many places, and there are large disparities in income and geographic concentrations of economic activities and of population. Main natural resources include timber, petroleum, and metallic ores. Natural threats include destructive typhoons, landslides, active volcanoes, frequent earthquakes, and tsunamis.

2. Climate. The Philippines has a tropical marine climate, usually with both a northeast (November-April) and a southwest (May-October) monsoon. They are typically warm and humid year round, with relative humidity ranging from about 85% in September to 71% in March. The rainy season usually lasts from June to October. The country is on the western Pacific typhoon belt and typically is affected by about 15, and is hit by 5-6, cyclonic storms each year. Daily temperatures at Manila (<200 m elevation) usually range from 21^{o}C for December-February to 34^{o}C in April-June. Manila’s average monthly rainfall usually reaches a peak in mid-July (about 43 cm) and is lowest in January-March (2-3 cm/ month). Climate-related natural threats include periodic destructive cyclones and flooding.

3. Population and Culture. The Philippines have been settled over the past several thousand years by various Asian peoples, mainly of Malaysian origin, but the Chinese minority (about 2%) is currently prominent in business and trade. The many rugged mountainous islands have allowed numerous isolated tribes and ethnic groups to retain their traditional cultures and languages. The country became a Spanish colony in the 16th century and was ceded to the U.S. in 1898, after the Spanish-American War. It was occupied by Japan (1942-1945), was retaken by Allied forces, including a significant number of Filipinos, and was granted independence from the U.S. on July 4, 1946.

It has a population of about 91 million (June 2007 est.), who are about 93% literate and 60% urbanized. Ethnic origins include 28% Tagalog, 13% Cebuano, 9% Ilocano, 8% Bisaya/Binisaya, 8% Hiligaynon Ilonggo, 6% Bikol, 3% Wray and 25% other. Religious preferences include 81% Roman Catholic, 5% Islam (Muslim), 3% Evangelical, 2% Iglesia ni Kristo, 2% Aglipayan, 5% other Christian, and 2% other. The official languages are Filipino (based on Tagalog) and

English, but there are at least eight different major dialects, with each ethnic group using mainly its own dialect locally.

The government has gone through many changes, including a military dictatorship (1965-1986), military and civilian uprisings and protests, periodic high-level corruption, and martial law. The Roman Catholic Church is very influential in cultural and political life, especially among the rural poor. Women have equal rights with men in inheritance laws and they have historically played a large role in business, the professions, and government.

4. **Sanitation and Living Conditions**. Potable water and sewage treatment are routinely available only to major urban sites. These are limited or not available in many urban outskirts, slums, and rural or remote areas. Housing ranges from mansions of the small minority of rich people to the open thatched huts of many poor remote tribes, with many gradations in between. Most consumer goods are only available to people in the upper socio-economic strata in major urban centers.

Average life expectancy at birth is about 70.5 years, but almost 50% of the population is <20 years old. The health system has been steadily improving, but care is not as readily available in rural areas or remote islands. Malaria has been eliminated from most of the country, but poor sanitation and associated diseases, like typhoid, are common in slums of major cities. General hospitals are nearly all located in population centers and most are privately run.

The education system is modeled after the U.S. but has proportionately many more private schools. All children are expected to attend primary school, about 80% attend secondary, and about 30% advance to college or technical schools. Sectarianism is common in higher grades and universities. For example the Chinese have their own schools, and two Spanish universities have been operated continuously since the early 1600's.

Partly due to mountainous terrain and uneven industry and population distribution, surface roads are most developed on the larger islands, and many roads need repair. Boats are a major means of transport, and air travel is the fastest way to go between islands. There are still some excellent coral reefs and tropical rainforests (mainly on Palawan) but deforestation from illegal logging, slash-and-burn agriculture, erosion, industrial pollution of urban air and coastal mangrove swamps, and reef destruction are all getting worse. Illicit drug concerns include increasing domestic production of methamphetamine and longstanding growing of marijuana in remote rural areas.

H. **Singapore**.

1. **Geography**. The Republic of Singapore is an island nation between the southern tip of Peninsular Malaysia and Indonesia. It has a total land area of about 683 sq km, 10 sq km of inland water surface, and is slightly more than 3.5 times the size of Washington, DC. Its northern half is bordered by the Johore Strait and the southern half by the Strait of Singapore. The lowest point is 0 m elevation anywhere along its 193 km coastline and its highest point is 166 m at Bukit Timah, near the center of the main island. The terrain is mainly lowlands, with a gently undulating central plateau containing a water catchment area and nature preserve.

Land use includes 1.5% arable land, 1.5% permanent crops and 97% other uses. It is physically joined to the Malay Peninsula by a causeway paralleled by a large fresh water main. Its main natural resources are fish and deepwater ports. Its principal commercial resources are its strategic location and its people. Main industries include electronics, chemicals, financial services, oil-related equipment, rubber processing and products, life science products (including pharmaceuticals), ship repair and tourism. The port at Pasir Panjang, one of the busiest seaports in the world based on tonnage handled, was built mostly on reclaimed land.

2. **Climate**. The climate of Singapore is tropical, hot, humid and rainy with usually a northeastern (December-March) and a southwestern (June-September) monsoon. The inter-monsoon periods of April-May and October-November usually have frequent afternoon or early evening rain or thunderstorms. There is very little air movement during the “airless” periods of late March and late September, as the trade winds are changing directions. Singapore’s daily temperatures usually range from 23^{o}C in January to 32^{o}C in May, and remain fairly steadily at 26-28^{o}C for every other month.

Average monthly rainfall is usually highest (26 cm/month) in December, drops to (16-17 cm/month) at the end of January, then remains steady at 17-19 cm/month (February-September) before gradually climbing again (October-November) to its December level. Climate-related natural threats include occasional destructive cyclones, periodic flooding, and rare tsunamis.

3. **Population and Culture**. Singapore has a population of about 4,553,000 (July 2007 est.), which is 93% literate and 100% urbanized. Ethnic origins include 77% Chinese, 14% Malay, 8% Indian and 1% other. Religious preferences include 43% Buddhist, 15% Islamic (Muslims), 9% Taoist, 4% Hindu, 5% Catholic, 10% other Christians, and 14% other. The official languages are Chinese (mainly Mandarin, but at least four other dialects), English, Malay, and Tamil. Smaller ethnic groups often use their own languages or dialects locally. Malays are among the poorest groups, but there is little or no overt ethnic tension. The largest segment of the labor force (39%) works in financial, business, or other services.

4. **Sanitation and Living Conditions**. Singapore was founded in 1819 as a British trading colony at a strategic point on Southeast Asian sea trade routes. It joined the Malay Federation in 1963, then withdrew and became independent on August 9, 1965. Singapore is one of the world’s most prosperous nations, with fairly low unemployment (about 3%) and a relatively high per capita GDP of > (U.S.) $20,000 per year. It has a well-developed free-market economy, stable prices, a relatively corruption-free government and business environment, and one of the highest living standards of any country in the world.

It is a world leader in high-tech industries, new biotechnologies, and finance and business services. Most energy, machinery, equipment, fuel and food must be imported. It is almost totally dependent on Malaysia for potable water. Its high-tech businesses are sensitive to world markets, and it has limited land. The global recession of 2001-2003 seriously affected Singapore’s exports of consumer electronic and software products, and business services.

The Southeast Asian regional outbreak of Severe Acute Respiratory Syndrome (SARS) in 2003 put a strain on Singapore’s health system resources and greatly reduced tourism and consumer spending. The mass transit system completed in 1991 is very efficient. There is almost no more space for new roads, and people must buy the right to purchase a new car via bidding at monthly auctions for a limited number of permits. Communications systems are very good throughout Singapore, with nine submarine cables to >100 countries, nearly 2 million phones, four satellite earth stations, > 1.3 million TVs, 2.6 million radios and ample internet service.

Singapore’s government is sensitive to criticism and exerts considerable influence over (but not outright censorship of) the news media and foreigners may not own a newspaper or broadcast station. Singapore is a parliamentary republic with multiple political parties, but one party, the People’s Action Party (PAP), has held an overwhelming majority of all elected offices and has essentially run the government since 1959. Education is not mandatory but school attendance is high. Most people consider a good education to be a requirement for jobs and personal advancement. The education system is relatively rigid and does not encourage innovations.

The health care system is modern and efficient. Average life expectancy at birth is nearly 82 years. The populace in general has a strong work ethic, and streets are usually litter-free, partly due to instant heavy fines for offenders. Crime is low overall, and punishments are often severe, but violent crime has increased in the past few years. Chewing gum (banned outright for 10 years) became available again in 2002, but only by prescription.

Environmental issues include industrial pollution, a serious shortage of land with related waste disposal challenges, limited domestic fresh water sources, and air pollution due to seasonal smoke and haze from forest fires in nearby Indonesia. Singapore has continuing, periodic disputes with Malaysia about their fresh water supply. Piracy is a serious threat to trade and tourism, especially any passing through the Malacca Strait just northwest of Singapore.

I. **Thailand**.

1. **Geography**. The Kingdom of Thailand, called Siam until 1939, and locally called Ratcha Anachak Thai or Prathet Thai, is slightly more than twice the size of the U.S. state of Wyoming, with total land area of 511,770 sq km, and includes about 2,230 sq km of inland water surface. It is divided into 76 provinces. It is bordered on the north and northwest by Myanmar, on the northeast and east by Laos, and on the south by peninsular Malaysia, the Gulf of Thailand and Cambodia. The southern peninsular part of the country is bordered on its east coast by the Gulf of Thailand and on its west coast by the Andaman Sea.

Thailand controls the only land route from Asia to Peninsular Malaysia and Singapore, and it is near major Indian Ocean shipping lanes. Mountains of 500-1,000 m elevation occupy roughly 10% of the country, mainly along the northern border with Laos, along the western border with Myanmar, and in the south, along the center of the Isthmus of Kra. The northcentral part of the country consists of a broad fertile central plain, laced with numerous rivers and tributaries; most of the Thailand's population, agriculture, and industries are located there. The Khorat Plateau in the northeast (mostly <500 m elevation) is forested, less developed and less populated. The lowest point is 0 m elevation anywhere on the 3,200 km of coastline, and the highest point is 2,576 m on Doi Inthanon near the extreme northwestern border with Myanmar.

The capital, Bangkok, is at the southern end of the central plains, near the Gulf of Thailand. Much of the country is forested, especially the eastern plateau, northern and western border provinces, and most of the Isthmus of Kra. Land use is 27% arable, 7% permanent crops, and 66% other uses (including 49,860 sq km of irrigated land). Notable subsidence of the land has occurred in and around Bangkok due to ground water depletion and recent droughts. Natural resources include natural gas, lignite coal, metal and mineral ores, fish, timber and arable land.

2. **Climate**. Thailand's climate is tropical, usually with a rainy, warm, cloudy southwest monsoon (mid May to September) and a relatively dry, cool northeast monsoon (November to mid-March). The southern isthmus is always hot and humid. Bangkok's daily temperature usually ranges from 20^{o}C in December-January to 35^{o}C in April remaining fairly steadily at 27-28^{o}C during February, and again from June through October. Bangkok's average monthly rainfall usually peaks at 31 cm/month in September and drops to about 2 cm/month at the end of December, before gradually climbing again (January-April) to remain at about 16-20 cm/month for May-August. Most of the country is hot and sultry from early March to mid May then rainy from mid May through October, and cooler and relatively dry from November to early March. Climate-related threats include occasional destructive cyclones, regional droughts, periodic flooding, and rare tsunamis. A major tsunami struck three southern provinces in December 2004, killing 8,500 people and causing tremendous property destruction.

3. **Population and Culture**. Thailand has a population of about 65 million which is 93% literate and 20% urbanized. Ethnic origins include about 75% Thai, 14% Chinese, and 11% other. Religious preferences include 94% Buddhist, 5% Islamic (Muslims), and 1% Christians and others. The official language is Thai, but English is often spoken (mainly as a secondary language, by the social “elite”), and smaller ethnic groups often use their own languages or dialects locally. There is generally little ethnic tension in the country, maybe due to the widespread influence of Buddhism. Most of Thailand’s Muslim population lives on the southern peninsula, north of Malaysia.

4. Sanitation and Living Conditions. Thailand was founded as a unified kingdom in the 14th century, traditionally considered to have been in the year 1238 (C.E.), and was never colonized. The current constitutional monarchy was established after a bloodless revolution in 1932. Thailand formed a limited alliance with Japan during World War II, then became a U.S. ally immediately afterward. After decades of military domination, ending in the 1990’s, Thailand’s politics have become very complex and are often based on short-lived coalitions or partnerships. The monarchy is hereditary, and the king has great personal prestige. Criticism of him is not tolerated.

Potable water is not readily available to most of the country, and adequate waste disposal is only available in limited parts of major urban areas. There is widespread, serious air pollution from vehicle emissions and water pollution from industrial wastes, especially in and around Bangkok. The education system is not well developed regarding content and accessibility, which has led to a shortage of skilled workers needed for many high tech industries. About 98% of children receive a primary education, 83% are enroilled in secondary schools, and 37% get some post-secondary training. More than 50% of the state universities are in Bangkok.

High quality and specialty health care is available mainly in the capital area. Most rural people have limited access to primary care, usually from paramedical workers (sometimes only volunteers) who have little clinical technical training. Only about 30% of such rural patients can afford the primary care they need. Average life expectancy at birth is about 72.5 years.

Illegal logging and deforestation and related soil erosion in northern provinces worsen flooding and droughts, and threaten available arable land, surface waters, and inland fisheries. Illegal hunting and related commerce in certain animals, their skins, or body parts is increasingly impacting endangered and threatened wildlife. Narcotics smuggling is a long standing problem. In 2003, 700 government officials were connected to the drug trade, 1,300 people were killed, 42,000 more were arrested, and (US) $12 million worth of drugs were seized in police raids.

Currently, there is periodic violence by Muslim separatists in some southern peninsular provinces. Tourism is growing, especially golf tourism. Prostitution and sex tourism continue to thrive, despite being illegal, and the government is embarrassed by the negative image conveyed. Bangkok is very crowded and has routine, massive traffic jams, which often greatly slow or interrupt local business travel and product movement. Country-wide transportation systems are being improved, with a mass transit system in Bangkok that includes a Sky Train and subway. A new road corridor through Laos to Vietnam is under construction. Domestic and international air travel is good, overall.

Domestic and international telecommunications, electronic media, and internet service are very good and improving, especially in urban areas, with most domestic broadcast stations in or near Bangkok. News media are allowed fairly open access, except for limited restrictions and censorship regarding certain military and government topics. Thailand is a major exporter of rubber and rice, but farming methods are inefficient and relatively low profit. About 49% of the labor force works in agriculture, 37% in services, and 14% in industry.

J. **Timor-Leste**.

1. **Geography**. The Democratic Republic of Timor-Leste, also called Timor Lorosa'e in Tetum and formerly Portugese Timor, occupies approximately the eastern half of the island of Timor, the Oecussi (Ambeno) region on the north coast of the western half of the island, and two nearby small islands, Pulau Atauro and Pulau Jaco. The word "timor" is derived from the Malay word for "east." The island of Timor, northwest of Australia is the largest and easternmost of the Lesser Sunda Islands at the eastern end of the Indonesian archipelago. Portugal began trading with Timor early in the 16th century and established a colony on the eastern end around 1550, and ceded the western half of the island to the Dutch via treaty in 1859. Japan occupied Timor from 1942 to 1945. Portugal resumed authority over Timor-Leste after the Japanese surrender.

Timor-Leste declared itself independent of Portugal on 28 November 1975. Nine days later (Dec. 7, 1975) Indonesian forces invaded. On August 30, 1999, an overwhelming majority of the people of Timor-Leste voted for independence from Indonesia in a UN-supervised referendum. An international peacekeeping force took control and stopped the violence on September 20, 1999. Subsequent reconstruction efforts were begun under a UN oversight mission.

Timor-Leste has a total area of about 15,000 sq km (including 1,000 sq km of irrigated land), slightly larger than the U.S. state of Connecticut. It has an elongate triangular shape, and is bordered on the north by the Savu Sea and Banda Sea, on the southeast by the Timor Sea, and on the west by Indonesia. Timor Island is mainly mountainous with narrow coastal plains interrupted by in places by coastal hills or mountains. The lowest point is 0 m elevation anywhere along the 706 km of coastline, and the highest point is 2,963 m on Foho Tatamailau, near the main western border with Indonesian Timor.

The capital, Dili, is on the northern coast of Timor Island, about 80 km east of the main border with Indonesian Timor. There are 13 administrative districts. Land use is 8% arable land, 5% permanent crops, and 87% other uses. Natural resources include gold, petroleum, natural gas, manganese, and marble. Landslides, cyclones, and earthquakes are fairly frequent.

2. **Climate**. Timor-Leste is less than 10 degrees latitude south of the equator. Its climate is tropical, hot and humid, with distinct rainy and dry seasons. Daily temperatures at Dili usually range from 23^{o}C in August to a consistently high 26-27^{o}C for October through May. The average monthly rainfall at Dili is usually highest (13-14 cm/month) from late December through mid March, then gradually declines to 1-2 cm/month from August through October. Climate-related threats include occasional destructive cyclones, periodic droughts, flooding, and rarely, tsunamis that chiefly affect the coastal plains.

3. **Population and Culture**. Timor-Leste has a population of about 1 million which is 59% literate and 8% urbanized. The population is still fluctuating, since large numbers were murdered or forced to relocate (many were physically forced into western Timor) during a violent rampage by the pro-Indonesian militias in late 1999. Rebuilding of the economic infrastructure, 70% of which was destroyed, has led to continuing population movements by expatriate and internally displaced people (currently about 150,000), and any census taken since 1999 may be inaccurate and subject to revision. Therefore, ethnic origins are difficult to determine, but historically they have included a majority of Austronesians (Malayo-Polynesians), a considerable minority of Papuans, and a much smaller minority of Chinese. Religious preferences have historically included about 98% Roman Catholics, 1% Muslims, and 1% Protestants and others. The official languages are Tetum and Portuguese, but Indonesian and English are also widely spoken.

4. **Sanitation and Living Conditions**. Immediately after the 1999 elections, anti-independence Timorese militias, organized and supported by the Indonesian military, started a large-scale, scorched-earth rampage. They killed about 1,400 people and forced about 300,000 into western Timor as refugees. An estimated 70% of Timor-Leste's physical infrastructure was destroyed, including water supply systems, homes, schools, and irrigation systems. Almost 100% of the country's electric power grid was destroyed.

An International Force for East Timor (INTERFET) led by Australian troops, deployed to Timor-Leste and stopped the violence. A military contingent from Australian remains along with a UN mission and international police force. International recognition of the country's independence from Indonesia occurred officially on May 20, 2002. The education system has not fully recovered from the 1999 violence, but overall attendance is increasing. During the period of Indonesian domination (1975-1999), classes were taught only in Bahasa Indonesia.

Availability of potable water, sewage treatment and waste disposal is limited to urban sites and may be inadequate even there. The standard of living in Timor-Leste has always been rather low, with a per capita GNP of less than (U.S.) $600/year. The health care system is very limited even in urban areas, with serious shortages of doctors (1 per 40,000 persons) and midwives. Traditional medicine and tribal healers are often the only available care in remote rural areas. Average life expectancy at birth has historically been shorter in Timor-Leste than in the rest of Indonesia, and it is currently about 67 years.

The country's infrastructure is being gradually rebuilt, but transportation is still difficult outside and between cities. Roads are few and usually not in good condition. There are no railroads and only three of the eight small airports have paved runways. Public transportation is very limited and not reliable outside cities. Timor-Leste currently depends heavily on foreign aid, mainly from Australia and Portugal, for needed infrastructure improvements.

Timor-Leste is a multiparty republic, with the Fretilin party currently holding the largest number of elected offices. The constitution and many features of the government are patterned after those of Portugal. There is little ethnic tension in the country in general, but political animosity and occasional civil violence are still fairly common, especially between persons or groups who are pro-independence versus those who are pro-Indonesian. Women do not hold prominent positions in the society, government, or businesses. Small crimes, violent crimes, and domestic violence are all common and widespread. Slash-and-burn agriculture and excessive logging over the past few decades have led to extensive erosion of already rather poor soils. The country is trying to encourage tourism but accommodations and transportation are limited.

K. **Vietnam**.

1. **Geography**. The Socialist Republic of Vietnam, or Vietnam (locally Cong Hoa Xa Hoi Chu Ngia Viet Nam, or Viet Nam) is a long, narrow country along the eastern edge of the Southeast Asian peninsula. It is 1,650 km long north to south and only about 50 km wide at its midpoint, near the town of Dong Hoi. It is bordered on the north by China, on the west by Laos, Cambodia, and the Gulf of Thailand, on the east and southeast by the Gulf of Tonkin and the South China Sea. The capital, Hanoi, is a few kilometers southeast of the center of the northern one-fourth of the country and about 100 km from the gulf of Tonkin, by the S. Hong (or Red) River. With about 325,360 sq km of land and 4,200 sq km of inland water surface, it is slightly larger than the U.S. state of New Mexico. Land use includes 20% arable land, 7% permanent crops, and 73% other uses (including about 30,000 sq km of irrigated land).

There are 59 provinces and 5 municipalities. The terrain includes low flat delta in the south and along the eastern edge in the north, the central highlands, and hilly, mountainous areas (>500 m elevation) in the north and northwest. Most of the uplands are forested, as is much of the rest of the country. The lowest point is 0 m elevation anywhere along the 3,400 km of coastlines and the highest point is at 3,144 m elevation at Fan Si Pan, in the far northwest, 40 km from China.

Vietnam's chief natural resources include mineral ores (e.g., phosphates), coal, metal ores (e.g., manganese, bauxite), offshore oil, forests, and hydropower (developed systems, mainly along the Red River in the north, currently produce excess capacity). It is the world's third largest producer of coffee and third largest exporter of rice. The government encourages tourism, but it has been increasing slowly due to limited transportation and accommodations. Typhoons often cause extensive flooding in the Mekong River delta in the south, serious droughts occur in the north, and the long coastline is susceptible to cyclonic storms or tsunamis (but both are rare).

2. **Climate**. Vietnam's climate is tropical in the south, usually with frequent heavy rains (occasional typhoons) June through January, and high humidity but much less frequent and lighter rains February-May; it is monsoonal in the north, usually with a hot rainy season (May-September) and a warm dry season (October-April). Hanoi's average daily temperature is usually low (about 13°C) in January, increasing to a consistent high of 31-33°C for June-August, then steadily decreasing to about 14°C in December. Average monthly rainfall at Hanoi is usually lowest (2-3 cm/month) from late-December through mid-February, steadily increases to a peak (32-34 cm/month) in late-August, then drops rapidly to about 4 cm/month by late November.

Extensive and sometimes rapid changes in elevation and terrain can result in sharp local contrasts in climate and weather. Higher elevations and mountains usually have cooler temperatures year round and almost never flood. Occasional droughts may severely impact agricultural production and people. Climate-related threats include occasional droughts (rarely flooding) in the north, periodic flooding in the south (mainly in the Mekong delta), and rarely, strong cyclones or tsunamis can cause serious destruction anywhere they hit along the coast.

3. **Population and Culture**. The population of Vietnam is currently about 85,300,000 persons (2007 est.) who are about 90% literate and 25% urbanized. Their ethnic origins include: 86% Kinh (Viet), 3% Chinese, 2% Thai, 2% Muong, and 7% other (including several indigenous tribes in uplands and remote sites). Claimed religious affiliations include 55% Buddhist, 7% Christian (mainly Roman Catholic), and 38% others or not stated. Humans have been living in what is present-day Vietnam since Paleolithic times. Vietnam has been subject to repeated violent invasions and waves of immigration by various other cultures, mainly from other nearby mainland countries, as well as China and India.

The Viet population is most likely descended from the Phung-nguyen culture, which settled in the Ma and Red River deltas in northern Vietnam at least 2,000 years ago. About 1,200 years ago, they developed wet rice cultivation, small copper mines, and casting of bronze (including unique large drums). Contrasting local geography has facilitated divergenc and isolation of many different populations, cultures, and sub-cultures that remain in place today. Minority groups have periodically protested (violently in 2001) the government taking their land. In most of those groups, family life, traditions and kinship or clan ties very strongly influence daily living. About 57% of the current labor force works in agriculture, 37% in industry, and 6% in services.

4. Sanitation and Living Conditions. Vietnam is a densely populated, developing country that was re-unified in 1976, after over 30 years of nearly continuous warfare. The country has since devoted much of its energy to recovery. It also has lost the financial support of the former Soviet Union and is trying to adapt its rigid, centrally planned economy and government to something more appropriate to the modern world. The current government seems committed to economic liberalization and international integration.

Potable water and adequate waste disposal are not readily available except in or near urban areas, and many slums and urban margins do not have them either. Slash-and-burn agriculture, munitions and chemicals used in past wars, and logging have caused serious deforestation, soil erosion, and silt problems in fresh water and coastal fisheries. Groundwater contamination is a widespread problem.

The education system is improving but depends on at least some private sponsorship for financial support. Nearly 100% of children receive a primary education and 70% a secondary education, but only 10% advance to college or technical schools. Universities offer mostly liberal arts training, and student cheating has reportedly been a problem in past.

Health care is mainly available in urban areas, with rural and remote places depending chiefly on traditional or tribal healing practices. However, Vietnamese medical researchers have developed a vaccine for hepatitis B and have extracted an anti-malarial drug, artemisinin from an indigenous tree. Average life expectancy at birth is currently about 71 years, but several decades of war have led to females significantly outnumbering males in older generations (i.e., those who are >40 years old). In 2003, an outbreak of Severe Acute Respiratory Syndrome (SARS) occurred in Vietnam and was successfully contained.

Women make up a large portion of the labor force but have only recently begun to occupy prominent roles in business and politics. Unemployment is low (about 2%), and inflation is about 7.5%. The news media is closely regulated by the government and some books are destroyed when found, but occasional criticism of corruption or waste may be tolerated. Military service is mandatory and conscripted soldiers (including females) must serve two or three years.

Electronic communication systems, including radio, TV, phones, internet and satellite links, are fairly good already and are being improved. Roads and railroads are not very good outside urban areas. Railroads connect Hanoi to Ho Chi Minh City, but trains can only travel about 15 km/hr and a one-way trip takes three days. Bicycles are a major means of travel within cities. Airports are being improved but air travel is still largely the province of the rich, government officials, military personnel, or tourists.

Poverty is being reduced, but there is still a big gap between people in the upper socio-economic levels and those living in rural, agricultural, or remote tribal areas. Since economic liberalization was begun crimes like theft, and "social evils" like drug use, prostitution, and begging have been rising, especially among young people who are being drawn to larger cities.

Some recent historic events in Vietnam have included French priests' converting some of the people of present-day Vietnam to Christianity in the 17^{th} century. Brutal persecution of those Catholics in the early 1800s caused France to actively colonize the country then merge it with present-day Laos and Cambodia, calling the resultant area French Indochina. Ho Chi Minh founded the Communist Party of Vietnam (CPV) in 1930. Japan invaded Vietnam in 1940. The Viet Minh resistance was formed in exile in China in 1941 and they drove the Japanese out of Hanoi and Saigon in 1945. The Vietnamese emperor abdicated and a republic was declared, with Ho Chi Minh as president. French troops re-entered the country and the first Indochina War began in 1946. It lasted until May 1954, when the Viet Minh very soundly defeated the French at Dien Bien Phu, causing them to withdraw from the region.

The Geneva treaty divided the country into North and South Vietnam along the 17^{th} parallel (17^{o} north latitude). The Soviet Union subsequently supported and progressively armed North Vietnam, and the U.S supported and progressively armed South Vietnam. In 1964, the Vietnam War began. The Paris Peace Accord was signed in 1973, but North Vietnamese troops continued fighting in partnership with the Viet Cong, invading, and finally defeating South Vietnam in 1975. Saigon was re-named Ho Chi Minh City.

Vietnam invaded Cambodia in 1978, ousted the brutal Pol Pot regime, and continued the occupation until 1989. In 1979, there was a nine-day northern border conflict in which Chinese troops invaded and destroyed everything within 40 km of their border, then withdrew; and the "boat people" crisis occurred. In 1988, the government began liberalizing economic and trade policies. By 1995, the U.S. had lifted all sanctions, fully normalized relations, and exchanged ambassadors with Vietnam. Vietnam is a member of ASEAN, WTO, and the UN.

V. Militarily Important Vector-borne Diseases with Short Incubation Periods (<15 days).

A. Malaria. Human malaria is caused by any of four protozoan species in the genus *Plasmodium* that are transmitted by the bite of an infective female *Anopheles* mosquito. Clinical symptoms of malaria vary with the species. The most serious malaria infection, *P. falciparum* malaria, can cause life-threatening complications, including kidney and liver failure, cerebral involvement and coma. Case fatality rates among children and nonimmune adults exceed 10% when not treated. The other human malarias, *P. vivax*, *P. malariae*, and *P. ovale*, are seldom life-threatening except in the very young, the very old, or persons in poor health.

Usual symptoms include malaise, fever, shaking chills, headache and nausea. The periodicity of the fever, occurring daily, every other day, or every third day, is characteristic for a given *Plasmodium* species. Nonfatal cases of malaria are extremely debilitating. Relapses of improperly treated malaria can occur years after the initial infection in all but *P. falciparum*. *Plasmodium malariae* infections may persist for as long as 50 years, with recurrent febrile episodes. Persons who are partially immune or have been taking prophylactic drugs may show an atypical clinical picture.

Treatment of malaria has been complicated by the spread of multiple drug-resistant strains of *P. falciparum* in many parts of the world, especially parts of Southeast Asia. Current information on foci of drug resistance is published annually by the World Health Organization (WHO) and can also be obtained from the Malaria Section of the U.S. Centers for Disease Control and Prevention (CDC), and the NCMI (formerly AFMIC).

Military Impact and Historical Perspective. Malaria has had a great impact on civilizations and military operations throughout recorded history. During the U.S. Civil War, 50% of white troops and 80% of black troops in the Union armies contracted malaria annually. During World War I, in the Macedonian campaign, the French army was crippled by 96,000 malaria cases. In 1918, the British Macedonian Army lost >2 million man-days due to malaria. During World War II, malaria caused five times as many US casualties in the South Pacific as did enemy actions.

The highest annual incidence rate of malaria during World War II (98.5 cases per 1,000) occurred in the China-Burma-India theater. In 1942, malaria was the major cause of casualties in General Stilwell's forces in North Burma. There were 9,160 cases of malaria in the China-Burma-India theater during 1943, with nearly 115,000 man-days lost. At one time, 55% of the beds in the 20th General Hospital, near Ledo in Assam, were occupied by malaria patients. An epidemic of malaria occurred during 1944 at the 1306th Air Force Base Unit, Air Transport Command, in Karachi, India (Pakistan). The incidence rose rapidly to 1,202 cases per 1,000 per year during the first two weeks of October, but dropped to 148 per 1,000 during the first two weeks of November following the institution of malaria control measures.

There were at least 81,000 confirmed malaria cases in the US Army in the Mediterranean Theater from1942 to1945. The average length of hospitalization for malaria in 1943 was 17 days, representing a total of 425,000 man-days lost per year, or the equivalent of a whole Division lost for a month. In 1952, during the Korean Conflict, the 1st Marine Division suffered up to 40 cases per 1,000 marines.

Battle casualties accounted for only 17% of American hospitalizations during the Vietnam War. Many units were rendered ineffective due to malaria. Many US military units experienced up to 100 cases of malaria per 1,000 personnel per year. Elements of the 73rd Airborne Brigade had an incidence of 400 cases of malaria per 1,000 during 1967 and early 1968. Almost 300 military personnel contracted malaria during Operation Restore Hope in Somalia. Malaria remains a threat to military forces due to widespread drug resistance in plasmodia, insecticide resistance in the vectors, and the consequent resurgence of malaria in many areas of the world.

Disease Distribution. Endemic malaria has been eradicated from most temperate countries, but it is still a major health problem in many tropical and subtropical areas. Worldwide, there are an estimated 300-500 million new cases of malaria annually, and 1-2 million deaths. The WHO estimates that in Africa nearly 1 million children under the age of 10 die from malaria every year. Globally, *P. falciparum* and *P. vivax* cause the vast majority of cases. *Plasmodium falciparum* occurs in most endemic areas of the world and is the predominant species in Africa. *Plasmodium vivax* is also common in most endemic areas except Africa. *Plasmodium ovale* occurs mainly in Africa, and *P. malariae* occurs at low levels in many parts of the world.

In most endemic areas the greatest malaria risk is in rural areas, with little or no risk in large cities. In Southeast Asia, malaria incidence is highest in forested hilly sites. Yet, in Myanmar, Malaysia and several other countries, malaria transmission in some urban areas is a serious public health problem. The general worldwide distribution of malaria is shown in Figure 1; and the distributions in certain countries in this region are shown in Figures 2-10. Comparisons among the three main genera which vector human diseases are shown in Figure 14.

Brunei Darussalam: Malaria is considered by the WHO to be absent from this country, and all of the cases (0-21 per year) since 1989 have been imported. However, falciparum and vivax malaria are endemic to surrounding areas of Malaysia, often at fairly high incidence levels. Multidrug-resistant forms of *P. vivax* have been reported from nearby rural sites in Sarawak.

Cambodia: Malaria transmission, mainly *P. falciparum*, occurs year-round throughout the country except in the city of Phnom Penh and immediately around the lake Tonle Sap. Risk of transmission is greater during the monsoon season (July-September) and is usually greatest in the forested areas and foothills of the northeastern border with Laos, the western border with Thailand, and the eastern border with Vietnam. Forms of *P. falciparum* resistant to mefloquine are prevalent in areas near the Thai border (Figures 2 and 11).

Indonesia: Risk of malaria, mainly *P. falciparum*, but also some *P. vivax*, is present year-round in rural areas of all islands, many are remote. Extremely high risk is present in all areas of the islands of Flores, Sumba, the western half of Timor, and Papua (Irian Jaya), except for the higher elevations of Papua's central mountain range. There is only limited or no risk of contracting malaria in most major cities and throughout most of Java and Sumatra except for certain rural foci. Most main tourist areas currently have very limited or no risk (Figure 3).

Lao People's Democratic Republic (Laos): Risk of contracting malaria, mainly *P. falciparum*, is present throughout the whole country year round, except there is no risk in the city of Vientiane. Some strains resistant to chloroquine and even to mefloquine have been reported from areas near the eastern border with Vietnam (Figures 4 and 11).

Malaysia: On the island of Borneo (Sabah and Sarawak), risk of contracting malaria, mainly *P. vivax*, is present nearly throughout the country and year round, except major urban areas and some coastal sites of Sarawak. Risk is higher in Sarawak than in Sabah. In Peninsular Malaysia, risk of malaria (about an equal risk of *P. falciparum* and *P. vivax*), exists in a number of remote rural areas, mainly in Pahang and Perak provinces (Figure 5). There is also a malaria risk in the Taman Negara National Park, but none in most coastal areas, urban sites, main tourist areas, and the Cameron Highlands. Some forms resistant to chloroquine have been reported.

Figure 1. Map of Malaria Distribution in the Eastern Hemisphere.

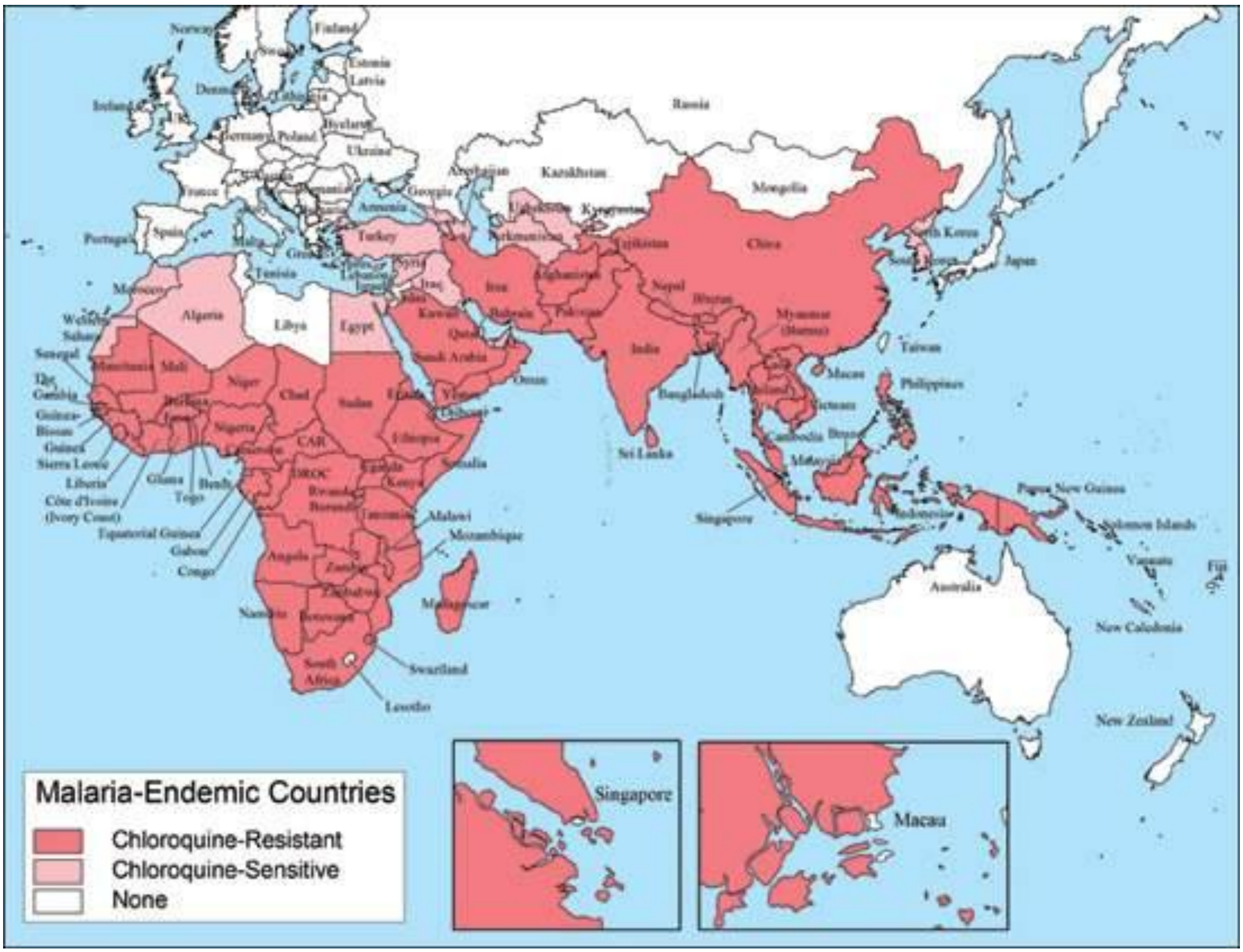
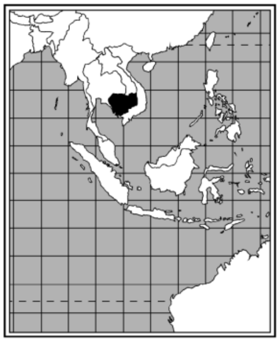


Figure 2. Reported Malaria distribution in Cambodia.

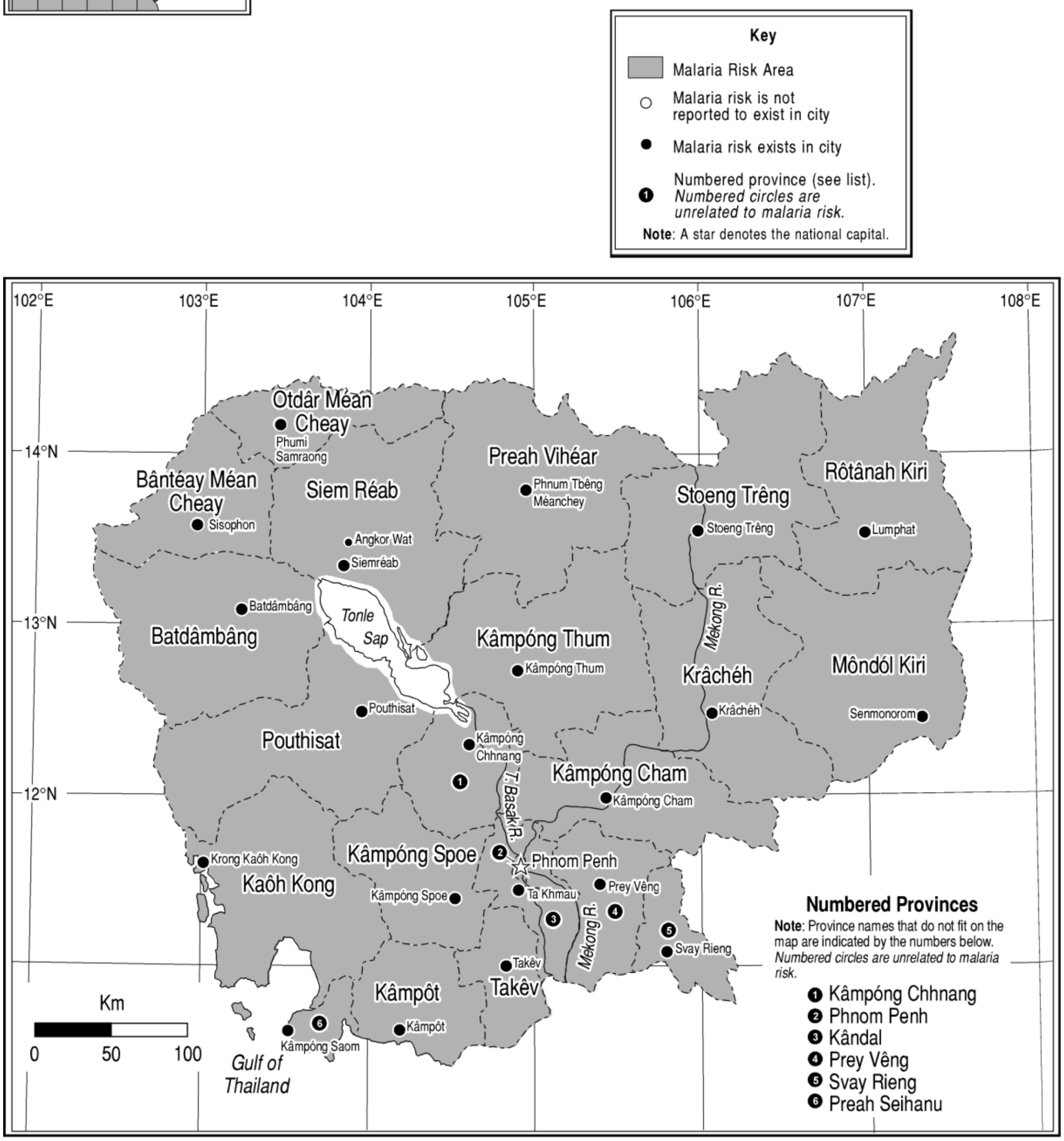
Malaria

Cambodia



Risk areas: Risk (predominantly *P. falciparum*) exists throughout the year in the whole country, except there is no risk in Phnom Penh or immediately around Tonle Sap.

Protective measures: Medicines that protect against malaria in most risk areas (including Angkor Wat, Batdambang, and Siem Reab) include mefloquine (Lariam), doxycycline, or atovaquone/proguanil (Malarone). Primaquine may be used in special circumstances (G6PD testing is required). Because mefloquine resistance is confirmed in the western provinces near the Thai border, mefloquine is not an option in this area. The best drug for you depends on your itinerary and on a number of personal factors that should be discussed between you and your health care provider. Take personal protective measures in risk areas.



MRA1D

Figure 3. Reported Malaria distribution in Indonesia.

Malaria

Indonesia

Risk areas: Risk (predominately *P. falciparum*) exists throughout the year in rural areas of all islands (most are areas not usually visited by tourists). In Papua (the western half of the island of New Guinea) and Nusa Tengarra Timur (islands of Flores, Sumba, and the western half of Timor) extremely high risk exists in all areas. Usual tourist resorts on Java are risk free, as are all cities on Java and Sumatra, including Jakarta, Surabaya, Bandung, Semarang, Yogyakarta, Solo (Surakarta), Medan, Palembang, and Padang. In rural Java, risk is limited to focal areas, but does include overnight visitors to Borobudur. On Bali, the metropolitan areas of Denpasar and all usual rural tourist areas are risk free. Low risk exists in resort areas on the island of Bintan with increased risk in inland jungle areas.

Protective measures: Medicines that protect against malaria in this area include mefloquine (Lariam), doxycycline, or atovaquone/proguanil (Malarone). Primaquine may be used in special circumstances (G6PD testing is required). The best drug for you depends on your itinerary and on a number of personal factors that should be discussed between you and your health care provider.

Numbered Provinces

Note: Province names that do not fit on the map are indicated by the numbers below. *Numbered circles are unrelated to malaria risk.*

1. Aceh
2. Sumatera Utara
3. Riau
4. Sumatera Barat
5. Jambi
6. Bengkulu
7. Sumatera Selatan
8. Lampung
9. Kalimantan Barat
10. Kalimantan Timur
11. Kalimantan Tengah
12. Kalimantan Selatan
13. Jawa Barat
14. Jawa Tengah
16. Jawa Timur
17. Nusa Tenggara Barat
18. Nusa Tenggara Timur
19. Sulawesi Utara
20. Sulawesi Tengah
21. Sulawesi Selatan
22. Sulawesi Tenggara
23. Maluku
24. Irian Barat

Key

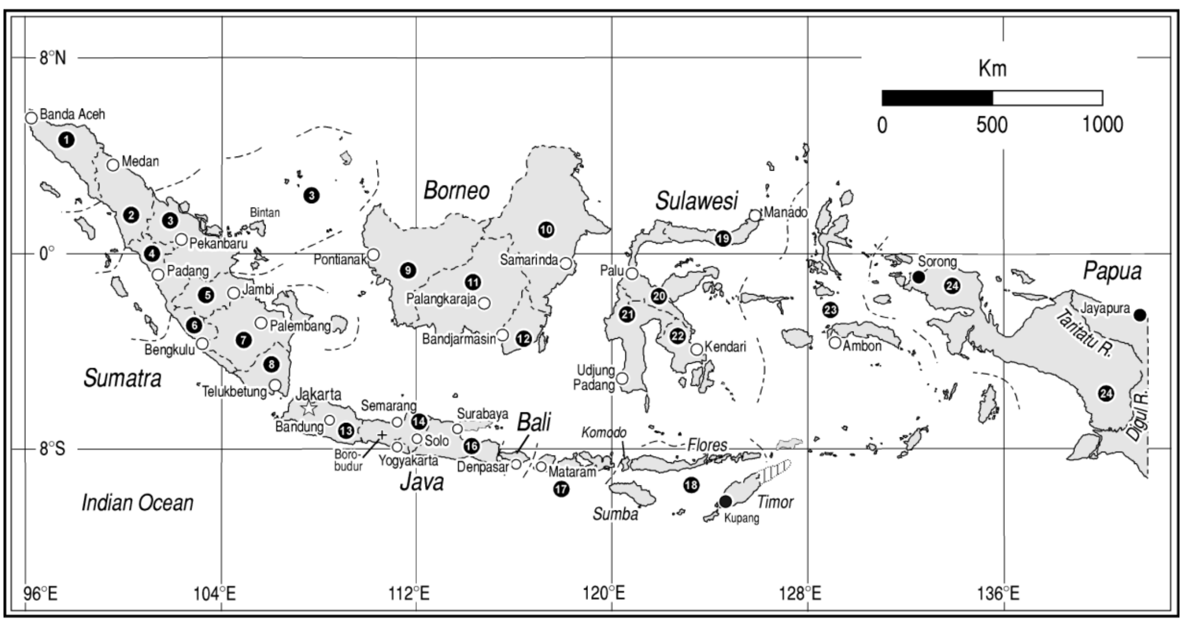
Malaria Risk Area

Malaria risk is not reported to exist in city

Malaria risk exists in city

Numbered state (see list). *Numbered circles are unrelated to malaria risk.*

Note: A star denotes the national capital.



MRA1K

Figure 4. Reported Malaria distribution in Laos.

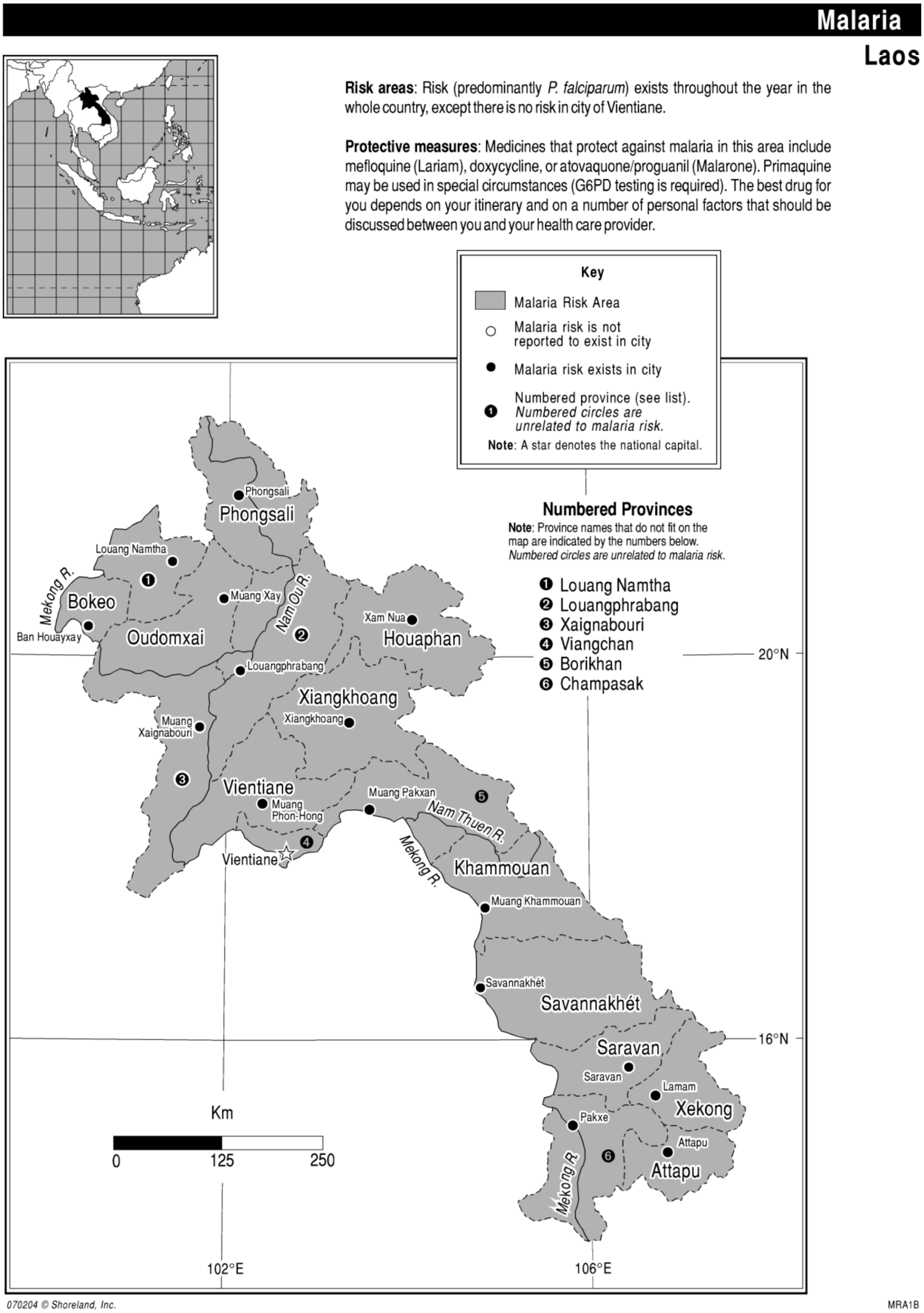
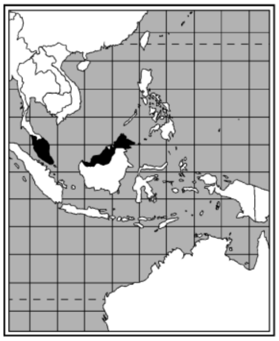


Figure 5. Reported Malaria distribution in Malaysia.

Malaria

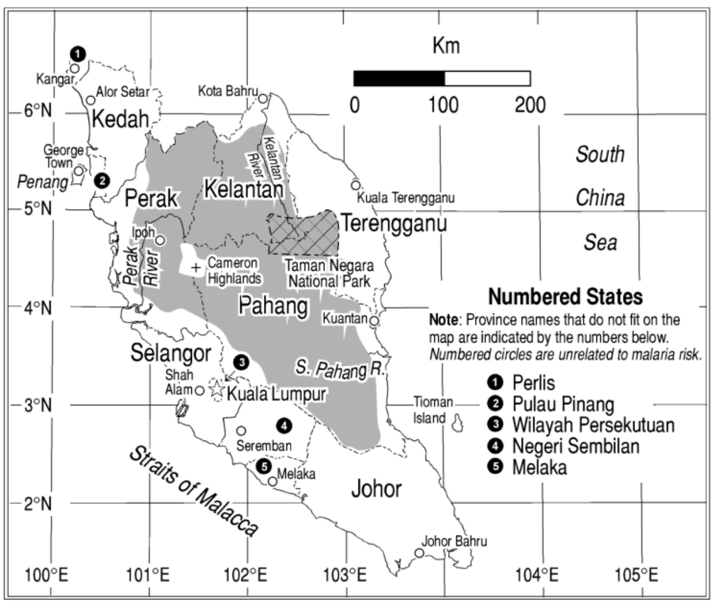
Malaysia



Risk areas: Island of Borneo (Sarawak and Sabah provinces) – Risk (predominantly *P. vivax*) exists throughout, except urban areas in Sarawak and some coastal areas in Sarawak are risk free. Risk is higher in Sarawak.

Peninsular Malaysia – Risk (approximately equal between *P. falciparum* and *P. vivax*) exists in limited rural foci in remote areas that are off usual tourist routes, predominantly in Perak and Pahang provinces. Risk exists in Taman Negara National Park. Coastal areas, urban areas, and usual tourist itineraries to the Cameron Highlands are risk free.

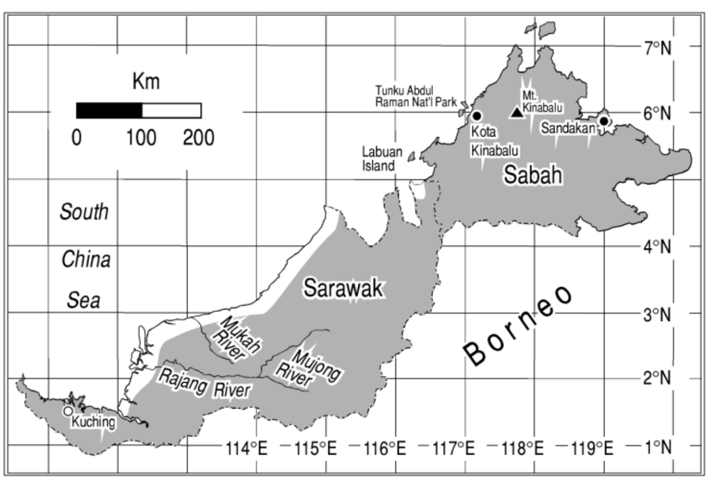
Protective measures: Medicines that protect against malaria in this area include mefloquine (Lariam), doxycycline, or atovaquone/proguanil (Malarone). Primaquine may be used in special circumstances (G6PD testing is required). The best drug for you depends on your itinerary and on a number of personal factors that should be discussed between you and your health care provider.



Key

- Malaria Risk Area
- Malaria risk is not reported to exist in city
- Malaria risk exists in city
- Numbered state (see list). *Numbered circles are unrelated to malaria risk.*

Note: A star denotes the national capital.



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MRA1J

Myanmar: Risk of contracting malaria, mainly *P. falciparum*, is present year round in nearly all rural areas lower than 1 km elevation throughout the country. Risk is highest in hilly, forested areas. There is almost not risk in the cities of Rangoon (Yangon) or Mandalay. Forms resistant to chloroquine and some also resistant to mefloquine have been reported in several areas along the northern and eastern borders with China and Thailand (Figures 6 and 11).

The Philippines: Malaria transmission occurs year round in all rural areas and islands below 600 m elevation, except that no risk is reported to exist in metropolitan Manila or the provinces of Aklan, Biliran, Bohol, Camiguin, Capiz, Catanduanes, Cebu, Guimaras, Iloilo, Leyte, Masbate, Northern Samar, and Siquijor. Risk of contracting malaria (mainly *P. falciparum*, but also *P. vivax*), is highest on the islands of Mindanao, Mindoro, Palawan, and the northern half of Luzon. Ther is no risk in the Borocay resort area or on the plains of Negros Island (Figure 7).

Singapore: The WHO considers that Singapore to currently be free of malaria risk, and cases reported from there in the past several decades were all imported cases. There is at least a limited risk of contracting malaria, both *P. falciparum* and *P. vivax*, in rural areas of all the nearest countries surrounding Singapore (*i.e*., Peninsular Malaysia, Indonesia, and Thailand).

Thailand. The risk of contracting malaria is mainly limited to evening or nighttime infective mosquito bites in rural forest edge or jungle areas bordering Laos in the north and east, Myanmar in the west, and Cambodia in the east. Most of these cases are *P. falciparum*, but *P. vivax* is also common. Risk is highest in the provinces of Chiang Mai, Mae Hong Son, Tak, Kanchanaburi, Ratchaburi, Chanthaburi, Trat, Prachuap Khiri Khan, Surat Thani, Sa Kaeo, and Yala. Risk is lower in most provinces of the southern isthmus and the island of Ko Phangan. There is little or no risk in the interior of Thailand nor in big cities and main tourist resorts (*e.g*., Bangkok, Chiang Mai, Pattaya, Phuket Island, Ko Samet, *etc*.). Some strains of falciparum and vivax in Thailand have been reported to be resistant to chloroquine. Strains resistant to mefloquine have been reported from border areas near Cambodia and Myanmar (Figures 8 and 11).

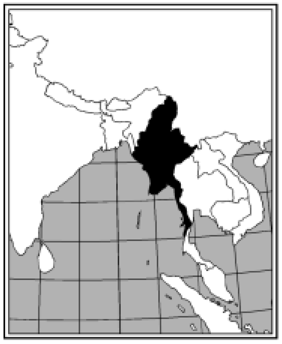
Timor-Leste. A high risk of contracting malaria, *P. falciparum* and *P. vivax* are about equally likely, is present year round throughout the whole country, including urban areas (Figure 9).

Vietnam. Despite several years of intense coordinated efforts to reduce, prevent and eliminate malaria, there is still a significant risk of contracting it (mainly *P. falciparum*, but also *P. vivax*), throughout the year in many rural areas. Highest risk is in areas near the north border with China, highlands lower than 1.5 km south of 18^{o} north latitude (*i.e*., the central highlands provinces of Dac Lac, Dac Nong, Gia Lai, and Kon Tum), Binh Phuoc province, and western portions of the central coastal provinces Quang Tri, Quang Nam, Ninh Thuan, and Khanh Hoa. There is reportedly no risk of malaria in the Red River delta region, the coastal plain north of Nha Trang, the area from Ho Chi Minh City (formerly Saigon) southwestward to Rach Gia, nor in the cities of Hanoi, No Chi Minh, Da Nang, Nha Trang, Qui Nhon, and Hai Phong. Strains resistant to mefloquine have been reported from most of the central region of the southern half of Vietnam, from the coast to the western border with Cambodia and southeastern Laos (Figures 10 and 11).

Figure 6. Reported Malaria distribution in Myanmar.

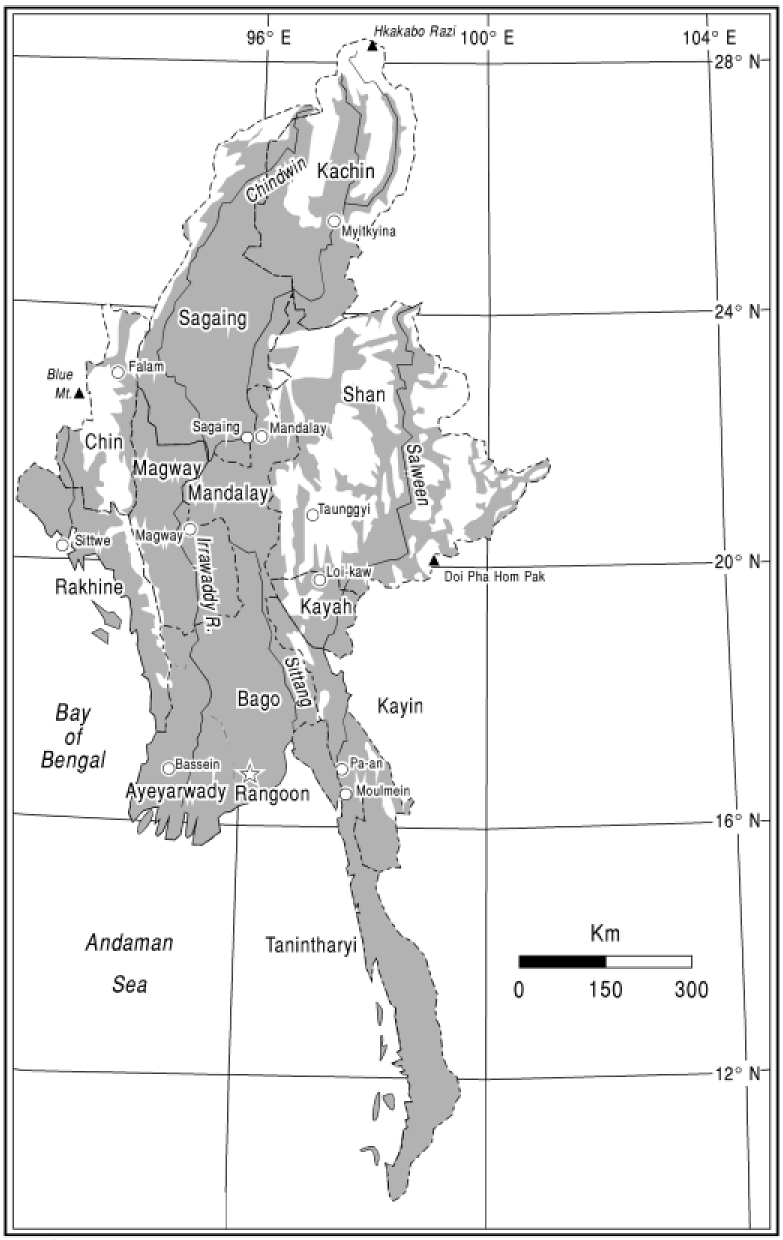
Malaria

Burma (Myanmar)



Risk areas: Risk (predominantly *P. falciparum*) exists in rural areas below 3,300 feet (1,000 meters). Risk is highest in remote rural, hilly and forest areas. No risk exists in the cities of Rangoon (Yangon) and Mandalay.

Protective measures: Medicines that protect against malaria in this area include mefloquine (Lariam), doxycycline, or atovaquone/proguanil (Malarone) except in Shan, Kayah, and Kayin provinces where mefloquine may not be protective. Primaquine may be used in special circumstances (G6PD testing is required). The best drug for you depends on your itinerary and on a number of personal factors that should be discussed between you and your health care provider.



Key

- Malaria Risk Area
- ○ Malaria risk is not reported to exist in city
- ● Malaria risk exists in city

Note: A star denotes the national capital.

MRA1E

Figure 7. Reported Malaria distribution in the Philippines.

Malaria

Philippines

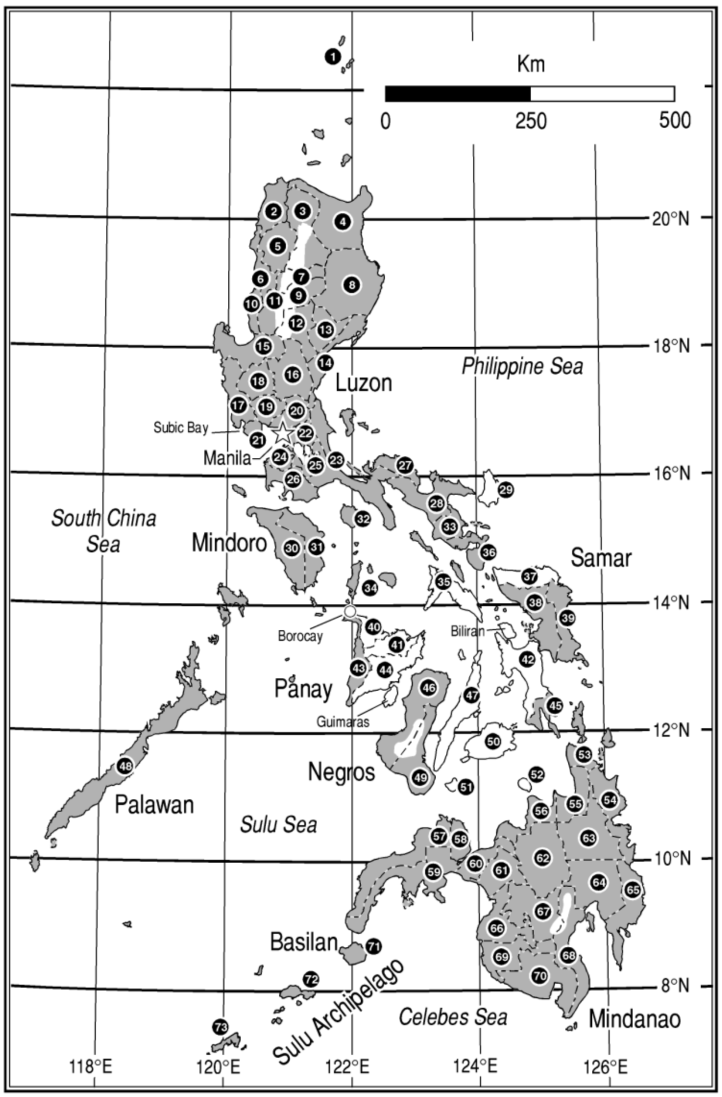
Risk areas: Risk exists throughout the year in all rural regions and islands below 2,000 feet (600 meters), except no risk is reported to exist in metropolitan Manila or the provinces of Aklan, Biliran, Bohol, Camiguin, Capiz, Catanduanes, Cebu, Guimaras, Iloilo, Leyte, Masbate, Northern Samar, and Siquijor. Risk is largely confined to rural areas not usually visited by short-term travelers and tourists. Risk is highest on the islands of Mindanao, Mindoro, Palawan, and the northern half of Luzon. No risk exists in the Borocay resort area or on the plains of Negros Island.

Protective measures: Medicines that protect against malaria in this area include mefloquine (Lariam), doxycycline, or atovaquone/proguanil (Malarone). Primaquine may be used in special circumstances (G6PD testing is required). The best drug for you depends on your itinerary and on a number of personal factors that should be discussed between you and your health care provider.

Key

- Malaria Risk Area
- ○ Malaria risk is not reported to exist in city
- ● Malaria risk exists in city
- Numbered province (see list). *Numbered circles are unrelated to malaria risk.*

Note: A star denotes the national capital.



Provinces

Note: *Numbered circles are unrelated to malaria risk.*

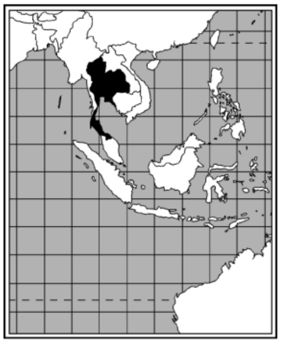
1 Batanes
2 Ilocos Norte
3 Kalinga-Apayao
4 Cagayan
5 Abra
6 Ilocos Sur
7 Mountain
8 Isabela
9 Ifugao
10 La Union
11 Benguet
12 Nueva Vizcaya
13 Quirino
14 Aurora
15 Pangasinan
16 Nueva Ecija
17 Zambales
18 Tarlac
19 Pampanga
20 Bulacan
21 Bataan
22 Rizal
23 Quezon
24 Cavite
25 Laguna
26 Batangas
27 Camarines Norte
28 Camarines Sur
29 Catanduanes
30 Mindoro Occidental
31 Mindoro Oriental
32 Marinduque
33 Albay
34 Romblon
35 Masbate
36 Sorsogon
37 Northern Samar
38 Samar
39 Eastern Samar
40 Aklan
41 Capiz
42 Leyte
43 Antique
44 Iloilo
45 Southern Leyte
46 Negros Occidental
47 Cebu
48 Palawan
49 Negros Oriental
50 Bohol
51 Siquijor
52 Camiguin
53 Surigao del Norte
54 Surigao del Sur
55 Agusan del Norte
56 Misamis Oriental
57 Zamboanga del Norte
58 Misamis Occidental
59 Zamboanga del Sur
60 Lanao del Norte
61 Lanao del Sur
62 Bukidnon
63 Agusan del Sur
64 Davao del Norte
65 Davao Oriental
66 Maguindanao
67 North Cotabato
68 Davao del Sur
69 Sultan Kudarat
70 South Cotabato
71 Basilan
72 Sulu
73 Tawi-Tawi

MRA1J

Figure 8. Reported Malaria distribution in Thailand.

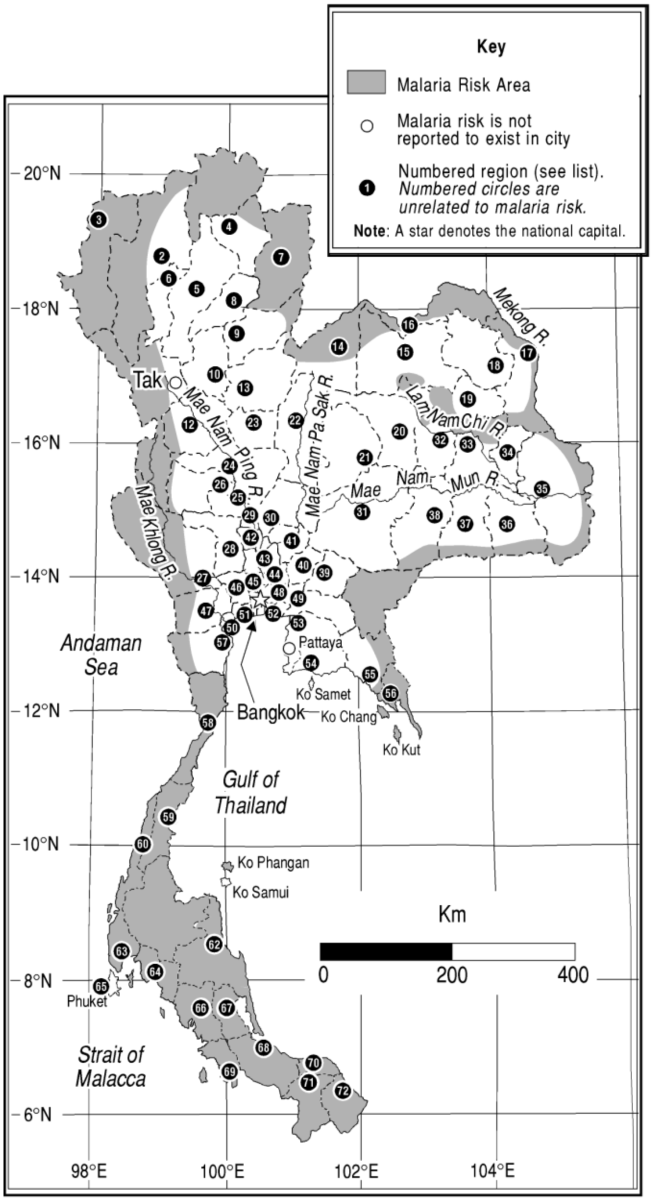
Malaria

Thailand



Risk areas: Risk is limited to evening or nighttime exposure in rural forest/jungle areas infrequently visited by travelers: primarily international border regions with Laos in the north and east, with Burma in the west, and with Cambodia in the east. Risk is highest in the provinces of Chiang Mai, Mae Hong Son, Tak, Kanchanaburi, Ratchaburi, Chanthaburi, Trat, Prachuap Khiri Khan, Surat Thani, Sa Kaeo, and Yala. Risk is lower in most provinces of the southern isthmus and the island of Ko Phangan. There is no risk in the interior of Thailand nor in the cities and main tourist resorts (Bangkok, Chiang Mai, Chiang Rai, Pattaya, Phuket Island, Ko Samui, Ko Samet, etc.)

Protective measures: Medicines that protect against malaria in this area include doxycycline or atovaquone/proguanil (Malarone). Primaquine may be used in special circumstances (G6PD testing is required). Because mefloquine resistance is reported from areas near the borders with Cambodia and Myanmar, mefloquine is not an option in Thailand. The best drug for you depends on your itinerary and on a number of personal factors that should be discussed between you and your health care provider.



Provinces of Thailand

Provincial capitals have the same name as their respective provinces. Numbers are in the approximate location of the provincial capitals. All capitals are represented with a black numbered circle and are unrelated to malaria risk. Refer to the ***Risk areas*** statement above and the ***Key*** at left to assess risk.

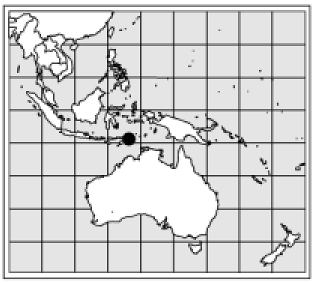
1. Chiang Rai
2. Chiang Mai
3. Mae Hong Son
4. Phayao
5. Lampang
6. Lamphun
7. Nan
8. Phrae
9. Uttaradit
10. Sukhothai
12. Kamphaeng Phet
13. Phitsanulok
14. Loei
15. Udon Thani
16. Nong Khai
17. Nakhon Phanom
18. Sakon Nakhon
19. Kalasin
20. Khon Kaen
21. Chaiyaphum
22. Phetchabun
23. Phichit
24. Nakhon Sawan
25. Chai Nat
26. Uthai Thani
27. Kanchanaburi
28. Suphan Buri
29. Sing Buri
30. Lop Buri
31. Nakhon Ratchasima
32. Maha Sarakham
33. Roi Et
34. Yasothon
35. Ubon Ratchathani
36. Sisaket
37. Surin
38. Buriram
39. Prachin Buri
40. Nakhon Nayok
41. Sara Buri
42. Ang Thong
43. Phra Nakhon Si Ayutthaya
44. Pathum Thani
45. Nonthaburi
46. Nakhon Pathon
47. Ratchaburi
48. Krung Thep Mahanakhon
49. Chachoengsao
50. Samut Songkhram
51. Samut Sakhon
52. Samut Prakan
53. Chon Buri
54. Rayong
55. Chanthaburi
56. Trat
57. Phetchaburi
58. Prachuap Khiri Khan
59. Chumphon
60. Ranong
61. Surat Thani
62. Nakhon Si Thammarat
63. Phangnga
64. Krabi
65. Phuket
66. Trang
67. Phatthalung
68. Songkhla
69. Satun
70. Pattani
71. Yala
72. Narathiwat
73. Sa Kaeo

MRA1L

Figure 9. Reported Malaria distribution in Timor-Leste.

Malaria

East Timor



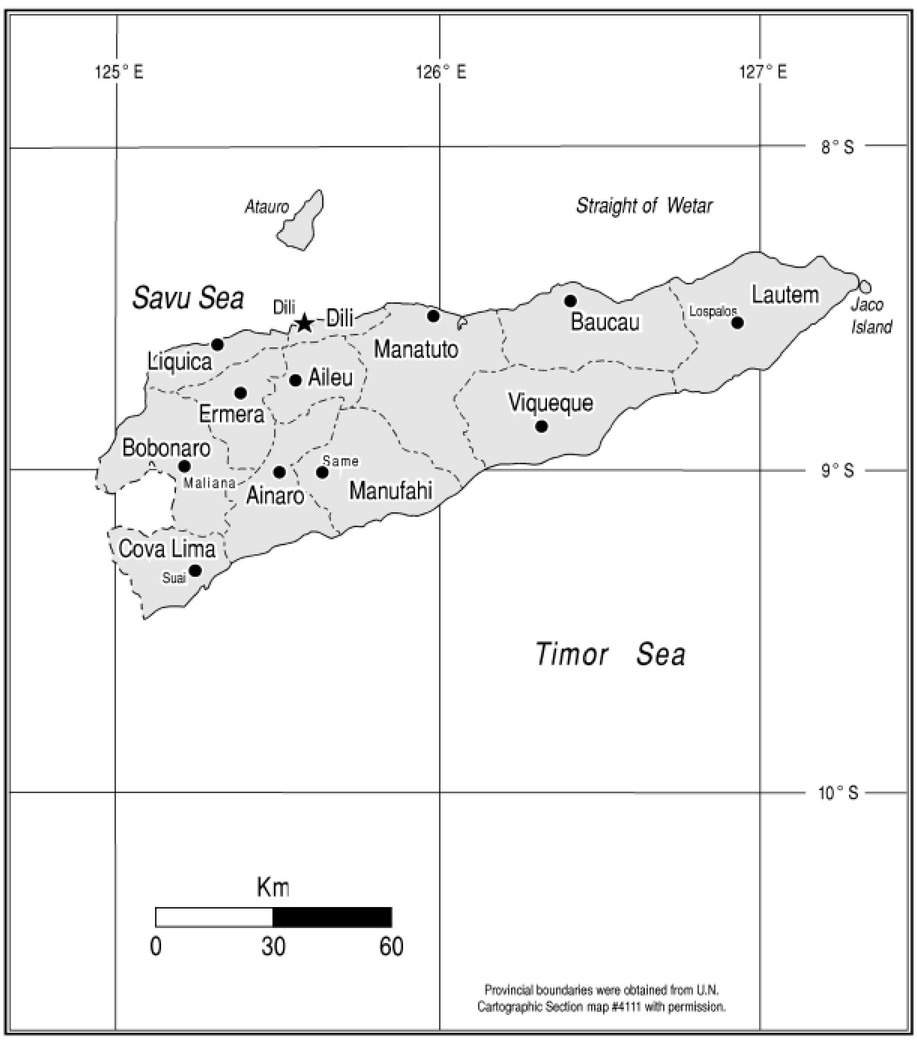
Risk areas: High risk (approximately equal *P. falciparum* and *P. vivax*) exists throughout the year in the whole country including urban areas.

Protective measures: Medicines that protect against malaria in this area include mefloquine (Lariam), doxycycline, or atovaquone/proguanil (Malarone). Primaquine may be used in special circumstances (G6PD testing is required). The best drug for you depends on your itinerary and on a number of personal factors that should be discussed between you and your health care provider.

Key

- Malaria Risk Area
- ○ Malaria risk is not reported to exist in city
- ● Malaria risk exists in city

Note: A star denotes the national capital.



MRA1B

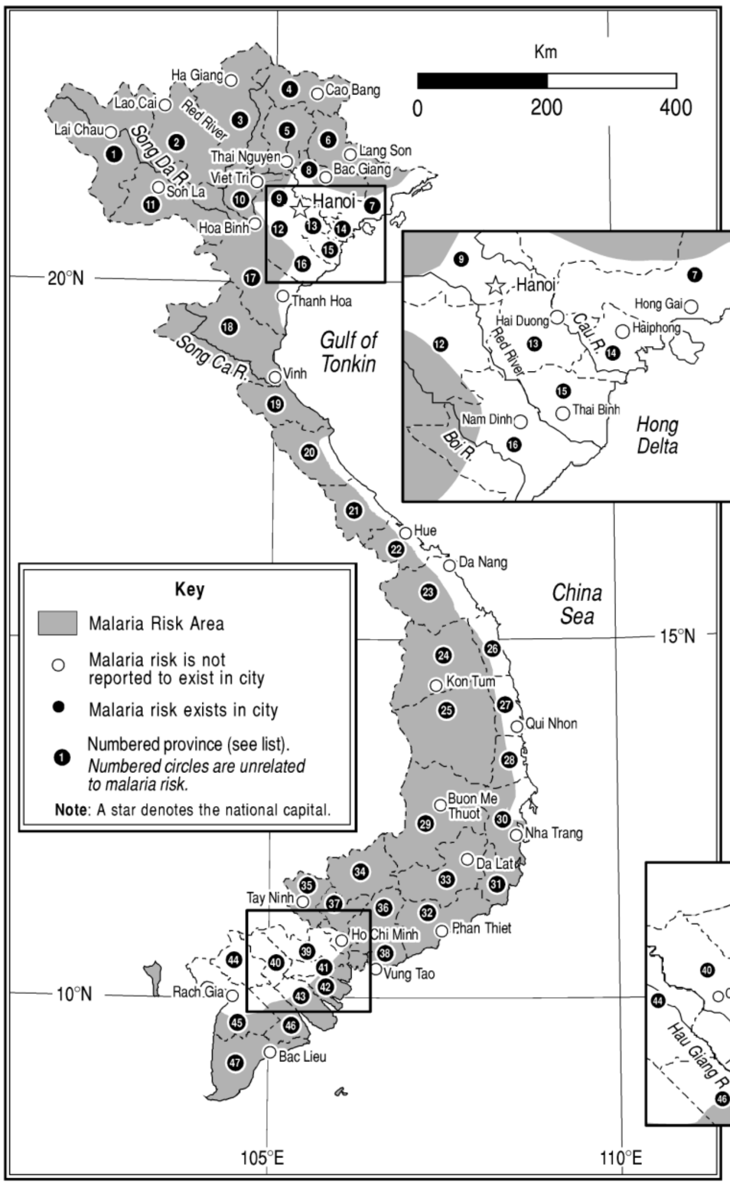
Figure 10. Reported Malaria distribution in Vietnam.

Malaria

Vietnam

Risk areas: Risk (predominantly *P. falciparum*) exists throughout the year in many rural areas. Highest risk areas are in the north along the border with China, highland and forested areas below 4,900 feet (1,500 meters) south of 18.5 N (notably the central highlands provinces of Dac Lak, Dac Nong, Gia Lai, and Kon Tum), Binh Phuoc province, and the western parts of the coastal provinces Quang Tri, Quang Nam, Ninh Thuan, and Khanh Hoa. No risk exists in the Red River delta region, the coastal plain north of Nha Trang, the area from Ho Chi Minh City (Saigon) southwest to Rach Gia, or in the cities of Hanoi, Ho Chi Minh, Da Nang, Nha Trang, Qui Nhon, and Hai Phong.

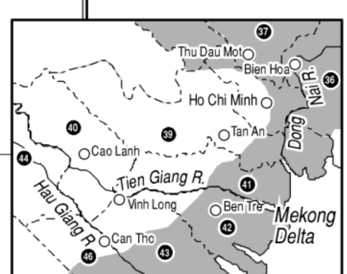
Protective measures: Medicines that protect against malaria in this area include mefloquine (Lariam), doxycycline, or atovaquone/proguanil (Malarone). Primaquine may be used in special circumstances (G6PD testing is required). The best drug for you depends on your itinerary and on a number of personal factors that should be discussed between you and your health care provider. Mefloquine resistance may occur in some areas.



Provinces

Note: Province names that do not fit on the map are indicated by the numbers below. *Numbered circles are unrelated to malaria risk.*

1 Lai Chau
2 Hoang Lien Son
3 Ha Tuyen
4 Cao Bang
5 Bac Thai
6 Lang Son
7 Quang Ninh
8 Ha Bac
9 Hanoi
10 Vinh Phu
11 Son La
12 Ha Son Binh
13 Hai Hung
14 Haiphong
15 Thai Binh
16 Ha Nam Ninh
17 Thanh Hoa
18 Nghe An
19 Ha Tinh
20 Quang Binh
21 Quang Tri
22 Thua Thien Hue
23 Quang Nam - Da Nang
24 Kon Tum
25 Gia Lai
26 Quang Ngai
27 Binh Dinh
28 Phu Yen
29 Dac Lak - Dac Nong
30 Khanh Hoa
31 Minh Thuan
32 Binh Thuan
33 Lam Dong
34 Binh Phuoc
35 Tay Ninh
36 Dong Nai
37 Binh Duong
38 Dac Khu Vung Tau Con Dao
39 Long An
40 Dong Thap
41 Tien Giang
42 Ben Tre
43 Cuu Long
44 An Giang
45 Kien Giang
46 Soc Trang
47 Ca Mau - Bac Lieu



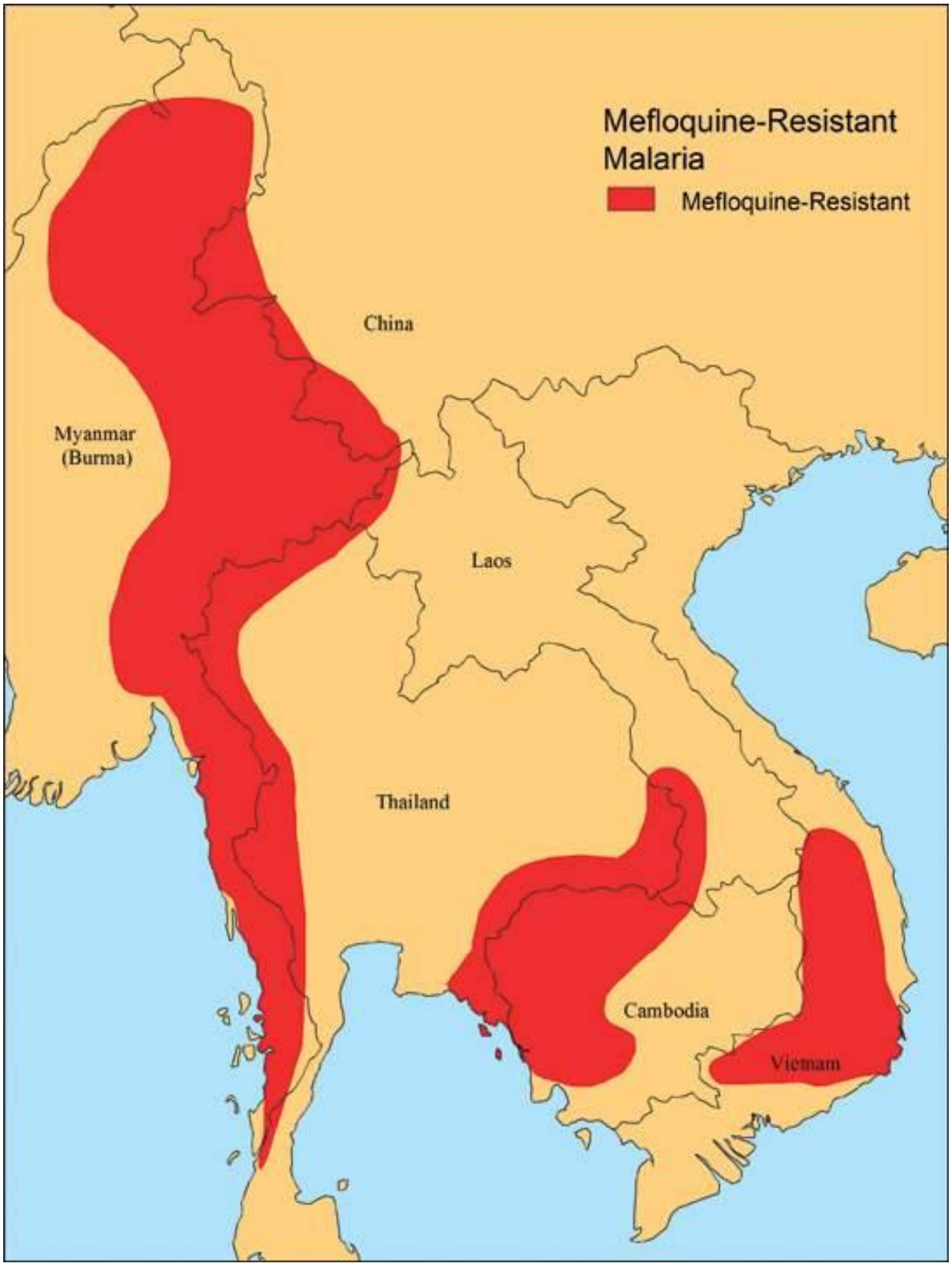


Figure 11. Reported Mefloquine-Resistant Malaria distribution in Southeast Asia.

Transmission Cycle(s). Humans are the only reservoir host of human malaria. Nonhuman primates are naturally infected by many *Plasmodium* species that can infect humans, but natural transmission is rare. Female mosquitoes of the genus *Anopheles* are the exclusive vectors of human malaria. *Plasmodium* species undergo a complicated development cycle in the mosquito. When a female *Anopheles* ingests blood containing the sexual stages (gametocytes) of the parasite, male and female gametes mature then unite to form a motile ookinete that penetrates the mosquito's midgut wall and encysts on its outer surface. Thousands of sporozoites develop in each cyst. They are eventually released, and some of them migrate to the salivary glands, enter them and mature to an infective state. Infective sporozoites are subsequently injected into a human host when the mosquito takes another blood meal (Figure 12).

The time between ingestion of gametocytes and liberation of infective sporozoites, is usually 8-35 days, and depends on the temperature and species of *Plasmodium*. Malaria parasites develop in a vector mosquito most efficiently when ambient air temperatures are between 25^{o}-30^{o}C. Parasite development is slower during cool seasons and at high altitudes, and may exceed the life expectancy of the vector.

An adult female *Anopheles'* life span varies widely depending on species and environmental conditions. Longevity is an important characteristic of a good vector. Once infected, a mosquito remains infective for life and can transmit sporozoites at each subsequent feeding (Figure 13). Vector competence is usually higher with indigenous malaria strains. This may reduce the likelihood that imported strains from migrant hosts will become established.

Vector Ecology Profiles. Worldwide, about 70 species of *Anopheles* transmit human malaria to man but only about 40 of those are important vectors. Any given species usually varies at least slightly in biology, behavior or both; and sometimes apparently very slight differences can lead to one geographic population of that species being a much more or much less important a vector (of any given pathogen) than another given geographic population.

General Bionomics. Female anopheline mosquitoes must ingest a bloodmeal for their eggs to develop. Feeding activity begins at dusk for many species, but some feed only late at night or at dawn. Most anophelines feed on exposed legs, but some may feed on arms, ears or the neck. Infected females tend to feed intermittently and thus may bite several people. Eggs mature 3 to 4 days after a bloodmeal and are deposited one at a time, mainly onto clean water with or without emergent vegetation, depending upon the mosquito species. Each female may lay up to 300 eggs.

Mosquito larvae feed on organic debris and minute organisms living in aquatic habitats. Oviposition sites may include ground pools, stream pools, slow moving streams, animal footprints, artificial water vessels, and marshes. Deep water (>1 m deep) is usually not suitable for larval development. There are 4 larval instars and 1-2 weeks are usually required to develop to the nonfeeding pupal stage. The pupa is active and remains in the water for several days to a week prior to adult emergence.

The life span of females is usually only 1 to 3 weeks, although under ideal conditions female mosquitoes may live for 2 to 3 months. Longevity of individual species varies. A long life span is an important characteristic of a good vector (Figure 13). The older the anopheline population is in an endemic area, the greater the potential for transmission. Males live only a few days. Females mate within swarms of males, usually one female at a time per swarm. Both males and females feed on plant sugars and nectar to get energy for flight and other activities.

Figure 12. Typical Malaria Life Cycle.

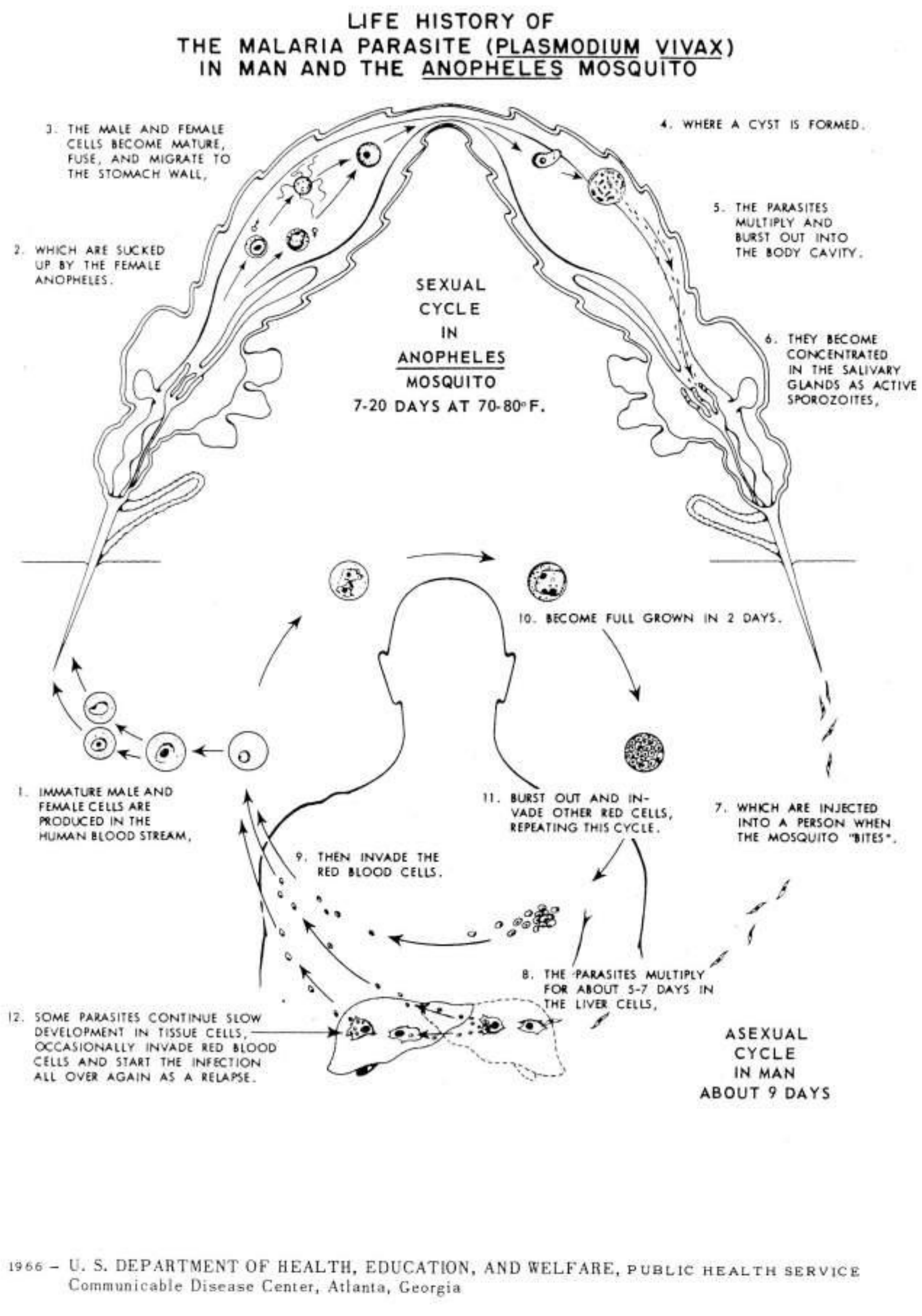


Figure 13. Malaria Disease Transmission Cycle.

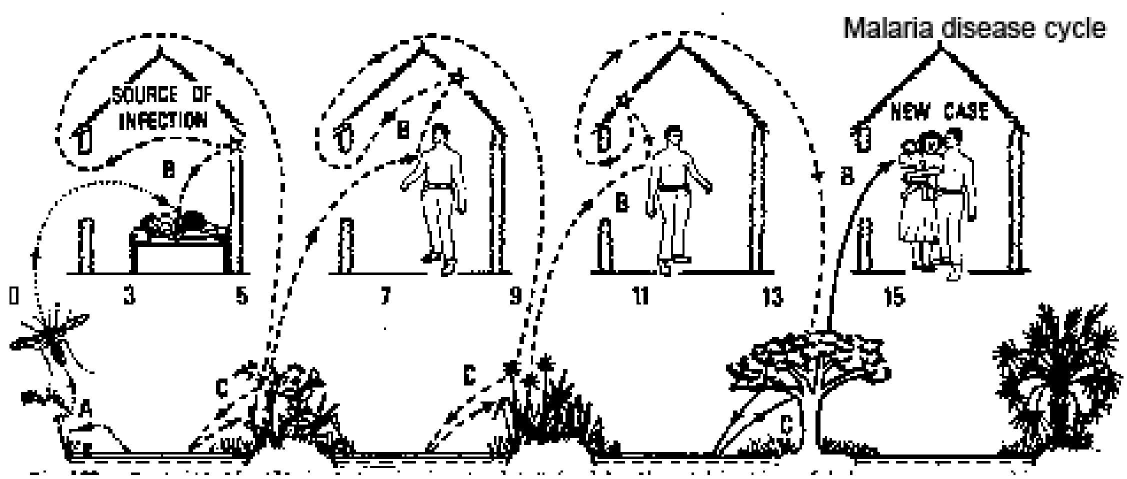


Figure 14. Comparison of Characters of Major Mosquito Vector Genera.

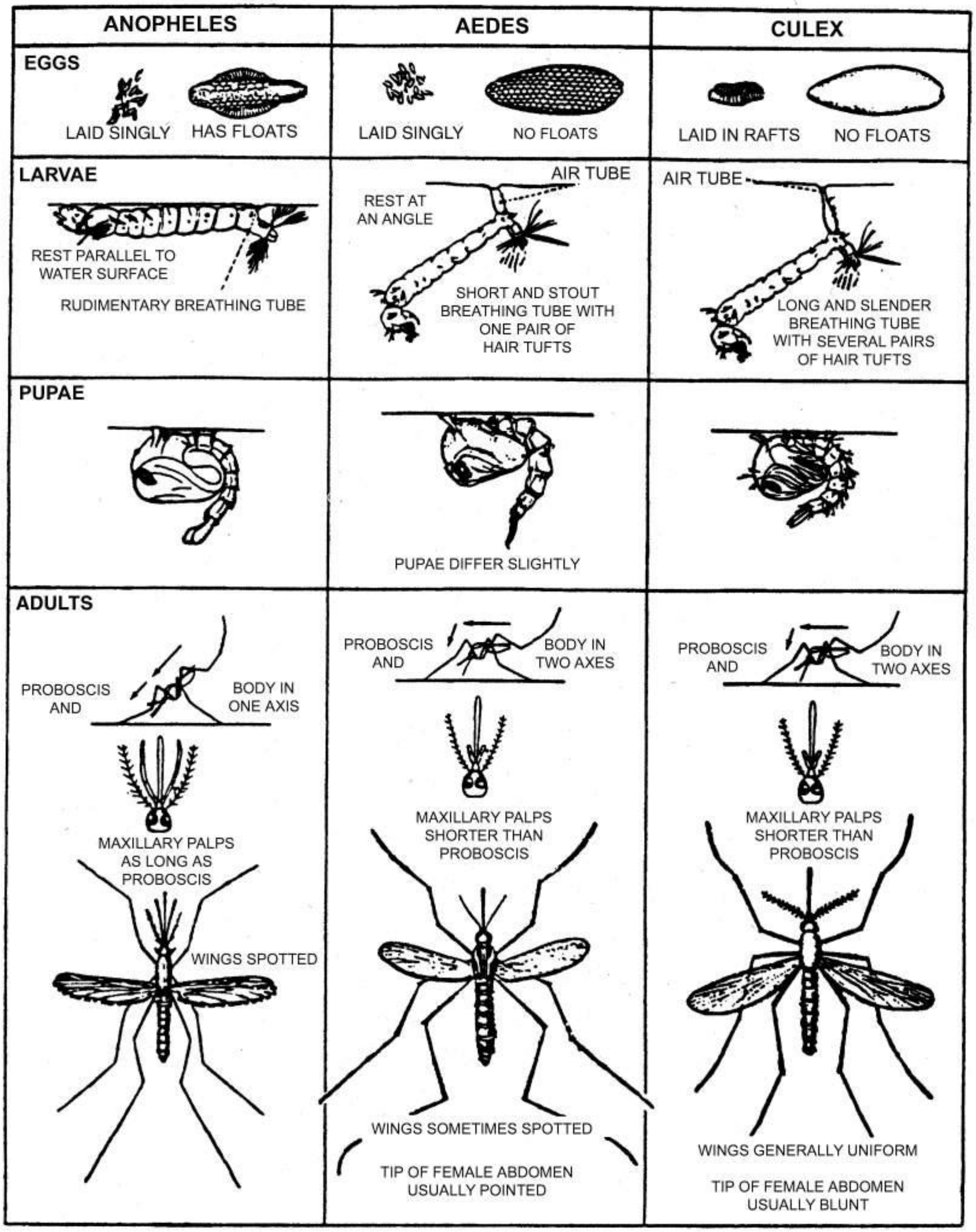
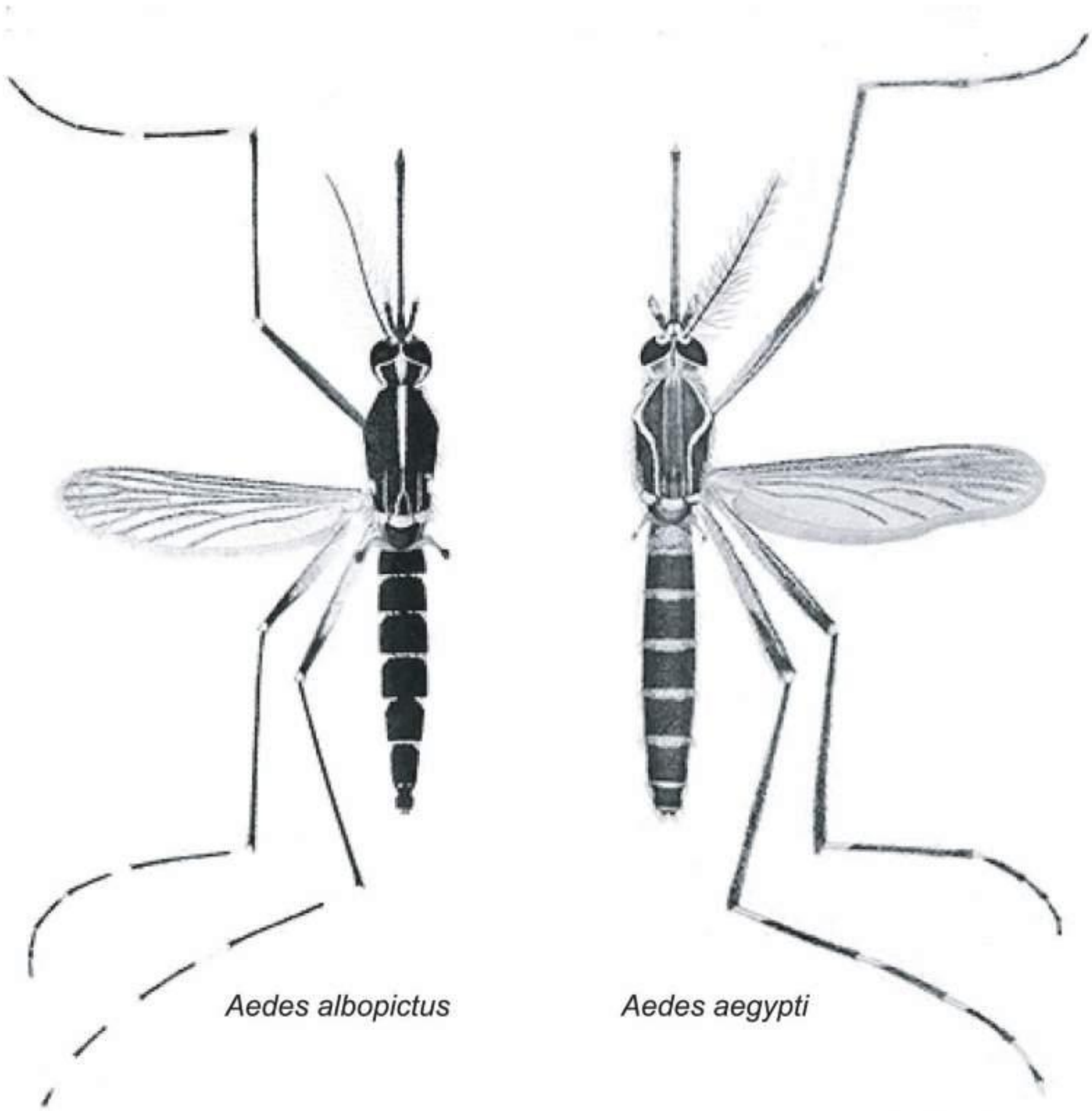


Figure 15. Comparison of Adult Female *Aedes aegypti* vs. *Aedes albopictus*.



Adult Feeding, Resting, and Flight Behavior. *Anopheles* species that are strongly attracted to and bite humans (anthropophilic) are usually more important as vectors than those species that strongly prefer feeding on non-human hosts (zoophilic). *Anopheles* females generally fly only short distances from their breeding sites. Flight range is the distance traveled from the breeding site over the course of the mosquito's lifetime. This is important when determining how far from military cantonments or human settlements to conduct larviciding operations. Vectors that feed and rest indoors are more susceptible to control by residual insecticides.

Specific Bionomics: There are at least 146 species of *Anopheles* reported from Southeast Asia (Table 1). At least 39 of them are reported to be human malaria vectors. Vector activity and efficiency can vary a lot from one country or habitat to another. Species which are primary vectors in one country or setting (forest, coastal swamp, higher elevation, *etc*.) may be only secondary vectors, or may not usually even be present, in another site only a few kilometers away. Breeding sites are often relatively focal and distributed irregularly.

Of the 39 malaria vectors reported from this region (Table 2), 11 species are considered to be primary vectors nearly everywhere they breed naturally; 22 others are considered to be only secondary vectors nearly every place they breed naturally; and six more species are primary vectors in some places and only secondary vectors in others. Remember that even if a given species is never a very efficient vector, if it is the only potential vector present in the location of concern, then it would be the "primary" vector species in that circumstance.

In many urban and suburban areas throughout the region, *Anopheles stephensi* is a primary vector. Yet, in many rural, forested areas, it is often collected, but is seldom infected and poses almost no vector threat to humans. This may be due to multiple currently undeterminable subspecies (or populations), which feed mainly on non-human hosts.

Previous studies in India reported that the two subspecies found there, *Anopheles stephensi stephensi* and *Anopheles stephensi mysorensis*, were morphologically almost indistinguishable but behaviorally very distinct. The former bred mainly in forests or swampy sites and seldom ever took blood from humans, but the latter, *An. s. mysorensis*, bred almost exclusively in clear fresh water in a wide variety of artificial containers in urban sites and avidly bit humans.

Species considered primary vectors in Southeast Asia include: *An. baimaii*, *An. balabacensis*, *An. campestris*, *An. cracens*, *An. culicifacies*, *An. donaldi*, *An. fluviatilis*, *An. letifer*, *An. leucosphyrus*, *An. sawadwongporni*, and *An. sundaicus*. Those considered mainly secondary vectors in this region include: *An. aconitus*, *An. annularis*, *An. bancroftii*, *An. farauti*, *An. jeyporiensis*, *An. karwari*, *An. koliensis*, *An. lesteri*, *An. ludlowae*, *An. maculatus*, *An. mangyanus*, *An. minimus*, *An. nemophilous*, *An. philippinensis*, *An. pseudowillmori*, *An. punctulatus*, *An. subpictus*, *An. tessellatus*, *An. umbrosus*, *An. varuna*, and *An. whartoni*. The species considered to be primary vectors in some parts but only secondary vectors in other parts of this region are: *An. dirus* (*s.s.*), *An. flavirostris*, *An. nigerrimus*, *An. sinensis*, *An. stephensi*, and *An. takasagoensis*.

1. Primary Vectors.

Anopheles baimaii occurs in the forested foothills of northern Myanmar and northwestern Thailand. It is one of a complex of "white-kneed mosquitoes," so called because of because of pale markings between their tibiae and tarsi. This is species D of the former *An. dirus* complex. It is an efficient human malaria vector because of its fairly strong anthropophilic blood feeding behavior and strong flight capability (2-4 km). This species feeds mainly outdoors but also indoors, but it tends to rest mainly outdoors, making it difficult to control with residual indoor sprays (RIS). It usually feeds at night (2200-0400) and transmits malaria mainly (maybe only) during a monsoon season. Larvae are most often found in partly shaded clear stream pools, undisturbed puddles or ruts, occasionally in cisterns or water storage jars, and rarely in edges of slow moving streams.

Anopheles balabacensis is found in a moderately open rain forest or jungle margin, in uplands or foothills of Indonesia, Malaysia, the Philippines, and Thailand. This predominantly forest-dwelling species readily bites humans outdoors or indoors, even through or under bed nets, mainly in evening or early morning hours (and sometimes at night). Females rest mainly outdoors, but sometimes indoors, too. They are moderately strong fliers (up to 2 km). Their anthropophilic habit and fairly long flight range make females of this species effective vectors of human malaria. Their larvae are usually found in shaded temporary pools, wheel ruts, or open puddles in a jungle margin or clearing.

Anopheles campestris is found mainly along the coasts and deltas of Cambodia, Indonesia, Malaysia, Thailand, and Timor-Leste. It has historically been widely misidentified as *Anopheles barbirostris*, which is a rather strongly zoophilic species, found mainly in upland open forests. It has also sometimes been confused with *An. donaldi*, which is a less common species more often found in margins of open forests and agricultural land, usually at higher elevations and not very near a sea coast. Females of this species readily bite humans and animals, outdoors or indoors, mainly before midnight. They rest either indoors or outdoors, and have a moderate flight range (up to at least 1 km). Larvae of *An. campestris* are usually found in well-shaded fairly deep fresh water pools, ditches, swamps, or corners of rice fields with at least some vegetation.

Anopheles cracens occurs in the forested foothills of northern Myanmar and northwestern Thailand. It is one of a complex of “white-kneed mosquitoes,” so called because of because of pale markings between their tibiae and tarsi. This is species B of the former *An. dirus* complex. It is reported to be an efficient human malaria vector because of its anthropophilic blood feeding behavior and moderate to strong flight capability (2 km). This species feeds mainly outdoors but occasionally indoors, too. It tends to rest mainly outdoors, making it difficult to control with residual indoor sprays (RIS).

Recent studies have shown a very high (up to 77%) rate of naturally occurring infection of wild-caught females by a monkey malaria, *Plasmodium cynomulgi* B strain. Its usual peak blood feeding period is 1900-2100 and it reportedly transmits human malaria most efficiently during a monsoon season. Larvae are found mainly in secondary rainforests, in clear stream pools, sunlit or shaded, stagnant, clear or slightly colored fresh water puddles or ruts, and rarely in edges of slow moving streams.

Anopheles culicifacies occurs in Cambodia, Indonesia, Laos, Myanmar, Thailand and Vietnam. At least three sibling species have been identified, with species A being the most anthropophilic, and therefore, an important malaria vector wherever it occurs. This species is widely distributed, and is mainly found in the margins of open agricultural areas with limited trees. Adults may congregate in large numbers in small dark spaces, cracks or crevices in homes or cow sheds during the day. It may be active year round in warmer locations, but survives well (overwintering as larvae) up to 2,100 m elevation in the northernmost parts of its range (in India).

Species B and C are reportedly mainly zoophilic, readily feeding on cattle and occasionally on humans. This species feeds throughout the night, but feeding usually declines after 0300 hours. Specimens which feed indoors often remain indoors to rest, but *An. culicifacies* females often feed and rest outdoors, too. Larvae breed in clean, fresh water in irrigation channels, slow-moving streams, shallow tanks, borrow pits with grassy edges, and wells. Adults generally fly distances of 0.4 km or less but are known to fly 5.2 km from their nearest larval habitats. This species is relatively long-lived and may survive through 8 gonotrophic cycles.

Anopheles donaldi is found mainly in margins of open forests and agricultural land, usually at moderate to higher elevations in Indonesia, Malaysia, and Thailand. It has historically sometimes been misidentified as *An. barbirostris*, which is a more strongly zoophilic species, found mainly in upland open forests. Females of *An. donaldi* are somewhat zoophilic, but readily bite humans, indoors or outdoors, mainly at night but rarely also during the day in shaded places. They rest mainly outdoors, but occasionally indoors, too. Their flight range has not been well studied, but is probably not very great (reportedly <1 km). Larvae of *An. donaldi* are usually found in well-shaded fresh water jungle pools, swamps, or corners of rice fields or slow streams with at least some vegetation.

Anopheles fluviatilis commonly occurs in forested uplands and foothills in Indonesia, Myanmar, Thailand, and Vietnam. At least three sibling species, designated S, T and U, have been identified. This species (larvae or adults) occurs year-round, except they tend to be less abundant in the early part of the monsoon season. This species is seldom found below 350 m and occurs up to 2,300 m elevation. It feeds and rests both indoors and outdoors, readily biting man and animals mainly before midnight. Sometimes they may continue to feed until 0300. This is an important vector of human malaria across most of its range. The flight range of females usually does not exceed 0.5 km, but flights up to 1.5 km have been reported. Larvae are found mainly in open, sunlit, grassy (vegetated) edges of slow moving streams, springs, irrigation canals, ponds, swamps, and lakes.

Anopheles letifer is a fairly large mosquito which occurs in coastal plains areas of Indonesia, Malaysia, the Philippines, Singapore, Thailand, Timor-Leste, and Vietnam. Females bite humans fairly often, indoors, mainly at night (dusk to dawn), but rarely also in shaded sites during the day, and they rest predominantly outdoors. Populations of this species in Malaysia have been reported to peak during the rainiest months of the year, and human malaria case incidence in those areas reportedly usually follows a similar pattern, with a slightly shifted (delayed) peak.

Larvae of this species are mainly found in shaded, peaty, acidic (pH <5.9) fresh water stagnant pools, or ponds in coastal plains. Little has been reported about their flight range, but they are probably weak to moderate range fliers (about 1 km or less), based on the locations of their breeding sites and their reported blood feeding habits. This species has reportedly been misidentified in past as *An. umbrosus*., which is not a very important vector of human malaria. That species has been observed to be more zoophilic than *An. letifer*, and sporozoites detected in wild-caught *An. umbrosus* have often been identified as belonging to different animal, but very rarely human, malaria species.

Anopheles leucosphyrus (*s.s.*) occurs in forested, usually hilly, areas of Indonesia, Malaysia, Thailand, and probably also Timor-Leste. Females readily feed on humans, and also animals, mainly indoors, but also outdoors. They rest mainly outdoors, but often indoors as well. This species is an important vector of human malaria, especially when their populations are large, and in places where they are the main potential vector species present. Larvae are usually found in clear freshwater seepage pools in forest margins or clearings, sometimes also in swamps.

Anopheles sawadwongporni is mainly found at both low and high elevations in forested hills of northern Cambodia, Myanmar, Thailand, and northern and western Vietnam. Often found in association with one or more other species of the *An. maculatus* group, and commonly found up to 1,500 m elevation. Mainly zoophilic, but readily bites man outdoors at night, and usually rests only outdoors. Rarely bites or rests indoors. Reported to be an efficient malaria vector within the more remote portions of its range. Although this has not been well studied, this species is presumed to be a weak to moderate flier, going up to about 1.5 km. Larvae are mainly found in partly shaded freshwater seepage pools and margins of lakes and streams.

Anopheles sundaicus is a coastal species which occurs in Cambodia, Indonesia, Malaysia, Myanmar, the Philippines, Singapore, Thailand, Timor-Leste, and Vietnam. It may also occur in Brunei, but has not yet been reported from there. They usually take blood meals at night from water buffalo or pigs in preference to humans. However, they will feed on humans fairly readily, and they often feed and rest indoors (in homes or animal sheds). Females are strong fliers (commonly >5 km), they have been found naturally infected with human malaria throughout much of their range, and they often develop locally very large populations. Larvae breed only in brackish water with a range of 0.4-3.0% salinity (with a range of 1.2-1.8% preferred). Larvae are often found in fish ponds, especially if algal mats are present. In addition, larvae of *An. sundaicus* are relatively tolerant of organic and some kinds of chemical pollution.

2. Secondary Vectors.

Anopheles aconitus is a small species about the size of *An. minimus*. This species occurs in open forested foothills (to about 1,000 m elevation) and plains in Cambodia, Indonesia, Malaysia, Myanmar, Thailand, Timor-Leste, and Vietnam. It occurs nearly year-round but is less abundant early in the monsoon season. It commonly occurs in houses and animal sheds and feeds avidly on man, and on cattle, too. It is a moderately strong flier (1.5 to 2.5 km). Larvae breed in rice fields, streams, fresh water drainage, and other shaded pools and ponds with emergent vegetation.

Anopheles annularis is a brightly marked, minor malaria vector species that occurs in parts of Cambodia, Indonesia, Malaysia, Myanmar, the Philippines, and Vietnam. This species may also occur in Timor-Leste. This is a complex with at least two sibling species, designated Species A and B. Species B is considered the better malaria vector. *Anopheles annularis* is highly zoophilic throughout most of its range, and it prefers to feed and rest outdoors, primarily before midnight.

It often occurs in large numbers during the post-monsoon seasons and into the dry, cool season. Adult females sometimes congregate in very large numbers inside homes or animal sheds at night, and readily feed on humans who may be present there. Adults are moderately strong fliers that disperse up to 1.7 km or more from their breeding sites to find a host. This species occurs up to 2,000 m elevation and may overwinter as both larvae and adults in northern parts of its range and at higher elevations. Larvae are found in rice fields or other clear permanent fresh water bodies with emergent vegetation.

Anopheles bancroftii is apparently a complex of multiple sibling species or subspecies which need further taxonomic study. They most often occur in moderately dense forests or jungles of foothills or uplands, and have been reported from Indonesia and possibly also occur in Timor-Leste. In the southern and eastern parts of its range (New Guinea and Australia), some populations of this species are highly anthropophilic, are often very numerous, and are problem biters during late evening and night. They sometimes bite humans in shaded sites during the day. They tend to rest mainly outside and are also often found resting inside homes or animal sheds. Larvae are mainly found in moderately to heavily shaded swampy fresh water or slow stream edges with algae and emergent vegetation. This species is often found breeding and feeding in or near the same locations as *An. farauti*, which is reportedly a more efficient vector of human malaria.

Anopheles farauti occurs in Indonesia, and possibly also in Timor-Leste, but its main natural distribution in farther south and east of Southeast Asia, in Australia and certain of the southwestern Pacific islands. This is currently considered to be a complex of seven different species (or subspecies) which need further taxonomic study. In some parts of its range, females feed very readily (almost exclusively) on humans, indoors, and some will also rest indoors. In other locations, they seem reluctant to enter, feed, or rest inside homes or animal sheds. Females are usually most active at night, but will sometimes bite humans during overcast daytime hours.

This species is considered to be a very efficient vector of human malarias throughout most of its range. Females of *An. farauti* (*s.s.*) usually rest outdoors, frequently on or among shaded stems of grass or bushes. Adults are moderately strong fliers (up to 1.5 km), and are rarely found near their larval breeding sites except when laying their eggs. Larvae are typically found in sunlit or partly shaded, fairly clear, fresh (rarely brackish) water in ditches, puddles, pools, ruts, old bomb craters, animal wallows, or almost any open depression.

Anopheles jeyporiensis is a small species resembling *An. minimus*. Females readily bite man inside buildings or tents, usually starting about two hours after nightfall. They tend strongly to rest outdoors, seldom remaining inside after feeding or during the day, but it is frequently found in houses and cattle sheds at night. This species occurs mainly in higher foothills with open forests, plantations, or agricultural areas in Cambodia, Laos, Myanmar, Thailand, and Vietnam. It has been reported at altitudes up to 2,000 m. Its flight range is moderate, often exceeding 0.8 km. Larvae breed in clear, cool, partly shaded fresh water, in and around rice fields, seepages, slow-moving grassy streams, and edges of ponds with moderate to heavy emergent vegetation.

Anopheles karwari is a medium sized, light gray species, which occurs in open forested sites on low to moderate elevation hills of Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Singapore, Thailand, Timor-Leste, and Vietnam. Females take blood mainly from animals, but occasionally bite humans, predominantly outdoors at night. They rest mainly outdoors, but rarely indoors, too. Their flight abilities have not been well documented, but they are likely to be moderate to strong fliers, probably going about 1 km, based on their breeding sites and feeding habits. Larvae are most often found in fairly clear fresh water seepages, small streams and ponds in sunlit or lightly shaded places.

Anopheles koliensis occur mainly in low coastal plains of Papua and some other eastern Indonesian islands (in the Lesser Sunda group) and on certain other islands of the southwestern Pacific. Females are strongly anthropophilic, feeding both indoors and outdoors at night mainly on man, and sometimes animals. They rest both indoors and outdoors near where they fed, often remaining there for several hours, not departing until the next day. Their flight range has not been well studied, but they are likely to be moderate to strong fliers, probably going about 1 km, based on their breeding sites, general habitat, and feeding habits. Larvae are most often found in temporary marshy or grassland pools of fresh water, drainage ditches, or in margins of slow streams flowing through open forested sites, and usually in full sunlight.

Anopheles lesteri is a medium-sized to fairly small, grayish species which occurs in wooded hilly sites in the Philippines (also China, Japan, and the Koreas). Females readily bite man indoors at night and rest indoors or outdoors. They are often found resting in corners or protected small partly-enclosed spaces in homes or animal sheds in colder sites or at higher elevations.

Adult females are strong fliers, routinely going up to 2 km. to or from breeding sites. Larvae are found mainly in cool, fairly clear, shaded pools, marshes, rice fields, edges of lakes or ponds, or other impounded fresh water.

Anopheles ludlowae occurs in forested uplands in Indonesia (especially south central Celebes), eastern Malaysia, and the Philippines. Females feed avidly on humans, mainly outdoors but also indoors at night. They tend to rest mainly outdoors but often indoors, too. Females rarely will also bite humans in shaded sites outdoors during the day. Their flight range has not been reported, but they are likely to be moderate to strong fliers, probably going 0.5-1 km, based on their breeding sites, general habitat, and feeding habits.

Larvae are mainly found in clear shaded or open fresh water ponds, lake margins, or slow streams. However, larvae of the populations in southern Celebes have been found almost exclusively in remaining shallow pools in the sand-and-gravel beds of large rivers, during dry seasons after the water level of the main stream had become very low. Those larvae were reportedly routinely flushed out with the next heavy pulse of river flow.

Anopheles maculatus occurs in fairly open forests in hilly areas of Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Thailand, Timor-Leste, and Vietnam. This is a complex of at least eight different sibling species or subspecies, most of which are primarily zoophilic, but will sometimes feed on humans, mainly outdoors after dark (mainly 1900-0200). At least one member of this complex is mainly anthropophilic and apparently an effective vector of human malaria. Female *An. maculatus* rest mainly outdoors after feeding, often in vegetation along a stream bed, and they typically disperse at least 1 km from their breeding sites to feed and later return to lay their eggs. Larvae usually breed in sunlit stream margins, edges of ponds, ditches and rice fields. They have been found in stagnant or polluted water, but never in brackish water.

Anopheles mangyanus has been found in heavily wooded sites in the Philippines, so far only at < 700 m elevation. Laboratory-reared populations of this species can readily become experimentally infected with human malarias, and this species has been repeatedly associated with intense local malaria transmission in newly cleared forest sites in the Philippines.

They have been observed to readily bite man in forest margins at night. They apparently bite, and then rest, almost exclusively outdoors. Based on very limited observations of their adult flight range, they can fly at least 1 km. Larvae are usually found in clear fresh water along shallow forest stream margins, with sandy or rocky beds, and they can be very numerous among the roots and stems of emergent plants along edges of irrigation canals, especially bamboo.

Anopheles minimus is a small grayish, speckled mosquito that occurs in open limitedly-forested upland areas and foothills of Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Thailand, Timor-Leste, and Vietnam. It is a moderately strong flier (up to 3 km), feeds strongly on humans mainly indoors, but will feed outdoors on man and animals. It generally rests indoors, but sometimes also outdoors. This species occurs year-round in many areas. The larvae breed in clean, cool, slow-moving stream with partially shaded (often grassy) margins in the dry season, but are also found in ground pools in the rainy season. Other larval habitats include irrigation ditches, springs, seepages, and rice fields.

Anopheles nemophilous occurs mainly in forested mountains and foothills at 100-1,500 m elevation in Peninsular Malaysia and Thailand. Females have been observed to bite man outdoors in forest margins, in forests canopy, and indoors at night (1830-2200), and animals outdoors at night. Flight range has not been reported, but it is likely to be a weak to moderate flier, probably going up to 1 km, based on breeding sites, general habitat, and feeding habits. Larvae are typically found in small, fairly clear, shaded, temporary pools of fresh water, ruts, puddles, or elephant footprints.

Anopheles philippinensis is a small species that occurs mainly in lowlands and coastal plains in Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Thailand, Vietnam, and possibly also Timor-Leste. It is most common during the monsoon and post-monsoon seasons. It is largely zoophilic and feeds at night on animals, but also on man, resting mainly outdoors, but occasionally, indoors. It generally does not disperse more than 1 km from its breeding habitats. Larvae breed mainly in rice fields and other brightly sunlit permanent bodies of rather clean water with submerged vegetation.

Anopheles pseudowillmori is a member of the *An. maculatus* species group, which nearly all typically occur in forested hilly areas. This species is found in fairly open forested uplands and foothills of Thailand and Vietnam. Females are mainly zoophilic, but also bite man, mainly outdoors at night (peak biting usually at 1800-2200). They mainly rest outdoors, rarely indoors, and are reported to be fairly weak fliers (< 1 km). Larvae are usually found in Fresh water ponds, stream margins, or rice fields with at least some vegetation.

Anopheles punctulatus is one member of the *An. farauti* species complex. This species if found mainly in low coastal plains of Papua and some other eastern Indonesian islands (in the Lesser Sunda group) and on certain other islands of the southwestern Pacific. Females are moderately anthropophilic, feeding both indoors and outdoors mainly on man, and sometimes animals. Their peak feeding occurs in the last two hours before dawn. They rest both indoors and outdoors near where they fed, often remaining at rest indoors for several hours.

Their flight range has not been reported, but they are likely to be moderate to strong fliers, probably going about 1 km, based on their breeding sites, general habitat, and feeding habits. Larvae are most often found in sunny road ruts and other temporary pools of fresh water, sometimes muddy, such as depressions or footprints in native trails, or in margins of slow streams flowing through open forests, and usually in sunlit or only partly shaded. Typical larval habitats are usually free of emergent plants, but may be surrounded by shore plants, and may have dense mats of algae in the water.

Anopheles subpictus occurs in coastal plains and at lower elevations (mainly < 1,000 m) in Cambodia, Indonesia, Malaysia, Myanmar, the Philippines, Thailand, and Timor-Leste. It seems well adapted to living near humans and domestic animals, especially in agricultural areas. There are two sibling species (A and B) which both feed mainly on animals outdoors but also on humans indoors and outdoors. They tend to rest mainly outdoors, but rarely indoors, too. In southern parts of their range, they occur year-round. Female *An. subpictus* feed indoors, mainly 1800-2100, and are rarely found biting indoors after 2300. There also is usually a second, predawn feeding peak.

This species occurs in large numbers during the late monsoon and post-monsoon seasons, with a secondary population peak in the spring after the start of the spring rains. *Anopheles subpictus* is a moderately strong flier, with a range of 3.2 km or more. With its coastal distribution, Species B is considered to be the better vector. In northern parts of the region, *An. subpictus* is most abundant during the pre-monsoon through post-monsoon seasons (June to November). Larvae can be found in muddy pools near houses but also in gutters, borrow pits, and brackish waters. Species A prefers water with low salinity, while species B prefers brackish water. Both species prefer breeding sites with emergent vegetation or algae.

Anopheles tessellatus is widespread in Southeast Asia (and eastern Asia, too). It occurs in a wide range of habitats, mainly along the margins of shaded streams in open forested or agricultural areas, from foothills to coastal plains in Cambodia, Indonesia, Laos, Malaysia, Myanmar, the Philippines, Thailand, Timor-Leste, and Vietnam. There are multiple subspecies recognized by some experts and further taxonomic study of the group is needed. Biting and breeding behavior of this species varies quite a bit over its geographic range. It is mainly zoophilic, but readily bites humans in most of its range.

Females mainly feed and rest outdoors, but they frequently enter homes and animal sheds and often rest indoors for several hours after feeding. Females have been observed to fly up to 2 km from a release point, or from a larval breeding site. Several field studies have shown that the proportion of a natural population of females which feeds on humans is usually small, but they have been shown to be capable of naturally transmitting human malarias, as well as Bancroftian filariasis. Larvae are found mainly in pools, puddles, or other collections of dirty, stagnant sunlit or shaded fresh water, either sunlit or shaded. Larvae are never very abundant in any given site.

Anopheles umbrosus is a large mosquito that occurs mainly in dense swampy jungles in coastal plains, and sometimes in adjoining foothills, of Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Timor-Leste. Females primarily feed on animals and only occasionally bite man, but they have been found naturally infected with human malaria species, especially in Peninsular Malaysia. They feed and rest mainly outdoors, but readily enter homes or animal sheds, both during the night and day. They have been reported to feed indoors while electric lighting was on nearby and bright enough for reading. They often seek hosts early in the evening and again after dawn in the morning.

This is the only species of the "*An. umbrosus* species group" which takes blood meals in the daytime, sometimes in only minimal shade. Females have been observed to fly >1 km from the nearest jungle margin or larval breeding site. Larvae breed in stagnant usually brown, peaty acidic water in stream pools, pond edges, or ditches within the jungle. Very rarely they are also found in rice fields near the jungle.

Anopheles varuna is a small mosquito similar in appearance to *An. minimus*. It occurs in margins of fairly open forests, often near humans in agricultural areas in foothills in Indonesia, Malaysia, Myanmar, Thailand, Vietnam, and possibly also in Cambodia. It is most abundant during the late monsoon and post-monsoon seasons. Females bite man and animals indoors and outdoors, and rest mainly outdoors, but also frequently indoors.

This species has a short flight range, dispersing up to 1 km. Wild-caught females have been found infected with human malaria in parts of its range. Larvae occur mainly in stagnant shaded or unshaded fresh water in ditches, domestic wells, ground pools, and stream margins.

Anopheles whartoni is a small grayish speckled mosquito found mainly in or near the edge of a jungle or forest in Cambodia, Malaysia, and Thailand. Females feed on man or animals, outdoors mainly in the first two hours after sunset. They rest almost exclusively outdoors. They have been found naturally infected with human malaria. Their flight range has not been reported, but they are likely to be weak to moderate fliers, probably going <1 km, based on their breeding sites, general habitat, and blood-feeding behavior. Larvae are found mainly in dark peaty fresh water of swamps or seepage pools, which is heavily shaded.

3. Primary/ Secondary Vectors.

Anopheles dirus (*s.s*.) is mainly a species of forest edges or forest clearings, in the foothills of Cambodia, Indonesia, Laos, Malaysia, Myanmar, Thailand, and Vietnam (maybe also Timor-Leste, but not yet documented there). This is sometimes called the "white-kneed mosquito" because of white markings between each leg's tibia and tarsus. The *An. dirus* complex includes at least seven sibling species within the Southeast Asian region. Although members of this complex are not very common in most of this region, their females are efficient human malaria vectors because of their strong tendency to take blood meals from humans and their strong flight capability (usually 2-4 km).

Female *An. dirus* readily feed indoors and outdoors but they very rarely rest indoors, making them difficult to control with interior residual sprays. Blood feeding occurs at night, mainly 2200-0400. Larvae are most often found in clear, shaded, fresh water in isolated stream pools, undisturbed puddles, hoofprints, and occasionally in cisterns or water storage jars.

Anopheles flavirostris occurs mainly in open margins of forests or agricultural land in uplands or foothills in Indonesia, the Philippines, and Timor-Leste. Females are fairly strongly anthropophilic but will also feed on cattle. Blood meals are usually taken at night, indoors, and sometimes outdoors, but they nearly always rest outdoors, which makes them difficult to control with interior residual sprays. Females' flight range has not been reported, but they are likely to be moderate to strong fliers, probably going 1 km or farther, based on their breeding sites, general habitat, and their feeding and resting habits. Larvae occur mainly in clear flowing fresh water of partially shaded streams, irrigation canals, seepage pools, and rice fields.

Anopheles nigerrimus is a large, rather dark mosquito that occurs in fairly open forested areas of lowlands and in the valleys of low hills in Brunei, Cambodia, Indonesia, Malaysia, Myanmar, Thailand, and Vietnam. Females of this species feed readily on humans and animals early in the evening, and occasionally in shaded areas during the day. They feed and rest mainly outdoors. This species' flight range has not been reported, but they are likely to be weak to moderate fliers, probably going up to 1 km, based on their breeding sites, general habitat, and feeding and resting habits. It generally does not have a long lifespan but is considered an important vector in many parts of its range in Southeast Asia. Larvae are found mainly in sunlit or partly shaded, cool, fresh water, in deep ponds, ditches, borrow pits, rice fields, and swamps, preferably containing some floating or emergent vegetation.

Anopheles sinensis is widespread throughout most of eastern, southern, and southeastern Asia. They are mainly found in open agricultural areas, or lower slopes and plains in mountain valleys. In this region, this species is found in Cambodia, Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Vietnam. They sometimes develop locally large populations. Females are mainly zoophilic, but sometimes bite humans, and have been found naturally infected (at least occasionally) with human malaria in several parts of their range. In some higher elevations, or more northern sites (*i.e.*, north of 34^{o} north latitude) they may be the only species present which is capable of transmitting human malaria.

Females feed mainly outdoors before 2100, but also sometimes indoors, and they rest mainly outdoors, but may sometimes rest inside houses and animal sheds for extended periods. Their flight range has not been well studied, but they are likely to be weak to moderate fliers (<1 km) based on their typical breeding sites, general habitats, and feeding and resting habits. Larvae are found mainly in sunlit, quiet, shallow, fresh water pools, marshes, seepages, ditches, stream margins, or sumps, with emergent vegetation and a fairly high content of organic matter.

Anopheles stephensi is a relatively small pale grayish species that occurs widely in urban areas and fairlyopen forest margins in Myanmar and Thailand (as well as most of the Middle East, India, and China). Females usually avidly feed on humans, primarily outdoors, and before midnight. There are at least two cytologically different races or subspecies, one urban and one rural. Both races feed outdoors, and less often indoors, but may rest either indoors or outdoors.

Females of the urban form are usually not strong fliers (< 2 km) and typically do not live past six gonotrophic (egg production) cycles. They also may feed in shaded sites near dusk. The rural form occurs year-round and females often fly > 4.5 km. Some populations of the rural form tend to be mainly zoophilic in some locations. Larvae are found mainly in shaded or sunlit relatively clean, fresh water in cisterns, wells, undisturbed puddles, clear ponds, and a variety of other manmade containers.

Anopheles takasagoensis is one of the seven members of the *An. dirus* species complex, and is mainly a species of forest edges or clearings in the foothills of northern and western Thailand (and Taiwan). Females of this species are slightly zoophilic, but usually also readily take blood meals from humans, usually from dusk to dawn, mainly outdoors, but sometimes indoors. They feed avidly on humans in some locations but distinctly prefer animals in other sites, possibly based on differences between the given populations. They tend to rest mainly outdoors, only very rarely inside a building. That can make them difficult to control with interior residual sprays.

The flight range of this species has not been reported, but it is probably a weak to moderate flier (up to 1 km), based on its typical larval breeding sites, general habitat, and feeding and resting habits. Blood feeding occurs at night, mainly 2200-0400. Larvae are most often found in clear, shaded, fresh water in slow stream edges, undisturbed puddles, hoofprints, ruts, and occasionally in cisterns or water storage jars.

Vector Surveillance and Suppression. Light traps can be used to collect night-biting mosquitoes, but not all *Anopheles* spp. are attracted to light. Adding carbon dioxide (CO_2) to light traps increases the number of species, and total numbers of females collected. Traps baited with animals, or humans, can be useful for determining feeding preferences of mosquitoes collected (use of humans as attractants may be subject to the requirements of formal human-use protocols). Adults can be collected from indoor and outdoor resting sites using a mechanical aspirator and flashlight. Systematic larval sampling with a long-handled white dipper provides information on species composition and population dynamics of species breeding locally that can be used to plan control measures.

Anopheles mosquitoes have unique morphological and behavioral characteristics that distinguish them from all other genera of mosquitoes (Figure 14). Adult *Anopheles* feed on a host with their body nearly perpendicular to the host’s skin. Other genera of mosquitoes feed with their body parallel or at a slight angle to the skin. These characteristics can easily be used by inexperienced personnel to determine if *Anopheles* are present in an area.

Anopheles larvae hang with the body parallel to the water surface by means of specialized palmate hairs that are unique to the genus. They are the only mosquitoes that have no air siphon. *Anopheles* larvae feed on micro-organisms and small particles floating on the water surface. This feeding behavior can be exploited to control *Anopheles* larvae by dispersing insecticidal dusts that stay on the water surface. Larvae are easily disturbed by shadows or vibrations and respond by swimming quickly to the bottom. They may wait a few seconds or even minutes before they resurface. This behavior should be considered when surveying for them.

Malaria suppression includes eliminating gametocytes from the bloodstream of the human reservoir population, reducing larval and adult *Anopheles* populations, using personal protective measures such as skin repellents, permethrin-impregnated uniforms and bednets to prevent mosquito bites, and chemoprophylaxis to prevent infection. Specific recommendations for chemoprophylaxis depend on the spectrum of drug resistance in the area of concern. Command enforcement of chemoprophylactic measures cannot be overemphasized. When Sir William Slim, British Field Marshal in Southeast Asia during World War II, strictly enforced chemoprophylactic compliance by relieving inattentive officers, malaria attack rates declined dramatically.

During the Vietnam War, malaria attack rates dropped rapidly in military personnel when urine tests were introduced to determine if chloroquine and primaquine ("CP pills") were being taken. Many prophylactic drugs, such as chloroquine, kill only the erythrocytic stages of malaria and are ineffective against the latent hepatic stage of *Plasmodium* that is responsible for relapses. Therefore, even soldiers who take chloroquine appropriately during deployment can become infected. Individuals who are noncompliant with the prescribed period of terminal prophylaxis are at risk for later relapses upon their return to the U. S. During the Vietnam War, 70% of returning troops failed to complete their recommended terminal prophylaxis.

The majority of cases in military personnel returning from Operation Restore Hope in Somalia resulted from failure to take proper terminal prophylaxis. Application of residual insecticides to the interior walls of buildings and sleeping quarters is an effective method of interrupting malaria transmission when local vectors feed and rest indoors. Nightly dispersal of ultra low volume (ULV) aerosols can reduce exophilic mosquito populations.

Larvicides and biological controls (*e.g.*, larvivorous fish) can reduce populations of larvae at their aquatic breeding sites before adults emerge and disperse. Some insecticides labeled for mosquito control are listed in TG 24, Contingency Pest Management Guide, and related current details and guidance can be found at www.afpmb.org. Chemical control may be difficult to achieve in some areas. After decades of malaria control or nearby agricultural pesticide applications, vector populations may now be resistant to particular insecticides (Appendix A).

Specially formulated larvicidal oils can be used to control insecticide resistant larvae. Pathogens, such as *Bacillus thuringiensis israelensis* (*B.t.i.*) and *B. sphaericus*, and insect growth regulators (IGRs) have also been used to control resistant larvae. However, there is growing evidence that resistance to these control agents has developed in some cases, although it is not nearly as widespread as resistance to chemical insecticides.

Sanitary improvements, such as filling and draining areas of impounded water to eliminate breeding habitats, should be undertaken to the extent possible. Instead of draining marshy areas, they can be excavated to form deep permanent impoundments with well-defined vertical banks that are unsuitable habitat for mosquito larvae. Other methods of source reduction can be utilized. In the some cities, water tanks are commonly sited on rooftops and are important breeding places for *Anopheles stephensi*, a vector of urban malaria. Fitting these with mosquito screening can prevent breeding unless the screens become torn or are removed.

The proper use of repellents and other personal protective measures is thoroughly discussed in Technical Guide (TG) 36, Personal Protective Techniques Against Insects and Other Arthropods of Military Significance. The use of bednets impregnated with a synthetic pyrethroid, preferably permethrin, is an extremely effective method of protecting sleeping individuals from mosquito bites. Buildings and sleeping quarters should be screened to prevent entry of mosquitoes and other blood-sucking insects. The interior walls of tents and bunkers can be treated with permethrin to control resting vectors.

B. Dengue Fever.

Dengue (breakbone fever; dandy fever) is an acute febrile disease characterized by sudden onset, fever for 3 to 5 days, intense headache, and muscle and joint pain. It is often called "breakbone fever" because of the severity of joint pain. There is almost no mortality in classical dengue fever. Recovery is usually complete, but weakness and depression can last several weeks.

Dengue is caused by a *Flavivirus* which has 4 distinct serotypes (dengue 1, 2, 3 and 4). Recovery from infection with any given serotype provides lifelong immunity from the same serotype but does not confer protection against other serotypes. Dengue hemorrhagic fever (DHF) and associated dengue shock syndrome (DSS) were first recognized during a 1954 epidemic in Bangkok, Thailand. Both DHF and DSS have spread throughout Southeast Asia, the southwest Pacific, Latin America and the Caribbean. Exposure to 2 serotypes, either sequentially or during a single epidemic involving more than one serotype, is necessary to cause DHF, which is a severe disease that can cause high mortality, especially in children.

Military Impact and Historical Perspective. Dengue epidemics were reported in 1779 and 1780 in Asia, Africa and North America. For the next 150 years there were usually long intervals between major epidemics (20-40 years), mainly because the viruses and their mosquito vectors were transported between population centers by sailing ships. Dengue virus (DEN) was first isolated and characterized in the 1940s. A global pandemic of dengue began in Southeast Asia after World War II and has intensified over the last 25 years. Epidemics of dengue usually affect large numbers of civilians or military forces operating in an endemic area. Outbreaks involving 500,000 to 2 million cases have occurred in many parts of the world.

During World War II, the incidence of dengue was largely restricted to the Pacific and Asiatic theaters. Only scattered cases of dengue were reported from other theaters, including North Africa. Campaigns in the Pacific were marked by dengue epidemics, and during the war the US Army had a total of nearly 110,000 cases. At Espiritu Santo in the Pacific, an estimated 25% of US military personnel contracted dengue, causing 80,000 lost man-days. Although dengue was endemic in most of the China-Burma-India theater, the majority of cases among U.S. troops occurred in the vicinity of Calcutta, India. From 1942 to 1944, the incidence of dengue was 25 cases per 1,000 per year.

From 1955 to 1976, the WHO reported incidence worldwide was consistently fewer than 40,000 cases per year, but from 1977 to 2007, there have been epidemic cycles every 2-4 years and a gradual trend toward greater overall case numbers and more countries reporting cases. In this period, the lowest number of annual dengue cases reported was 110,000 in 1979, and the highest was 1.3 million cases in 2002.

Disease Distribution. According to the WHO and the U.S. CDC, dengue has become the most common and most important mosquito-borne virus affecting humans. It is present in nearly all tropical countries (Figure 16). Its distribution is essentially the same as that of its main vectors, *Aedes aegypti* and *Aedes albopictus*, between 40^o north and 40^o south latitude. Dengue, especially DHF, has been expanding throughout the world. An estimated 2 billion people currently live in areas at risk for dengue transmission, another 120,000 people visit dengue-endemic areas each year, and 50-100 million new cases of dengue are reported annually.

Epidemics and sporadic cases occur year-round in most urban and semi-rural areas of Southeast Asia below 1,000 m elevation. Both of the main vector species and clinical cases occur up to about 3 km elevation. Dengue epidemics in this region usually coincide with the monsoon season when mosquito populations are high. All 4 dengue serotypes are circulating in Southeast Asia, and dengue is endemic in at least some places in every country in this region (Figure 17). One or both of the two main dengue vectors are endemic in every country, too.

Vector populations and the risk of dengue are often greater in urban areas, where both vectors can breed in drains, cans, cisterns, hollow cut stems of bamboo or other plants, *etc*. Both vector species can grow from egg to adult in almost any container, puddle, or pool which retains liquid water continuously for longer than 10 days. Continuing uncontrolled urbanization, with resulting slums and shantytowns, has increased breeding habitats for both vectors. Despite the fact that dengue is widespread and common throughout most of the tropical regions of the world, case detection and reporting varies a lot among countries.

For the Southeast Asian region overall, from 2006 through a comparable period of 2007, there were about 18% more reported cases and 15% more reported deaths. Indonesia has the highest annual reported dengue incidence of any country in the world with 106,425 cases and 1,027 deaths reported in 2006 and 127,687 cases (a 20% increase) and 1,296 deaths (a 26% increase) reported in 2007. Thailand had 41,116 cases and 59 deaths reported in 2006 and 58,836 cases (a 43% increase) and 81 deaths (a 37% increase) reported in 2007. Myanmar had 8,674 cases and 102 deaths reported in 2006 and 9,578 cases (about 10% increase) and 117 deaths (a 14.7% increase) reported in 2007. Timor-Leste had 144 cases and no deaths reported in 2006 and 156 cases (an 8% increase) and 1 death reported in 2007. Peak months of transmission are, respectively for Indonesia and Timor-Leste – February; for Thailand – June; and for Myanmar – July. Both Myanmar and Thailand usually have very low transmission rates toward the end of each calendar year. Usual case fatality rates are less than 0.2% for Thailand, about 1% for Indonesia and Timor-Leste, and slightly greater than 1%; and for Myanmar. In some non-urban focal outbreaks in Myanmar and Indonesia, case fatality rates have been reported as high as 5%.

Transmission Cycle(s). Dengue virus is mainly transmitted by *Aedes* species in the subgenus *Stegomyia*, and is usually maintained in a human-*Ae. aegypti* cycle in tropical urban areas. A monkey-mosquito cycle helps maintain the virus in sylvatic situations in Southern Asia, Southeast Asia, and West Africa. For example, an epizootic of dengue was detected among toque macaques, *Macaca sinica*, at Polonnaruwa, Sri Lanka, between October 1986 and February 1987. The epizootic was highly focal, but transmission among macaques, or other wild primates, may have important public health implications for the region.

Female vector mosquitoes are able to transmit dengue virus 8-10 days after an infective blood meal and then remain infective as long as they live. Members of the *Aedes scutellarus* species complex (*e.g*., *Aedes polynesiensis*) are dengue vectors in Polynesia, and *Ae. scutellaris* occurs in Indonesia and the Philippines, but may not be a major dengue vector in either of those countries. *Aedes niveus* is reported to transmit dengue in parts of Malaysia, and it also occurs in Indonesia, Thailand, and Vietnam. Dengue virus replicates rapidly in these species at temperatures above 25^{o}C. Lab studies have verified transovarial transmission of dengue virus in both *Ae. aegypti* and *Ae. albopictus*. The classical Dengue disease cycle is shown in Figure 18.

Vector Ecology Profiles. The yellow fever mosquito, *Ae. aegypti*, is the world's primary dengue vector. It is widespread throughout the region, although it has not been reported from some of the highest elevations (>3,000 m). This species is more common in cities or villages than in rural areas. It is very abundant in slums and shantytowns, where drinking water is stored in tanks or jars and there are numerous artificial containers. Widespread, uncontrolled urbanization in Southeast Asia has greatly increased the abundance of both of the main dengue vector species. *Aedes aegypti* lays its eggs singly or in small groups of 2-20 just above the water line of typical larval habitats. Eggs may withstand dessication for 3 months or more.

Larvae hatch after eggs have been submerged for 4 or more hours. *Aedes aegypti* larvae are most often found in artificial water containers, like flowerpots, cisterns, water jugs, and tires. Masonry water tanks were found to be the preferred breeding site during a 1990 dengue epidemic in Calcutta. Water is stored in a variety of containers in many rural homes due to irregular water supply. In some surveys, indoor containers of all types had *Ae*. *aegypti* larvae more often than outdoor containers. The abundance of larval populations usually parallels fluctuations in both rainfall and humidity.

In 1997, surveys conducted in used and waste tire dumps along India's major highways found 35 - 88% of tires contained larvae of *Ae*. *aegypti* or *Ae*. *albopictus*, although *Ae*. *aegypti* predominated. That confirmed the importance of waste tire dumps as breeding sites for dengue vectors. Occasionally, *Ae*. *aegypti* is reported from coconut shells or bamboo stumps, although these are more typical habitats for *Ae*. *albopictus*. Larvae usually prefer clean, clear water. They develop quickly in warm water, maturing to the pupal stage in about 9 days. Pupae remain active in their water container until adult emergence, 1 to 5 days after pupation. *Aedes aegypti* rarely disperses more than 50 m from its larval breeding site, but over several days it has reportedly dispersed up to 600 m. It does not fly in winds over 5 km per hour.

Aedes aegypti prefers human hosts and feeds primarily around human homes. It is a diurnal feeder and readily enters homes. This species is not attracted to light; it responds to contrasting light and dark areas presented by human dwellings. When feeding outdoors, it prefers shaded areas. It feeds on the lower legs and ankles, increasing its biting activity when temperatures and humidity are high. It is easily disturbed when feeding and, because it feeds during the day, is often interrupted by a host's movements. This behavior results in multiple bloodmeals, often taken within the same dwelling, which can increase transmission of virus. *Aedes aegypti* rests in cool, shaded areas within dwellings, often in closets, under tables, or in sheds. Similarly, it rests outdoors in shaded areas of trees, shrubs, and structures.

The Asian tiger mosquito, *Aedes albopictus*, is second only to *Ae*. *aegypti* in importance as a dengue vector. Adults of the two species can easily be distinguished by the pattern of silver scales on the top of their thorax (Figure 15). *Aedes albopictus* is more common in rural than urban areas. It has larval and adult biology and feeding habits similar to *Ae*. *aegypti* but it often breeds in natural containers, such as tree holes, leaf axils, and bamboo stumps.

A cold-hardy strain of this species has become adapted to breeding in vehicle tire casings (used tires) and has been spread throughout much of the tropics and fairly large areas in temperate regions of the world since 1996. It is a slightly stronger flier than *Ae*. *aegypti*. It is strongly anthropophilic but has a broader host range than *Ae*. *aegypti* and may feed on water buffalo, dogs and pigs. It does not readily feed on birds. Larvae of this species were found by USDA quarantine inspectors in many of the small water containers in shipments of "Lucky Bamboo" sent from Asia (China, Hong Kong, *etc*.) to be sold as houseplants in the U.S. in 2004.

Development time varies from 5 days to 3 weeks, depending on temperature. Adults emerge 1-5 days after pupation. Females feed every 3-5 days for the duration of their life (usually 1-4 weeks). Females fly close to the ground and generally usually do not go farther than 100 m from their emergence sites. They do not fly in winds over 5 km per hour.

Adults may also feed on nectar from plants. Autogeny occurs in this species, but very few eggs are produced that way. Peak feeding periods outdoors are usually early morning and late afternoon. Adults usually feed and rest outdoors in undergrowth, but indoor feeding and resting also occurs. *Aedes albopictus* is most abundant during the monsoon and post-monsoon months, with numbers greatly reduced in the dry season.

Vector Surveillance and Suppression. The seasonality of dengue incidence is well documented in most countries in the region. Efforts to prevent the disease and suppress the vectors must be started before transmission begins each year, and should be maintained throughout the usual transmission season. Since rainfall and local conditions can greatly affect dengue transmission, and there are few reliable accurate models to guide them, responsible parties in each country should make use of available epidemiological, vector surveillance and rainfall data to focus and time their preventive and control efforts.

Landing rate counts provide a quick relative index of adult abundance. The number of mosquitoes that land on an individual within a short period of time (*e.g*., 1 minute) is recorded. Resting collections consist of the systematic search for dengue vectors in secluded places indoors, such as in closets and under furniture. Resting collection studies performed with mechanical aspirators are an efficient but labor-intensive means of evaluating adult densities. Densities are recorded either as the number of adult mosquitoes per house or the number of adult mosquitoes collected per unit of time.

Several indices have been devised to provide a relative measure of the larval populations of *Ae*. *aegypti*. The house index is the percentage of residences surveyed that have containers with vector larvae. The container index is the percentage of containers at each premise that have larvae. The Breteau index is the number of containers with *Ae*. *aegypti* larvae per 100 premises. The house index has been most commonly used historically, but such indices may require some interpretation. Public Health experts usually consider that dengue transmission is likely when the house index is >4, the container index is >3, or the Breteau index is >5. Emergency vector control may be indicated when the house index is >35, the container index is >20, or the Breteau index is >100.

Adult egg-laying activity can be monitored using black oviposition traps that container-breeding *Aedes* readily utilize. The number of eggs laid in the ovitrap gives a relative indication of abundance of these dengue vectors. Ovitraps are especially useful for early detection of new infestations in areas from which vectors had been eliminated.

There is currently no vaccine and no specific treatment for dengue, so control is contingent upon reducing or eliminating vector populations. Historically, ground or aerial applications of insecticidal aerosols have been relied upon to reduce adult populations during dengue epidemics. Many vector control specialists have questioned the efficacy of ULV adulticiding. During some outbreaks of dengue fever, ULV dispersal of insecticides has had only a modest impact on adult mosquito populations.

Aedes aegypti is a domestic mosquito that frequently rests and feeds indoors and, therefore, is not readily exposed to aerosols applied out-of-doors. The sides of large storage containers should be scrubbed to remove eggs when water levels are low. Water should be stored in containers with tight-fitting lids to prevent access by mosquitoes. A layer of oil will prevent mosquito eggs from hatching and will kill the larvae.

The elimination or frequent dumping (at least once weekly) of breeding sources, like old tires, flowerpots, and other artificial containers, is the most effective way to reduce mosquito populations and prevent dengue outbreaks. In Singapore, passage of sanitation laws and their strict enforcement to eliminate breeding sites reduced the house index for *Ae*. *aegypti* larvae from 25% to 1%. Proper disposal of trash, bottles and cans in and near living areas must be rigidly enforced. Individuals can best prevent infection by using personal protective measures during the day when vector mosquitoes are active. Wear permethrin-impregnated clothing (*e.g*., uniforms) and use extended-duration DEET repellent on exposed skin surfaces (see TG-36).

Figure 16. Reported Distribution of Dengue (DEN) in Southeast Asia.

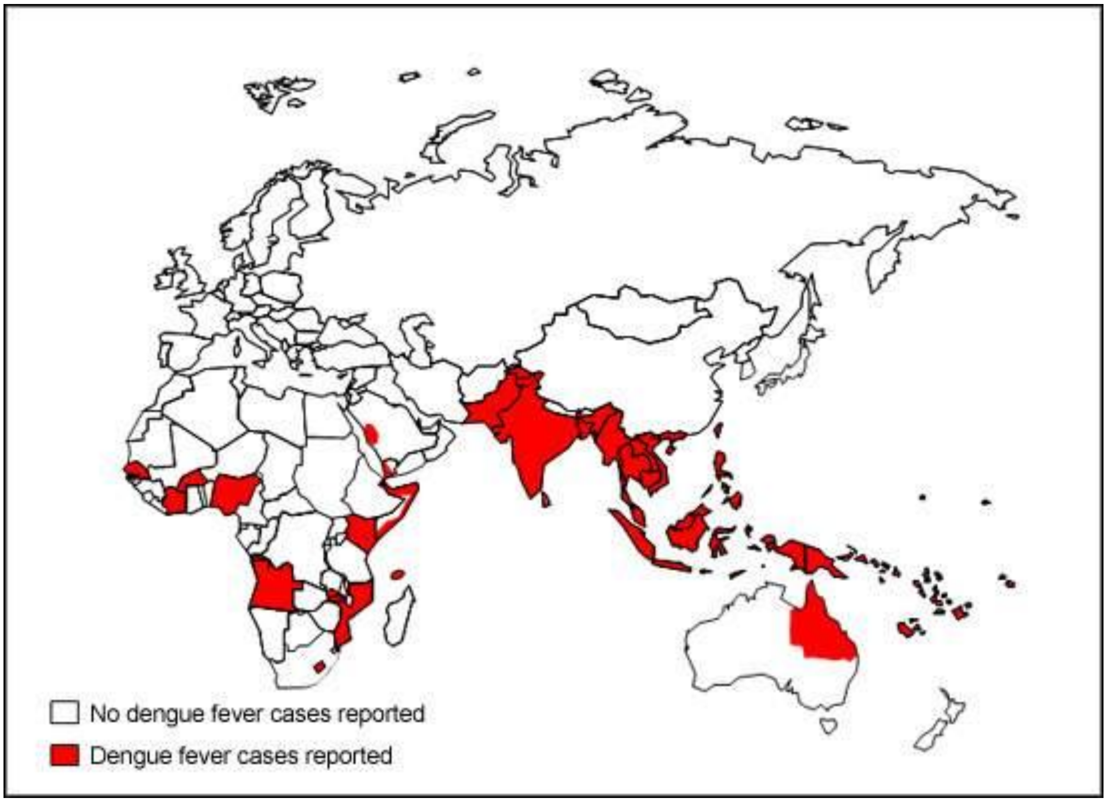


Figure 17. Map of Dengue Endemicity for Southeast Asia.

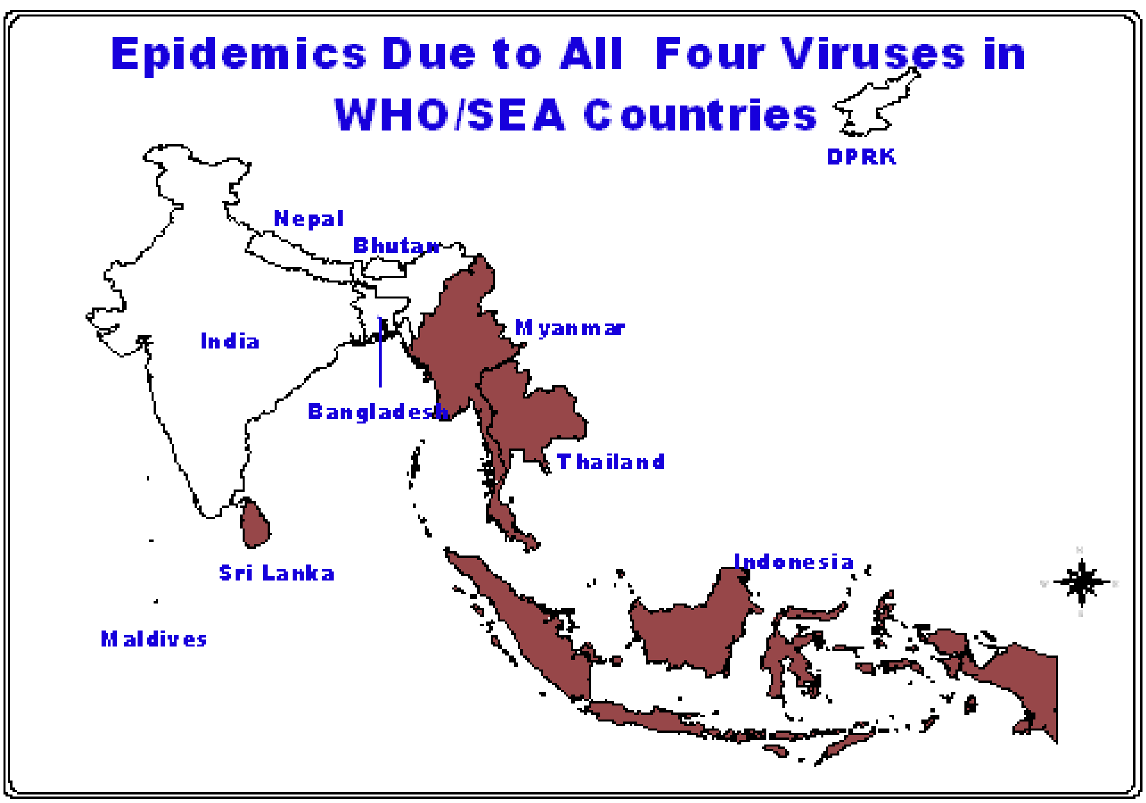
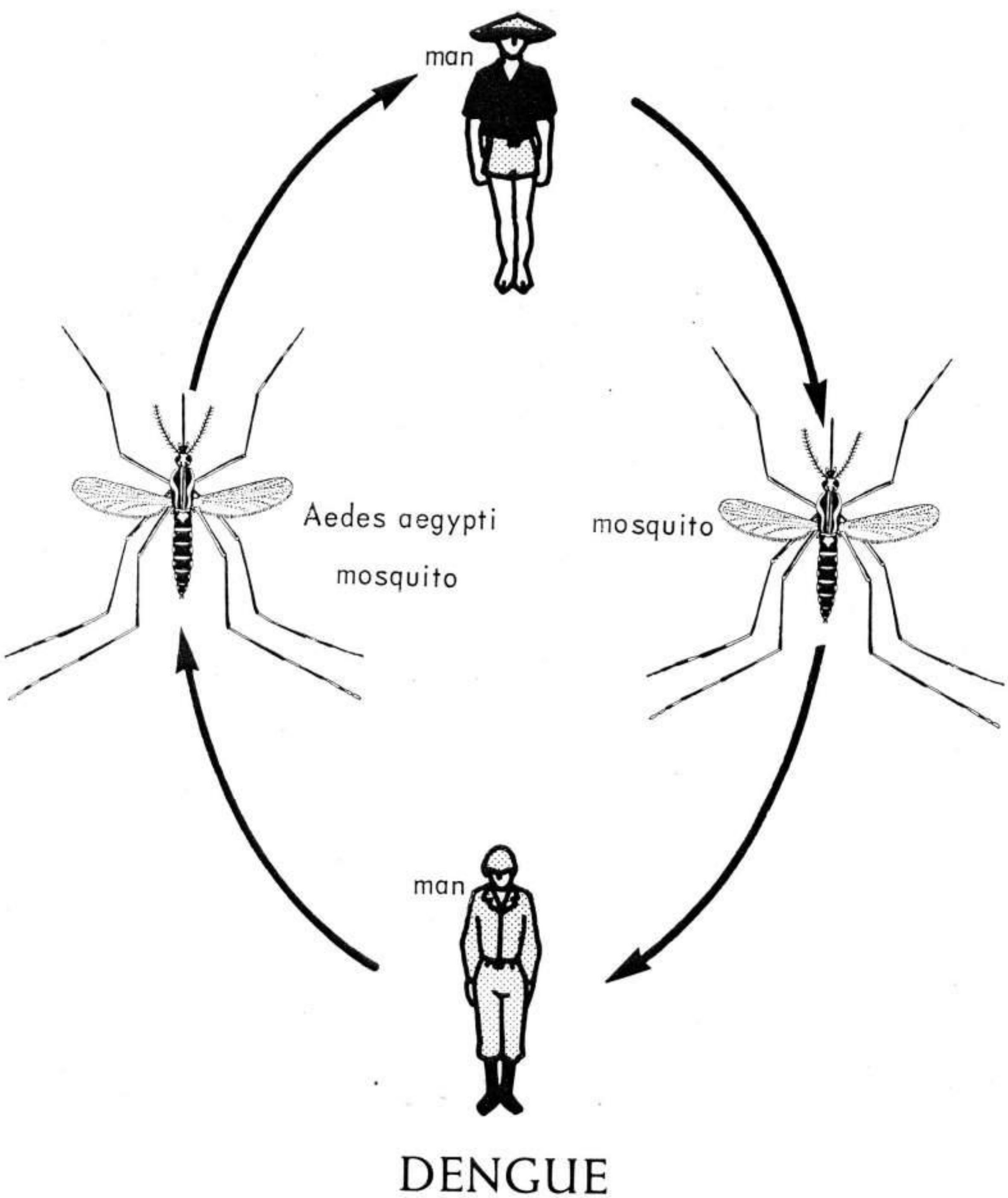


Figure 18. Dengue disease cycle.



C. Japanese Encephalitis.

Japanese encephalitis (JE) is caused by a *Flavivirus* in the family Flaviviridae. It is closely related to St. Louis Encephalitis (SLE) virus. Most infections are inapparent or produce a mild systemic illness with fever, headache or asceptic meningitis. Based on serologic studies, only about 1 in 300 JE infections show obvious symptoms. The typical incubation period is 5 to 15 days. Severe infections have acute onset, high fever, severe headache, and vomiting. Inflammation of the brain, spinal cord and meninges can cause stupor, tremors, convulsions (especially in infants), spastic paralysis, coma and death.

Case fatality rates can be as high as 60%. Fatal cases usually develop coma and death within 10 days of first symptoms. In past epidemics, about 25% of symptomatic cases were rapidly fatal, 50% lead to permanent neurological or psychiatric sequelae, and 25% resolved in 1 to 2 weeks. Neurological impairment is most severe in infants. No specific therapy is effective and treatment is mainly supportive. The known distribution of JE is depicted in Fig. 19.

Military Impact and Historical Perspective. Reports of a disease resembling JE go back to 1870 in Japan, but this disease attracted little attention until a large epidemic in 1924 caused 6,125 human cases and 3,797 deaths. It was recognized in Korea in 1926 and in China in 1940. The virus (JEV) was first isolated in 1935 from brain tissue of a fatal case in Japan. No arthropod-borne virus causing encephalitis had been discovered, nor had the diseases that they cause been recognized before the 1930s. So, there is no record of JE or other arthropod-borne encephalitides in the medical history of World War I.

During World War II, there was considerable preparation by U.S. military medical personnel for arthropod-borne viral (arboviral) encephalitides, but these diseases turned out to be less of a threat than expected. There was one small but important outbreak of JE that involved both natives and troops on Okinawa in the summer of 1945. Only 11 cases with two deaths were confirmed in U.S. military personnel. However, large numbers of U.S. troops had been assembled for the projected invasion of the home islands of Japan, and the danger of an epidemic greatly concerned medical planners. The news of "a dread Japanese brain disease" on Okinawa spread among the troops with demoralizing effects. Commercial availability of effective JE vaccines has greatly reduced the threat of this crippling disease to future military operations in JE-endemic areas. Currently, only about 1 case of JE is reported per year in U.S. civilian or military personnel traveling or living in Asia.

Disease Distribution. This disease (JE) is endemic in 21 countries from northern Asia and Japan southward through China, to Indonesia and westward through India. It is the leading cause of viral encephalitis in Asia, with 30,000 to 50,000 cases a year. Since the 1940's, human cases and local outbreaks of JE have been sporadic yet widely dispersed in many countries of Southeast Asia. In 2006, the WHO reported that JE is actively transmitted year-round in all or most of Brunei, Indonesia, Malaysia, lower peninsular Myanmar, the Philippines, Singapore, and Timor-Leste, as well as at least seasonally throughout the rest of Southeast Asia.

Risk of transmission is greatest just before, during, or just after the monsoon season for any given country, when the main vector mosquito species' populations are their largest. Programs and practices which change irrigation systems, drainage, or amount and nature of irrigated land (like an increase in the total number, or total area, of rice paddies near a village or city) often lead to expanded or more productive larval mosquito habitats, which in turn, may greatly and suddenly increase the risk of transmission of JE or other similar diseases.

Transmission Cycle(s). This virus (JEV) is maintained in a mainly rural zoonotic cycle between rice field breeding mosquitoes and wading water birds such as egrets, herons and ibises. Pigs are important reservoir hosts that develop a high concentration of the virus in their circulating blood (viremia) and, when abundant, serve as the main amplifying host for JEV (see

Figure 20). Large numbers (or herds) of swine (pigs) are not common in Southeast Asia, but many rural families usually keep one or a few pigs year round. Cattle are often more abundant than swine. Bovines develop low or no viremia but do serve as a source of blood meals that help produce large vector populations.

Rodents and other domestic animals are not usually important in natural cycles of JEV transmission, but almost all domestic animals can be infected by it. Adult animals rarely develop signs of illness, although fatal encephalitis sometimes occurs in horses. Several species of bats are susceptible to JEV and develop viremias for 6 days or more that are sufficient to infect vector mosquitoes. Humans are considered to be dead-end hosts, and human infections are usually a consequence of increased vector densities associated with increased rainfall or irrigation.

Vector Ecology Profiles. Primary JEV vectors in Southeast Asia are *Cx. tritaeniorhynchus*, *Cx. fuscocephala*, *Cx. gelidus*, *Cx. pseudovishnui*, and *Cx. vishnui*. Additional vectors include *Cx. quinquefasciatus* (= *Cx. pipiens fatigans*), *Cx. whitmorei*, *Cx. bitaeniorhynchus*, *Mansonia annulifera*, *Ma. uniformis*, and *Anopheles subpictus*.

Culex. tritaeniorhynchus is the most common JEV vector, and is considered to be the most important one, throughout the region. It feeds readily on amplifying hosts, mainly pigs and birds in the heron family, as well as on humans. It is also strongly attracted to cattle. This species is both endophagic and exophagic, and is endophilic, especially during cooler months in northern parts of the region. Adults begin feeding early in the evening and continue feeding throughout the night, with decreasing activity after about 0200 hours. They are moderately strong fliers that will travel up to 3 km for a blood meal.

Females of this species deposit rafts of 75-150 eggs each directly onto a water surface, usually 3 - 4 days after a bloodmeal. Eggs usually hatch 2 - 4 days after they are laid, and larval development requires 7 - 9 days at 25 - 30^{o} C. At lower temperatures, larval development may require 15 - 20 days. The pupal stage lasts about 2 days. Adults often have 2 population peaks in northern regions, during the usual pre-monsoon period of March - May, and again in the usual post-monsoon period of November - February. Adults may be entirely absent from late November to early February in northern regions and at higher elevations (>1 km), and they may undergo a larval diapause.

In southern areas, peak abundance occurs from May through June, and again from October through December. Common oviposition sites are diverse, including rice fields, water troughs, irrigation spillovers, and undisturbed ground pools. Rice fields are generally colonized soon after the planting and flooding of the paddy.

Larvae of *Cx. tritaeniorhynchus* generally prefer lightly shaded ground pools with low concentrations of organic matter and some emergent vegetation. Paddy fields are ideal breeding sites for this species. Increased irrigation and expansion of rice growing in the region has increased the abundance of this species and the potential for transmission of JEV to humans. It has been calculated that an average paddy plot (320 sq m) could produce 30,000 adults daily. Transovarial JEV transmission has been demonstrated in this mosquito species, but its importance in maintaining the virus is unknown.

Culex vishnui and *Cx. pseudovishnui* occur widely in most of this region. Their seasonal abundance is similar to that of *Cx. tritaeniorhynchus* with a peak in the pre-monsoon to early monsoon season and another peak in the post-monsoon period. Their breeding sites are primarily paddy fields and shaded ground pools, and they are both chiefly exophagic and exophilic, preferring to rest in fields or forests, although a small percentage will feed on man in houses. *Culex vishnui* feeds mainly on pigs, while *Cx. pseudovishnui* is more attracted to cattle, but also feeds on birds. Their life cycles are similar to *Cx. tritaeniorhynchus*, but their population peaks generally occur from March through April and September through October. The flight range of these species is also similar to *Cx. tritaeniorhynchus*, averaging about 3 km from the breeding site to feeding sites. Transovarial JEV transmission has been demonstrated in *Cx. pseudovishnui*.

Culex fuscocephala occurs widely throughout the region. Its life cycle and seasonal abundance are similar to *Cx. tritaeniorhynchus*. Seasonal peaks usually occur from March to April, and again from August to September. Larval breeding sites include rice fields, borrow pits, and temporary ground pools with low organic content and some shade. This species is slightly endophagic, but also feeds readily outdoors. It feeds continuously throughout the night, but feeding declines sharply just before dawn. This species is largely zoophilic, preferring cattle to other hosts, but occasionally feeds on pigs, birds and humans. It rarely disperses more than 2 km from its larval breeding sites.

Culex gelidus has a life cycle and seasonal abundance similar to *Cx. vishnui* and *Cx. pseudovishnui*. This species is strongly attracted to pigs, but also feeds readily on cattle and humans. Peak abundance occurs during the monsoon seasons when borrow pits, ditches, rice fields and ground pools are widely available as larval habitats. Larvae frequently breed in pits used to soak coconut husks to make rope and mat fibers. It is both endophilic and exophilic and readily feeds indoors or outdoors. Its life cycle is similar to that of *Cx. tritaeniorhynchus*, but, its average dispersal from breeding sites is < 2 km.

Culex quinquefasciatus, often referred to as *Culex pipiens fatigans* in older literature, is a common mosquito throughout the region. This species is both endophagic and exophagic, and is relatively endophilic, especially during cool months in northern parts of the region. Adults feed early in the evening, usually within two hours of sunset, and are strong fliers that can travel 3 to 5 km for a blood meal. Details on the bionomics of *Cx. quinquefasciatus* are presented in the section on vectors of filariasis, below.

Culex whitmorei is far less common than the species discussed above. Its life cycle is similar to that of *Cx. tritaeniorhynchus*, although it is most abundant in the middle of the monsoon season, usually from July to September. Larval breeding sites are mainly temporary ground pools and, occasionally, rice fields. This species is slightly endophagic but mainly exophilic. Cattle are its preferred hosts, but man and birds are also bitten occasionally.

Culex bitaeniorhynchus is even less common than *Cx. whitmorei* but it is widely dispersed throughout the region. Its larvae breed in warm, polluted, semi-permanent or permanent pools with abundant algal growth. Partial shading or sunlit areas are preferred. Females bite early in the evening, mainly on birds, which enhances their role as a zoonotic vector of JE. Seasonal distribution is usually from the early monsoon season (May or June) to the early dry season (December or January). This species is known to transmit JEV transovarially.

Anopheles subpictus occurs throughout most of the region. It is a complex of two sibling species, A and B. Larvae of species A occur in muddy pools near houses, in gutters, in paddy fields, and borrow pits in open forested areas; and those of species B more common in coastal areas, often breeding in brackish water. This species has been reported in Cambodia, Indonesia, Malaysia, Myanmar, the Philippines, Thailand and Timor-Leste.

This species is primarily zoophilic but feeds readily on man. It may feed on birds, but that has not yet been well documented. *An. subpictus* is exophilic and exophagic but will also feed and rest indoors. This species occurs during the pre-monsoon through post-monsoon seasons (June to November) in northern parts of the region. In southern areas, it occurs year-round. Females feed indoors primarily from 1800 to 2100 hours, rarely biting indoors after 2300 hours. It can fly up to 2 km from its breeding sites to feed but is not considered a strong flier.

Aedes vigilax (a pool of adult specimens) has been reported to have been naturally infected with JEV in a field study on Badu Island in the Torres Strait, between Australia and Papua New Guinea. A subsequent lab study confirmed that this species can acquire JEV via blood meals.

This species has been collected from Indonesia, Malaysia, Thailand and Vietnam, and is a known vector of several other arboviruses pathogenic to humans.

Mansonia annulifera is a fairly common species throughout the region, and may be capable of transmitting JEV, but it is probably not an important JEV vector. Details of the life cycle and bionomics of this species are presented in the later section on filariasis.

Mansonia uniformis is more common than *Ma*. *annulifera* in many areas, particularly lowlands. However, this species is not as efficient a vector of JEV as *Ma*. *annulifera*. Details of its life cycle are presented in the later section on vectors of filariasis.

Vector Surveillance and Suppression. Most *Culex* vectors of JEV are readily collected in light traps and/or gravid traps. Animal-baited traps can collect large numbers of zoophilic species. Adults can also be collected with an aspirator from resting sites in or near homes or animal shelters. JEV can often be detected in mosquitoes before outbreaks in humans occur. Routine surveillance systems based on isolation of virus from mosquito pools are too time-consuming to be of practical use in most military situations.

Testing sentinel pigs weekly for seroconversions has been used successfully by public health workers to detect JEV activity in endemic areas. Mosquito control efforts may be based on the occurrence of seroconversions in pigs which generally precede JE outbreaks in the human population by 1-2 weeks. Control of JE vectors over large areas with insecticides would be impractical, environmentally unacceptable and prohibitively expensive. Applying suitably labeled insecticides to rice paddies can dramatically reduce larval populations, but control usually lasts only about a week.

Transmission of JEV has been successfully interrupted in some cases by applying residual insecticides to the interior walls of homes. However, insecticide resistance has become widespread in several vector species (Appendix A). Vector mosquito adult populations have sometimes been reduced by ULV aerosols during periods of epidemic JEV transmission. Long-term control is best achieved by source reduction, like elimination of breeding sites by draining or filling small stagnant bodies or containers of water, intermittent irrigation of rice paddies, or by adding fish that eat mosquito larvae. Protection of military personnel is best achieved by use of the personal protective measures outlined in TG-36 and by vaccination.

Some novel new techniques for control of adult mosquitoes include bait stations which contain toxic sugar solutions, use of nucleic acids which kill individual adults after direct contact (certain double-stranded RNA has been effective in limited topical application lab tests), and precisely targeted outdoor residual insecticides applied to vertical surfaces of typical adult resting sites near human habitations or places where humans are often active, like a patio. Although these are still in early stages of field trials, they may offer potential additional publicly acceptable ways to help reduce local adult vector and pest mosquito populations while greatly limiting the amounts of chemical insecticides used and the overall impact on the environment and non-target species.

Figure 19. Distribution of Japanese Encephalitis (JE, or JEV).

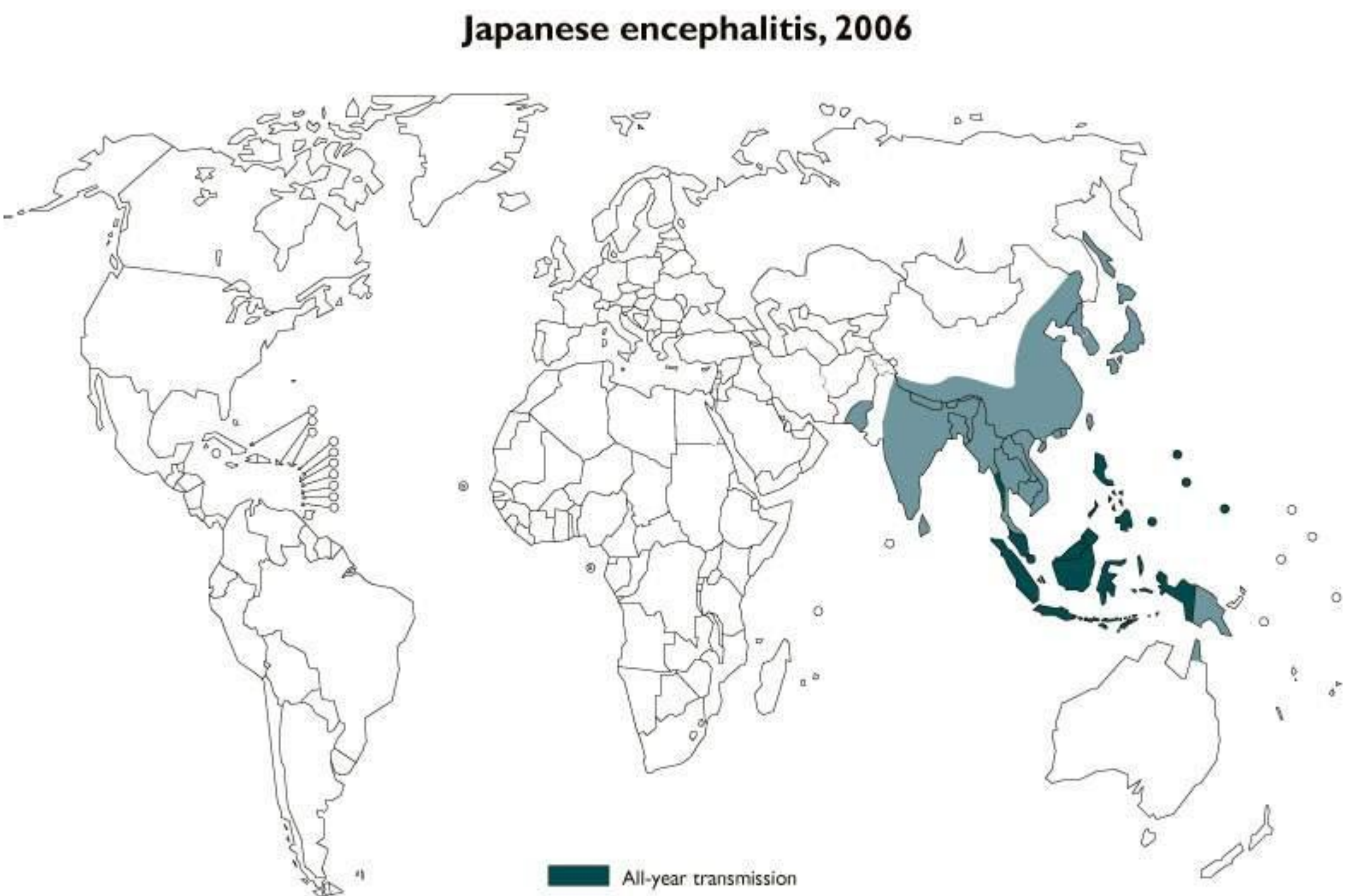
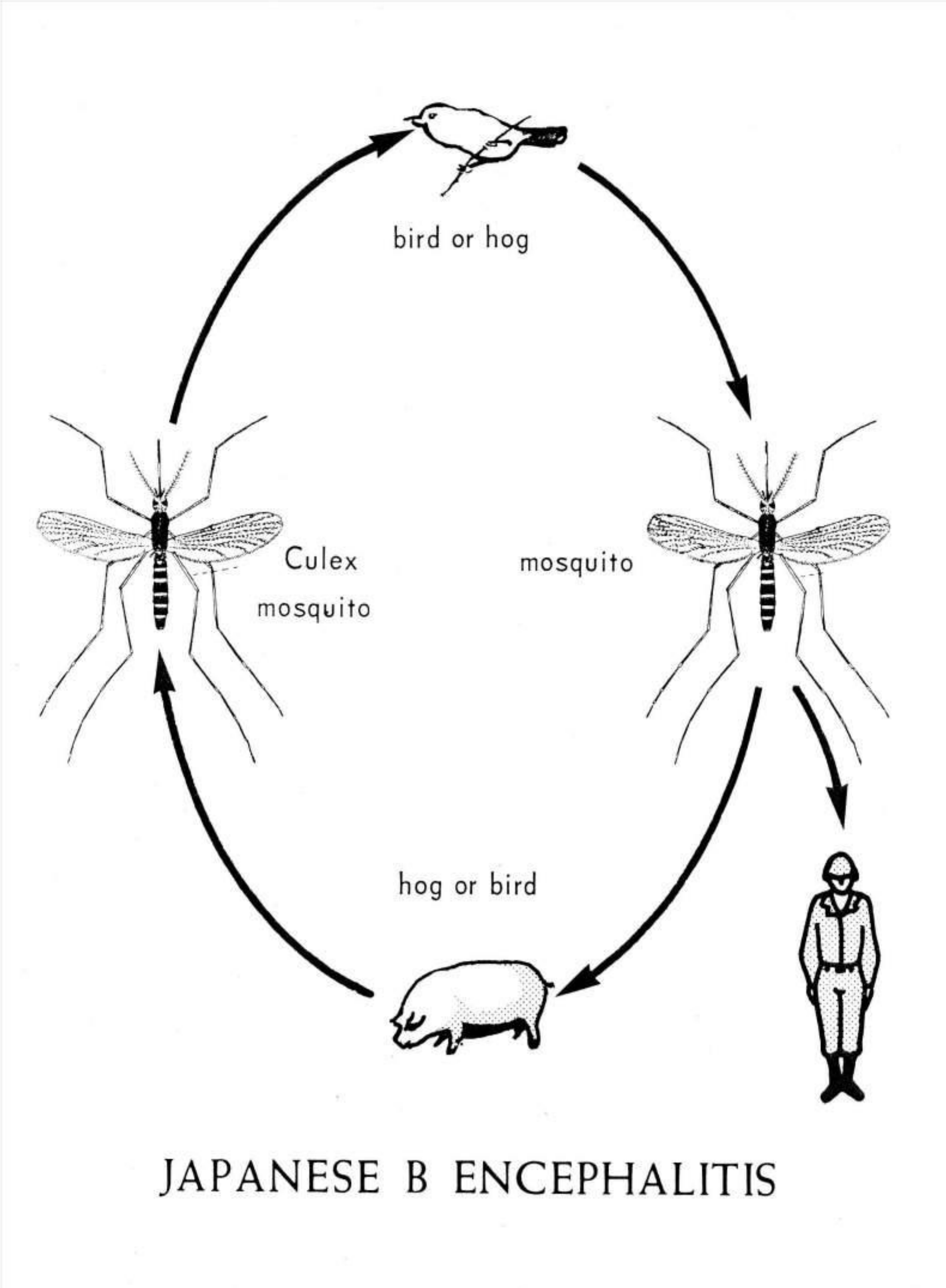


Figure 20. Disease Cylce of Japanese Encephalitis Virus (JEV).



D. Chikungunya Fever. Disease caused by the chikungunya virus (*Alphavirus*, family Togaviridae) is characterized by sudden onset, fever, rash, nausea, vomiting, and severe joint pains that may persist as a recurrent arthralgia for months or years. The usual incubation period is 3-11 days, and the acute illness lasts 3-5 days. Minor hemorrhages have been attributed to chikungunya virus disease in Southeast Asia and India. Full recovery is often slow but is usually complete, and is followed by lifelong immunity, but arthralgia may last months or years.

This virus can cause occasionally severe symptoms in older humans and may contribute to some fatalities in cases given inadequate supportive care. Inapparent infections are common, especially in children, among whom clinical disease is rare. Chikungunya can be differentiated from dengue in that pain is mainly located in the joints rather than the muscles, and the febrile period is shorter and usually not biphasic (*i.e*., it usually has only an initial period of high fever, while dengue often has a second period of fever).

Military Impact and Historical Perspective. This disease was first recognized in 1952, during epidemics among inhabitants of Southern Province, Tanzania. Chikungunya is a Swahili word meaning “that which bends up” and refers to the stooping posture often adopted by victims due to severe joint pain. The virus (CHICV) was first isolated in 1952, but its relationship to other arboviruses was not fully determined until the late 1950s. Chikungunya viral infections definitely pose a military threat because there is currently no vaccine or specific therapy and the onset is usually abrupt and incapacitating, often for very long periods. The health threat from CHICV in parts of Southeast Asia is serious, especially in Indonesia and Malaysia, because the virus and several vector species are widespread and well established there.

Disease Distribution. Chikungunya virus is enzootic throughout tropical Africa from which it has spread to other parts of the world, primarily Southeast Asia and India (Figure 21). In Indonesia, CHIKV had occurred only sporadically until 1985 after which none was reported until a series of outbreaks from January 2001 to April 2007. During this surge of cases, at least 15,207 human cases were reported from 7 provinces with a peak incidence in 2003.

Serious recent epidemics of CHICV have occurred in La Reunion (266,000 cases in 2006 alone) and other islands in the western Indian Ocean, and those probably were the source of several smaller secondary outbreaks imported into Europe via tourists. Subsequent transmission was probably effected by local populations of *Ae*. *albopictus*. Outbreaks in most countries are more likely to occur during or just after a rainy season. The current endemic status of chikungunya virus in Southeast Asia is fluctuant and depends heavily on rainfall patterns and related vector mosquito populations.

Transmission Cycle(s). Chikungunya fever outbreaks at country or regional levels have historically occurred in cycles about 10 or more years apart with very little apparent presence between them. There are no records of clinical disease in domestic animals or wildlife caused by CHICV. However, there is a strong body of evidence implicating wild primates as potential reservoir hosts (Figure 22). Antibodies to this virus have been found in the rhesus monkey, *Macaca mulatta*, which is widely distributed in the region (Laos, Myanmar, Thailand, Vietnam, and possibly Cambodia).

Experimentally infected bonnet macaques, *M*. *radiata*, which occur naturally only in southern India, develop viremias sufficient to subsequently infect *Ae*. *aegypti*. Macaques’ role in CHIKV epidemiology in Southeast Asia is unknown but there are at least 13 species of macaques native to the region (8 known only from Indonesia). Most human outbreaks of chikungunya fever in this region have occurred in urban areas or their margins, whereas in Africa human infections usually occur in rural areas. The virus can survive for considerable periods in the epidemic human-to-*Ae*. *aegypti*–to-human cycle, resulting in sporadic outbreaks at irregular intervals.

Vector Ecology Profiles. Most isolations of CHIKV in Southeast Asia have been made from *Ae*. *aegypti*, with *Ae. albopictus* as an important secondary vector. Most Southeast Asian species of *Culex* and *Anopheles* do not become infected by this virus under natural conditions, but some have been experimentally infected in a lab. Transovarial transmission does not appear to play a role in the maintenance of CHIKV in nature, since chikungunya fever has disappeared from urban areas where *Ae*. *aegypti* has remained abundant. See the earlier section on dengue for the biology of *Ae*. *aegypti* and *Ae*. *albopictus*. This virus has also reportedly been recovered from several other species of *Aedes* in natural and/or lab settings (*i.e*., in Africa from *Ae*. *furcifer-taylori* and *Ae*. *luteocephalus*; and from the Palearctic species *Ae*. *caspius* and *Ae*. *detritus*).

Vector Surveillance and Suppression. Epidemics of chicungunya fever are infrequent, separated by long intervals (usually >10 years), and public health officials in most Southeast Asian countries cannot routinely do, nor justify, continued long-term surveillance for virus activity in known vector species due to other health care demands. Reduction of adult vector mosquito populations by ULV spraying can help temporarily reduce disease risk during a chikungunya fever outbreak.

However, the most feasible long-term control strategies involve reducing vector breeding by environmental management techniques, especially in agricultural areas under extensive irrigation. Personal protective measures to prevent mosquito bites are the most effective and currently the most practical means of avoiding individual infection with CHIKV. Consult TG-13, Ultra Low Volume Dispersal of Insecticides; TG-24, Contingency Pest Management; and TG-40, Methods for Trapping and Sampling Small Mammals for Virologic Testing. Also see vector surveillance and suppression for malaria, above.

Figure 21. Distribution of Chikungunya Fever (or the virus, CHIKV).

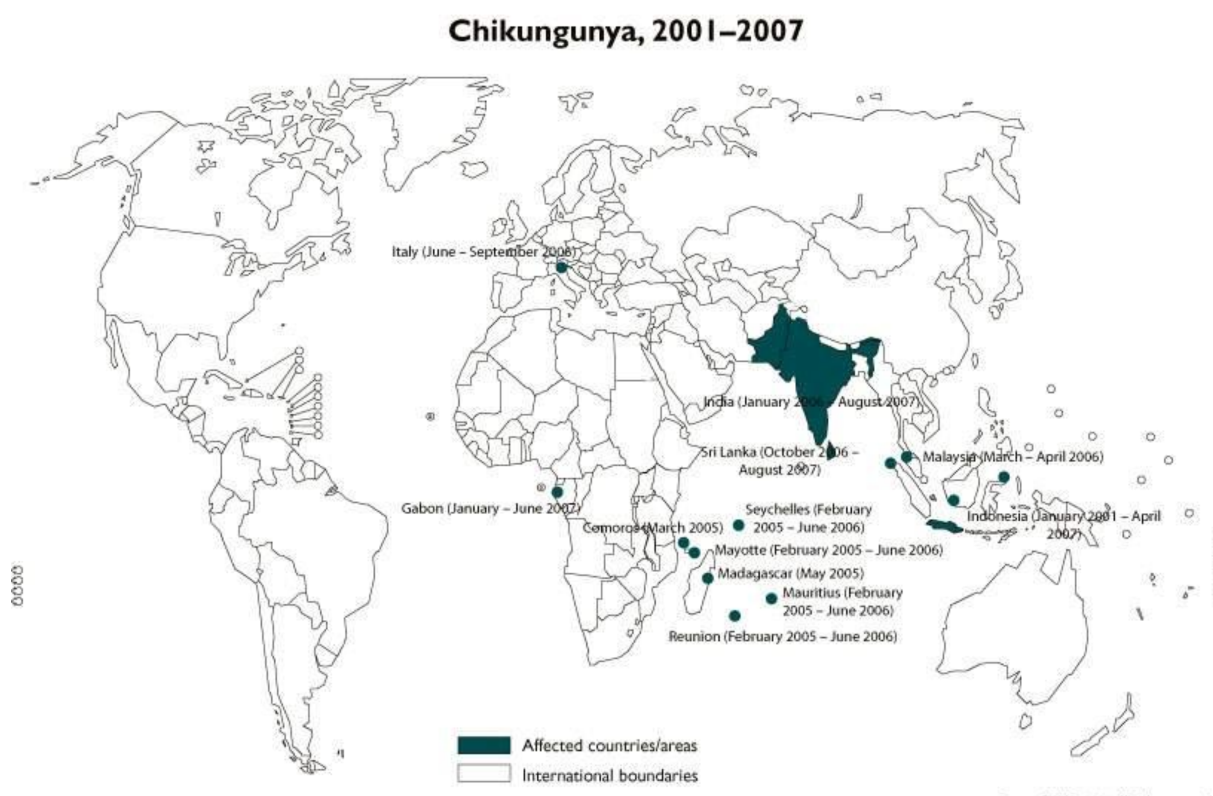
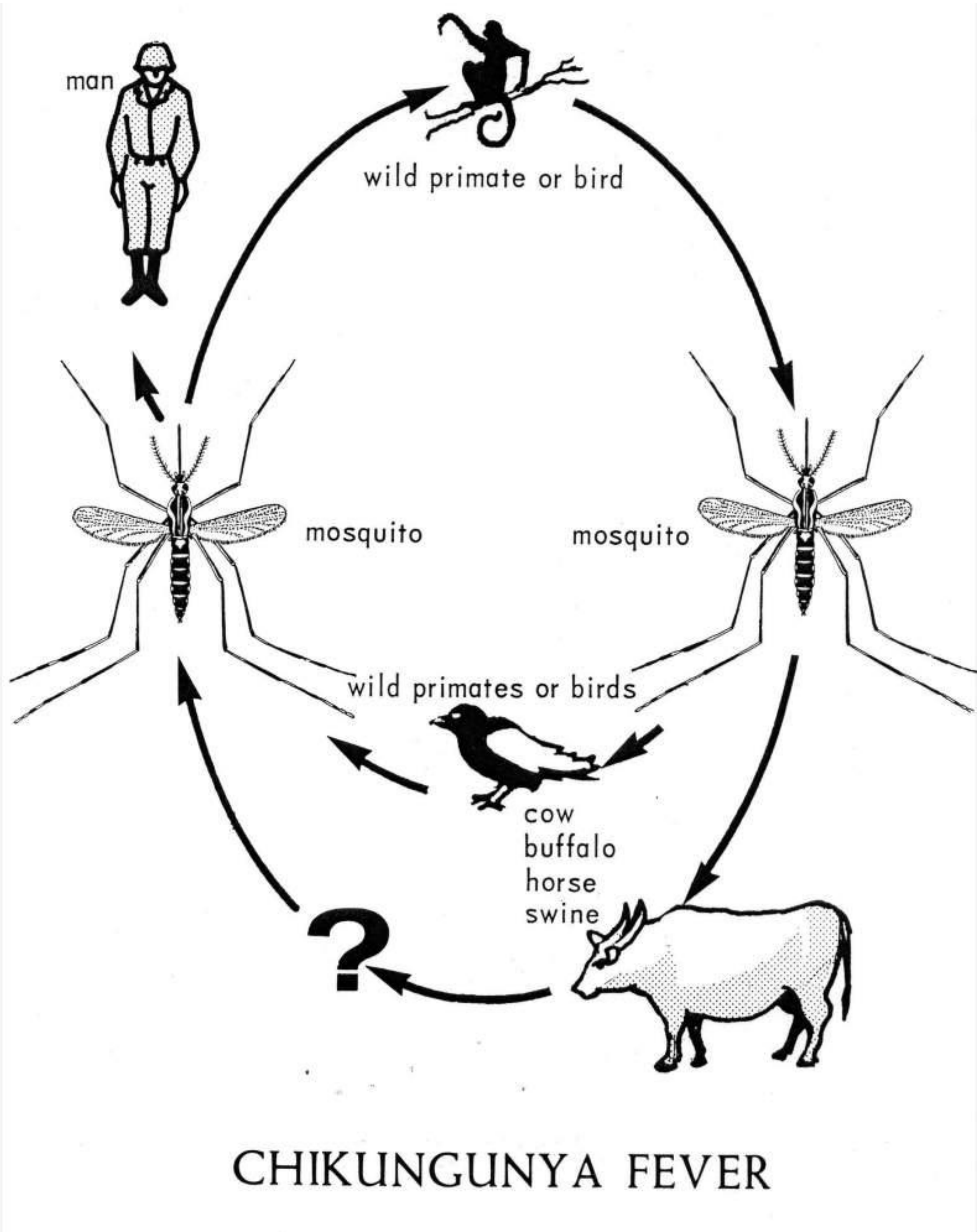


Figure 22. Typical Disease Cycle of Chikungunya Fever (or the virus, CHIKV).



E. Sindbis Virus. Sindbis virus belongs to the genus *Alphavirus*, family Togaviridae. It is closely related to the Western equine encephalitis (WEE, or WE) virus complex. The incubation period is less than a week and symptoms may include fever, headache, rash, and pain in multiple joints. Syndromes resulting from Sindbis virus infection have been called Ockelbo disease in Sweden, Pogsta disease in Finland, and Karelian fever in the former Soviet Union. No fatal human cases have been reported, so far.

Military Impact and Historical Perspective. Sindbis virus was first isolated in 1952 from *Culex* mosquitoes collected in the village of Sindbis north of Cairo, Egypt. It has since been reported from Europe, Asia, sub-Saharan Africa and Australia, and it is wide-spread in Southeast Asia. The first human cases were confirmed when Sindbis virus was isolated from patients with fever in Uganda in 1961. Human epidemics caused by this virus were documented in South Africa in the late 1960s, and clusters of cases with fever, arthralgia and rash have been observed in Sweden. Although outbreaks of Sindbis virus in areas of northern Europe have caused significant human morbidity, this disease is expected to have only a minor impact on military operations in Southeast Asia. Human Sindbis fever cases could be confused clinically with dengue, chikungunya and West Nile fever, based on symptoms.

Disease Distribution. Sindbis virus is one of the most widely distributed of all known arboviruses. Studies have demonstrated its transmission in most areas of the Eastern Hemisphere. Very little is known about the epidemiology of this virus and its role in human disease in Southeast Asia. It has been isolated from birds, *Culex* mosquitoes and a dermanyssid mite in India, and antibodies to Sindbis virus have been found during surveys of birds in several Southeast Asian countries.

Transmission Cycle(s). A wide range of wild and domestic vertebrate species can become infected with this virus. Most experimentally infected wild bird species easily produce viremias high enough to infect several different mosquito species. Wild and domestic birds are considered the main enzootic reservoir. Reported cases of Sindbis virus infections apparently have caused no significant illness in any domestic animal species, so far.

Bird-feeding *Culex* spp. are probably the main vectors of this virus in enzootic and human infections. Viral isolations and transmission experiments have shown that some *Aedes* spp., that are less host-specific and feed readily on both birds and humans may be important vectors linking the enzootic cycle to human infection. Mechanisms that allow the virus to survive overwinter and between enzootic transmission cycles in temperate areas have not been identified.

Vector Ecology Profiles. The most strongly implicated vectors of Sindbis virus in Southeast Asia currently are *Cx. bitaeniorhynchus* and *Cx. vishnui*. See Japanese encephalitis (above) for the general biology of these species. For a fairly complete list of mosquitoes and their known distributions in Southeast Asia, see Table 1.

F. Other Arthropod-borne Viruses. A number of enzootic arboviruses are circulating in Southeast Asia, but little is known about most of them. Several of these are mosquito-borne viruses pathogenic to humans reported from Southeast Asia, including: West Nile virus (WNV, see Figure 23), Wesselbron virus, Zika virus, *etc*., but they are relatively uncommon or rare and currently pose no more than limited, occasional, usually local, risk to the indigenous population or to any military exercise which might be conducted in the region.

Wild reservoir hosts of many of these are various species of birds, and maybe also the vector mosquitoes which usually transmit them. Available epidemiological information indicates that they would have a only minor impact on any future military operations in the region. However, medical personnel should be aware of these arboviruses because they will frequently be treating FOUOs and, in serological tests, may see reactions to closely related viruses known to cause significant disease in the region.

Please refer to current on-line updated information about these viruses, and related diseases they cause, by reviewing and searching such publicly available websites as those of the WHO, www.who.org/ (suggest searching "news," the "weekly epidemiologic record," or by specific topic of interest); and the U.S. CDC, www.cdc.gov/ (suggest searching "news," "*Emerg. Inf. Dis*.," by specific topics of interest).

Vector Ecology Profiles. Primary vectors of most of these viruses in Southeast Asia are *Cx. quinquefasciatus*, *Cx. tritaeniorhynchus*, and *Cx. vishnui*. Additional vectors may include *Cx. pseudovishnui* and possibly *An. subpictus*. Of the primary vector species, *Cx. quinquefasciatus* is considered to be the best vector of several of them, especially WNV and closely related viruses.

Culex quinquefasciatus is the most common vector species for these (especially WNV) throughout the region that feeds readily on both man and birds, which is essential to linking the zoonotic and epidemic cycles of these viruses. Details on the bionomics of this mosquito species are presented in the section on filariasis, below.

Culex tritaeniorhynchus breeds mainly in the pre-monsoon and monsoon periods (mid-May through mid-September) in northern parts of the region. Farther south, it may breed year-round. Details of the bionomics of this species are presented in the section on JE, above. A low rate of experimental transovarial transmission of WNV by this vector species has also been reported.

Culex vishnui and *Cx. pseudovishnui* are usually most abundant during the pre-monsoon and monsoon seasons in any given area. Details of the bionomics of these species are presented in the section on JE, above.

Anopheles subpictus occurs widely through this region. Two sibling species, A and B, have been reported, with species A predominating in most inland and upland areas, but species B predominating in coastal areas.

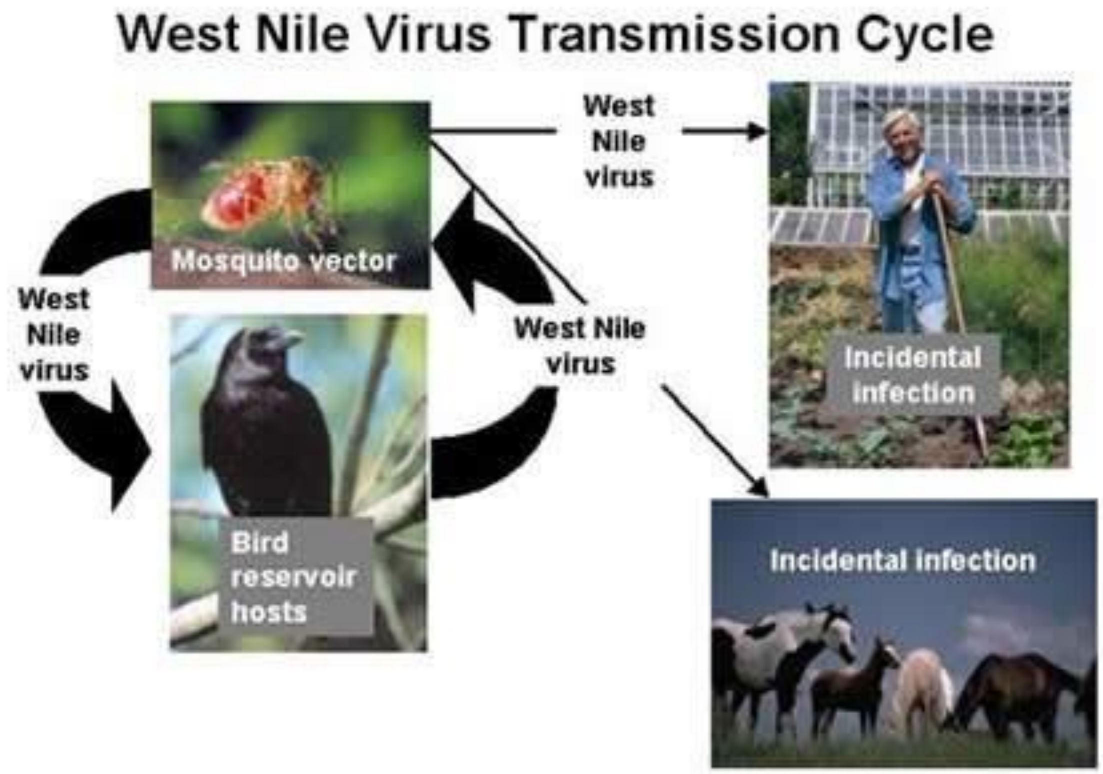
Anopheles subpictus is mainly zoophilic but often feeds aggressively on man. Its feeding behavior on birds has not been reported, but birds are the main reservoir of many of these viruses, especially WNV, and WNV has been isolated from this species. Details of the distribution and bionomics of this species are presented in the section on malaria (above). A list of Southeast Asian mosquitoes and their distribution can be found in Appendix A.1.

Vector Surveillance and Suppression. Epidemics of West Nile fever (caused by West Nile Virus or WNV) and closely related viral diseases are infrequent in this region and public health officials in Southeast Asian countries can rarely justify continued long-term surveillance for these viruses' activity, due to other health care demands. Pigs and chickens have been used as sentinel hosts to detect activity of WNV and related viruses. Surveillance for dead crows and related birds may be a useful indicator of certain viral activity, especially WNV, in a given area.

Reduction of adult mosquito populations by ULV spraying may be a means of disease control, to temporarily reduce transmission during outbreaks. The most feasible long-term control strategies involve reducing vector breeding by environmental management techniques, especially in extensively irrigated agricultural areas. Experimental evidence suggests that vaccination with JEV vaccine may also provide some protection against WNV, specifically.

Personal protective measures to prevent mosquito bites are the most practical means of avoiding infection with WNV and other arboviruses. Consult TG-13, Ultra Low Volume Dispersal of Insecticides by Ground Equipment; TG-24, Contingency Pest Management; and TG-40, Methods for Trapping and Sampling Small Mammals for Virologic Testing. Also see vector surveillance and suppression for malaria (above).

Figure 23. Typical Disease Cycle of West Nile Virus and Closely-Related Arboviruses.



G. Q Fever. Querry (or Q) fever, is an acute, self-limiting, febrile rickettsial disease caused by *Coxiella burnetii.* Onset may be sudden, with chills, headache and weakness. Pneumonia is the most serious complication. There is considerable variation in severity and duration of illness. Infection may be inapparent (subclinical) or present as a nonspecific fever of unknown origin. Acute Q fever is self-limited, and the case fatality rate in untreated acute cases is usually less than 1%. Chronic Q fever is a serious and often fatal illness with high mortality rates. Illness occurs months to years after the acute infection, and endocarditis occurs in up to 10% of patients.

Military Impact and Historical Perspective. *Coxiella burnetii* was originally described from Australia in 1937. Since then, *C. burnetii* has been found to have a worldwide distribution and a complex ecology and epidemiology. Q fever first appeared among Allied troops in 1944 and 1945, when several sharp outbreaks occurred in the Mediterranean theater. The disease was not recognized right away because the rickettsial pathogen had been reported to occur naturally in humans only in Queensland, Australia. Those outbreaks pointed out the need to consider Q fever in the differential diagnosis of cases of primary atypical pneumonia, but this knowledge did not become widespread in field military medicine for several more years. The British Army in the Mediterranean had several localized outbreaks of atypical pneumonia characterized by a high attack rate, up to 50% of some units, which was probably Q fever, but no serologic data were ever obtained. The U.S. military reported 3 cases of Q fever in military personnel during the 1991 Persian Gulf War.

Disease Distribution. *Coxiella burnetii* has been reported from more than 50 countries and all continents. Human case incidence is highest in persons routinely exposed to domestic animals, such as sheep and dairy farmers, veterinarians or slaughterhouse workers. Incidence is greater than reported because of the mildness of many cases. Q fever is enzootic throughout Southeast Asia, with most countries reporting sporadic isolated cases, but only occasional outbreaks. This disease was first reported from Malaysia in 1951, and is now considered to be endemic at low levels of incidence in both Malaysia and Vietnam. Later studies by Marchette (1965) and by the Institute for Medical Research (IMR), in Kuala Lumpur, showed that the enzootic cycle involved at least 3 species of small forest mammals and 4 species of ticks (2 *Haemaphysalis* spp., 1 *Dermacentor* sp., and *I. granulatus*). Q-fever is probably also established in several other countries in Southeast Asia, but the self-limiting usually mild symptoms and little or no routine precise surveillance make its true incidence nearly impossible to determine.

Vector Ecology Profiles. Several species of ixodid ticks can transmit *C. burnetii* to animals but are not an important source of human infection. *Coxiella burnetii* has been isolated from the following species of ticks in Asia: *Aponomma gervaisi*, *Boophilus microplus*, *Haemaphysalis intermedia*, *H. kinneari*, *H. spinigera*, *H. turturis*, *Hyalomma hussaini*, *Rhipicephalus haemaphysaloides* and *R. sanguineus*. The role of these ticks in the epidemiology of Q fever is unknown.

Transmission Cycle(s). In nature there are 2 cycles of *C. burnetii* infection. One cycle involves arthropods, especially ticks, and a variety of wild vertebrates. The most important reservoirs are small wild rodents, but infection has also been demonstrated in insectivores, lagomorphs, carnivores, ungulates, marsupials, monkeys, bats, birds, and even reptiles. In India, *Coxiella burnetii* has been isolated from *Aponomma gervaisi* ticks collected from a king cobra. Antibodies to Q-fever have been found in commensal rodents and shrews, including rats (*Rattus rattus*, *R. norvegicus*), bandicoots (*Bandicota indica*, *B. bengalensis*), the house mouse (*Mus musculus*), and the ground shrew (*Suncus murinus*). High seroprevelances of *C. burnetii* antibodies have also been found in wild brown rat populations from four Oxfordshire farmsteads in the UK. This finding was the first report of *C. burnetii* in domestic rats outside India, and suggests that commensal rodents may be an important reservoir for this pathogen.

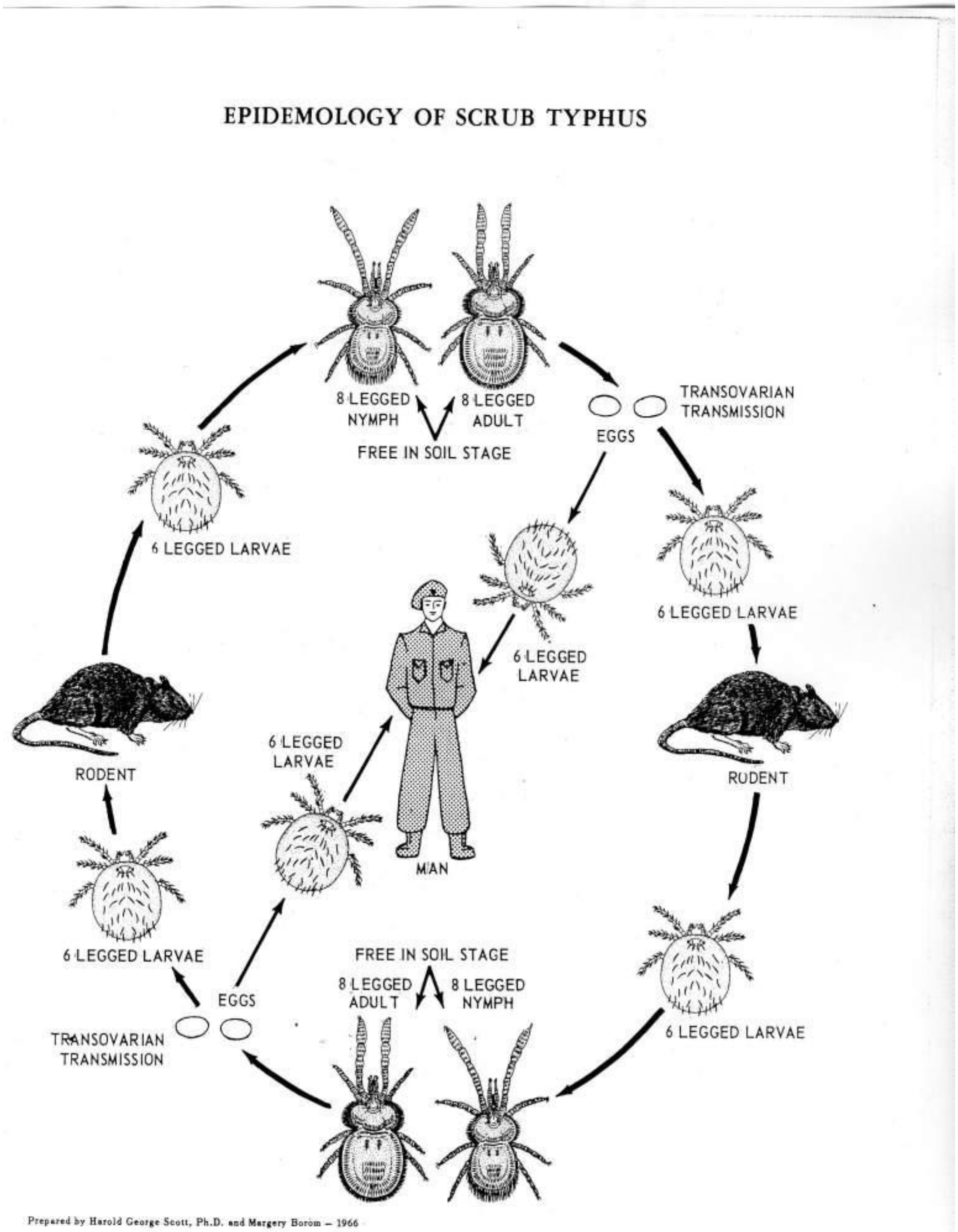
The other cycle is maintained among domestic animals. Although humans are rarely if ever infected by ticks, arthropods may transmit infection to domestic animals, especially sheep and cattle. Domestic animals have inapparent infections but shed large quantities of infectious organisms in their urine, milk, feces and, especially, their placental products. Because *C. burnetii* is highly resistant to desiccation, light and extremes of temperature, infectious organisms can become aerosolized, causing widespread outbreaks in humans and other animals, often at a great distance from their source. Dust in sheep or cattle sheds may become heavily contaminated. Once established, animal-to-animal spread of Q-fever is maintained mainly through airborne transmission. Airborne particles containing viable rickettsiae can be carried downwind >1 mile. Outbreaks of Q fever in humans have been traced to consuming infected dairy products and contact with contaminated wool or hides, infected straw, and infected animal feces. *Coxiella burnetii* may enter through minor abrasions of the skin or mucous membranes. Although rare, human-to-human transmission of Q fever has occurred. Infectious agent in the blood and tissues of patients may pose a hazard to medical and laboratory workers.

Vector Surveillance and Suppression. No commercial vaccine is available in the U.S., but effective experimental vaccines have been developed. Severe local reactions can occur in individuals with a positive skin or antibody test or a documented history of Q fever. Efforts to identify and decontaminate infected areas and to vaccinate domestic animals are difficult, expensive and impractical. *Coxiella burnetii* is resistant to many disinfectants. Military personnel should avoid consuming local dairy products and contacting domestic animals, hides or carcasses. Soldiers should not rest, sleep, or work in or near animal sheds or other areas where livestock has been housed.

H. Scrub Typhus. This disease is also called: Tsutsugamushi disease, chigger-borne rickettsiosis, Japanese river fever, mite-borne typhus fever, and tropical typhus. It is a rickettsial disease characterized by a primary skin ulcer (eschar) that develops at the site of attachment by an infective mite. The infectious agent is *Orientia* (formerly *Rickettsia*) *tsutsugamushi*. The incubation period is usually 10 to 14 days. Clinically, scrub typhus resembles other rickettsial diseases with abrupt onset of fever, headache, malaise, and swollen lymph nodes. Late in the first week of fever, a maculopapular rash appears on the trunk and extends to the extremities. Without antibiotic therapy, fever lasts about 2 weeks. The case-fatality rate in untreated cases varies from 6% to 35%, but in some instances can be as high as 60% depending on the area, strain of rickettsia, and previous exposure to the disease. Following an attack of scrub typhus, immunity to the homologous strain persists for at least 1 year. Mortality is highest among the elderly.

Transmission Cycles. Transmission is by the inffective bite of a larval *Leptotrombidium*, subgenus *Leptotrombidium*, mite (Figure 24). Blood-meal hosts include a variety of small mammals and birds, but the most important alternate reservoir hosts are rats of the genus *Rattus*. However, domestic rodents are not involved in the epidemiology of scrub typhus. Only the larval (chigger) stage of the mite can acquire and transmit infectious agent, since only larvae are parasitic. Transstadial and transovarial passage of rickettsiae occur, and mites are considered the main natural disease reservoir. Experimentally, it has been difficult to infect *Leptotrombidium* mites by feeding them on infected rodents, and those chiggers that become infected rarely pass the infection transovarially to offspring. Most foci of scrub typhus are the result of natural or man-made changes in the environment and are characterized by the presence of vector mites, wild rodents, particularly *Rattus* spp., and transitional secondary vegetation such as grass, shrubs and saplings. That transitional, brushy or scrubby margin (often called an ecotone) between forest and herbaceous, usually grassy, areas is the ideal setting for survival and reproduction of the vector mites (chigger mites) and their natural larval blood-meal hosts, mainly indigenous rats or other small mammals.

Figure 24. Disease Cycle of Scrub Typhus.



Vector Ecology Profiles. The primary vector of scrub typhus in Southeast Asia is *Leptotrombidium deliense*. This species occurs in most countries of this region, especially Indonesia and Thailand. *Leptotrombidium akamushi* is another possible vector species, based on its vector status in Southeast Asia. However, this species has only been reported from India and has not been definitely incriminated as a vector in this region. *Leptotrombidium deliense* has been found primarily in forests, while *L. akamushi* occurs mostly in grasslands.

Chigger vectors inhabit submontane, tropical, and temperate zones in the region. Hilly areas with disturbed vegetation are the primary habitats, and in many areas the life cycle continues year-round. Adult mites lay 1 to 5 eggs per day in damp, well-drained soil. Over a period of 6 to 12 weeks, 300 to 400 eggs may be deposited. The six-legged larvae that emerge from eggs ascend the tips of grasses to heights of 6 to 8 cm to await a suitable host. Most often, hosts are rodents, birds or insectivores, although humans are readily attacked. Shrews and bandicoots are common hosts in India. The distribution of the mites is dependent on the home ranges of the hosts, which do not usually overlap. Mite colonies therefore tend to be isolated from each other and occur as "mite islands." Their focal distribution is also due to their specialized ecological requirements. Relatively small changes in moisture content of the soil, temperature and humidity can determine survival and distribution of chigger mites. Larvae attach themselves to host tissues with mouthparts known as chelicerae and form a stylostome (combination of chigger mouthparts and host tissues, also called a feeding tube) at the point of attachment. Larvae are very small (0.15 to 0.3 mm), but after engorging they may increase six-fold in size. They are usually reddish or orange but may be pale yellow or straw-colored. On rodents or birds, primary attachment sites for larval chiggers are inside ears or around the eyes. They may also congregate around the anus and genitalia. On people, the trunk or extremities are the primary attachment sites. Chiggers seek out areas where clothing is tight against the skin, such as the waist or ankles. A lesion or eschar usually develops at the feeding site of each infected chigger. Chiggers do not suck blood. The feeding tube allows tissues digested by the chigger's saliva to be pumped into the digestive tract. This may require several days, although some will feed and drop off the host within 48 hours. Larvae that have fed develop into inactive, eight-legged protonymphs. Protonymphs molt to the active deutonymph stage. The next stage, the tritonymph, is also inactive and molts to the adult stage. Both the adult and deutonymph stages are free-living predators of soil-inhabiting arthropods and their eggs. Adults are small mites (1 to 2 mm), usually reddish and covered with numerous feathered hairs, giving them a velvety appearance. The nymph resembles the adult but is smaller (0.5 to 1.0 mm), and the body is less densely covered with hairs. The life cycle may occur in as little as 40 days in tropical areas, resulting in several generations per year. In more temperate areas of the Himalayas and in the semi-deserts of Pakistan, up to 300 or more days may be required to complete the life cycle. During cold months of the year, adults enter partial or complete hibernation.

Vector Surveillance and Suppression. Larval chiggers can be collected directly from hosts. Attached chiggers can be removed from dead or anesthetized animals with fine forceps and placed for temporary storage in 70% alcohol. Alternatively, a dead host can be placed in a jar with water and detergent, and the jar shaken vigorously to remove ectoparasites from the animal. The liquid is then poured into a funnel containing filter paper. Any mites will be strained out by the filter paper. Live hosts can be placed in cages that have wire or hardware cloth bottoms so that any mites that drop off after engorging will fall into a pan of water placed under the cage.

In the field, 12-inch squares of black paper or plastic can be placed on the ground in suspected chigger habitat for 1 to 5 minutes, after which the total number of chigger mites that congregate on the black squares are counted. Locate plates about 100 m apart. If nothing else is available, the black surface over the toes of combat boots can be used to visualize crawling chiggers. Mites can be separated from nesting material, grass, leaves and other debris with a Berlese funnel.

The wide and patchy distribution of chigger mites make their control very difficult. Vegetation can be removed mechanically or with herbicides around military encampments to make the habitat unsuitable for survival of the mites. Mite populations have been reduced by the application of residual insecticides, but this is generally not feasible over large areas. Limited applications of insecticides may be applied to the ground, vegetation and environs of camps, buildings and paths traveled by people. Permethrin-impregnated uniforms are highly effective against crawling arthropods like chiggers. No experimental vaccine has been developed, but weekly doses of doxycycline have been shown to be an effective prophylaxis in limited studies.

I. **Relapsing Fever (tick-borne).** Relapsing fever (also called: endemic relapsing fever; cave fever) is a systemic spirochetal disease in which periods of fever alternate with periods of no fever. The number of relapses varies from 1 to 10 or more. The severity of illness decreases with each relapse. The duration of tick-borne relapsing fever is usually longer than the closely related louse-borne relapsing fever. A number of species of *Borrelia* are responsible for the disease. The taxonomy of the pathogen is complex. The close vector-spirochete relationship has led to the definition of most spirochete species by their tick vectors. There is great strain variation among tick-borne *Borrelia*, and a single strain can give rise to many serotypes. Some authorities once viewed all species as tick-adapted strains of the louse-borne relapsing fever spirochete, *B. recurrentis*, but molecular techniques are beginning to unravel taxonomic differences between strains.

Military Impact and Historical Perspective. Although clinical symptoms of tick-borne relapsing fever can be severe, impact on military personnel would be minimal due to very low incidence (rarity) and the focal nature of this disease in Southeast Asia.

Disease Distribution. The status of tick-borne relapsing fever is unclear in Southeast Asia. Historically, sporadic cases have been reported from the nearby countries of India and China, and rare cases may still be reported.

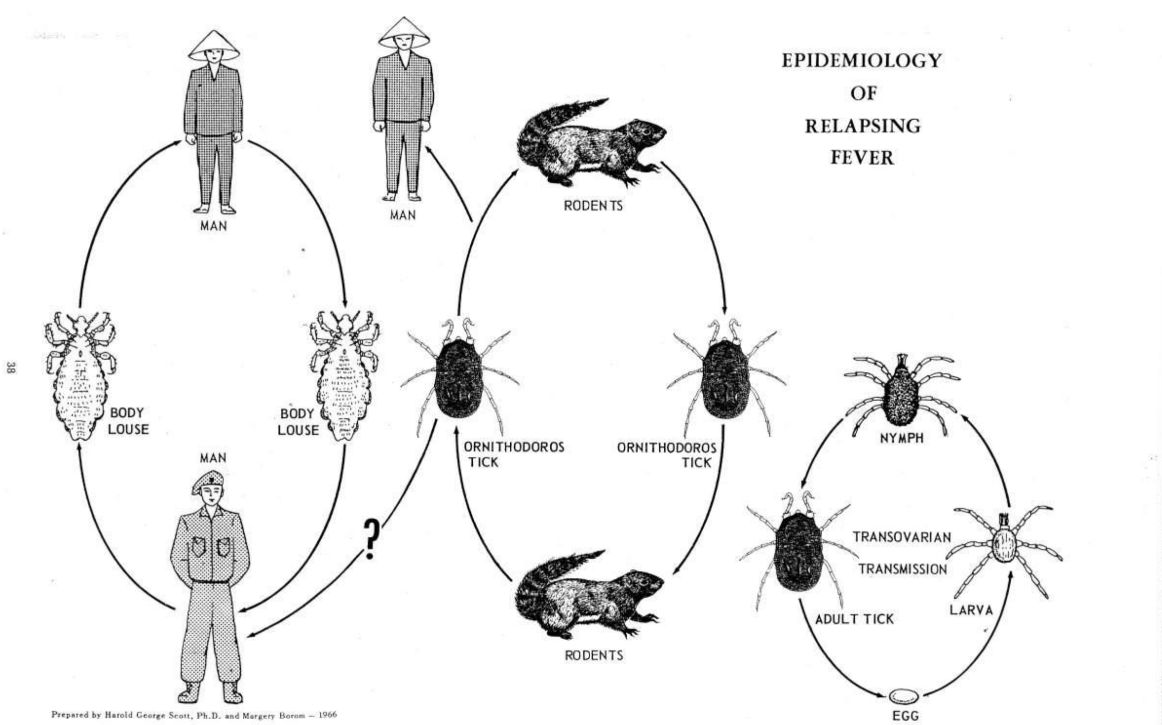
Transmission Cycle(s). Soft ticks of the genus *Carios* (formerly *Ornithodoros*) are the most important vectors of tick-borne relapsing fever. Infection is transmitted from human to human, animal to animal, or animal to human by the bite of infective ticks. Rodents are sources of infection for ticks, although ticks are more important as a long-term reservoir (see Figure 25). In some tick species, the pathogen has been maintained naturally for years by transovarial transmission. The rate of transovarial transmission varies greatly among tick species. Ticks of both sexes and all active stages transmit the pathogen by bite or by infectious coxal fluids exuded from pores in the basal leg segments. Spirochetes can pass into bite wounds or penetrate unbroken skin. Exposure to infected blood of patients can cause infections in medical personnel.

Vector Ecology Profiles. *Carios* spp. ticks are the vectors of tick-borne relapsing fever in Southeast Asia. In addition to their role in the transmission of relapsing fever, this genus is important because it includes species that inflict painful bites, some of which can cause local or systemic reactions in humans. Most *Carios* ticks have restricted habitats, such as rock outcroppings, caves, dens, burrows, nests, and other sheltered habitats. Some species are parasitic on livestock and are found in stables and places where host animals rest. Adult *Carios* spp. mainly feed at night, usually during only 1 to 2 hours. Males are slightly smaller than females but similar in appearance. Larvae may remain attached to a host for several days. Subsequent nymphal stages are active and need blood meals to develop. Engorgement is rapid, and nymphs drop off their hosts after feeding. Nymphs and adults of some species feed quickly and painlessly, so their bites may go unnoticed by a human host until long after the tick has detached. After a variable number of molts (usually 4 or 5), adults emerge and mate. Unlike ixodid (hard) ticks, female *Carios* do not die after oviposition. Females may live many years without a bloodmeal, but blood is required for egg development. Over the life span of a female, the number of eggs deposited may total several hundred, with up to 8 batches of eggs produced. A list of tick species and their reported distribution in Southeast Asia appears in Table 3.

Carios capensis, *Carios batuensis*, and *Carios vespertilionis* have each been incriminated as potential vectors of this pathogen, as well as Q fever and certain arboviruses, in Thailand and Indonesia, but their relative importance in this role has not been very well documented, so far.

Vector Surveillance and Suppression. Argasid ticks like *Argas* spp. and *Carios* spp., are found mainly in, and rarely move very far beyond, the restricted habitats of their respective hosts. They usually occupy loose, dried soil of dwellings, cracks and crevices in mud-walled animal shelters, animal burrows and resting places, and (rarely) underneath loose bark of logs or older trees. They can be collected by passing soil through a metal sieve or by blowing a flushing agent into cracks and crevices and other hiding places. Some species are attracted by carbon dioxide, and dry ice can be used in the collection of burrow-dwelling ticks. *Carios* ticks also fluoresce under ultraviolet light. There is little seasonal fluctuation in their numbers since their microhabitats are relatively stable. Personal protective measures (see TG 36) are the most important means of preventing bites and diseases transmitted by soft ticks. Tents and bedding can be treated with the repellent permethrin. Encampments should not be established in areas which are likely to be infested with Argasid (soft) ticks. Troops should avoid using indigenous shelters, caves, or old bunkers for bivouac sites or recreational purposes. Control of small mammals around cantonments can reduce or eliminate potential vector hosts. Rodent-proofing structures, to prevent entry or colonization by rodents and their ectoparasites, is an important preventive measure. Limited area application of appropriate acaricides, especially in rodent burrows, can reduce soft tick populations. Medical personnel may elect to administer antibiotic chemoprophylaxis after exposure to tick bites when risk of acquiring infection is high. See TG 36, for personal protective measures.

Figure 25. Typical Disease Cycle(s) of Relapsing Fever (*B. recurrentis*).



J. Plague. Plague, popularly called pestis or the black death, is a zoonotic bacterial disease involving rodents and their fleas, some species of which occasionally transmit the infection to man and other animals. The infectious agent, *Yersinia pestis*, causes fever, chills, myalgia, nausea, sore throat and headache. Bacteria accumulate and swelling develops in the lymph nodes closest to the infecting bite. Because fleas most often bite people on lower extremities, the nodes in the inguinal region are involved in about 90% of cases. The term bubonic plague is derived from the swollen and tender buboes that develop. Plague is most easily treated with antibiotics in the early stages of the disease. Untreated bubonic plague has a case fatality rate of about 50%. Infection may progress to septicemic plague, with spreading of the bacteria in the bloodstream to many parts of the body. Secondary involvement of the lungs results in pneumonia. Pneumonic plague is of special medical significance since respiratory aerosols may serve as a source of person-to-person transmission. This can result in devastating epidemics in densely populated areas. Pneumonic and septicemic plague are invariably fatal if untreated but usually respond to early antibiotic therapy. To ensure proper diagnosis, medical personnel should be aware of areas where the disease is enzootic. Plague is often misdiagnosed, especially when travelers or military personnel develop symptoms after returning from an enzootic area.

In 1995, the first multi-drug resistant strain of the plague organism, *Y. pestis*, was discovered in Madagascar. The resistance elements were borne on plasmids and were determined to be closely related to similar genetic amterial on plasmid in several related microbes, specifically certain strains of *E. coli* and certain serotypes of *Salmonella* (Welch *et al*. 2001). Soon afterwards, a closely related but different plasmid was found in another strain of *Y. pestis* from Madagascar which made that host plague organisms resistant to an additional widely used antimicrobial (Guiyoule *et al*. 2001). These resistant strains could pose a significant public health challenge. They might spread and become further adapted, possibly developing resistance to even more antimicrobials. Both clinicians and public health leaders should keep themselves informed of the current status and any changes in the prevalence of, and treatment failures possibly due to, these new plague strains. This might force an even greater emphasis on controlling the vector fleas of plague as a vital routine step in any outbreak of the disease.

Military Impact and Historical Perspective. Epidemics of plague have been known since ancient times and have profoundly impacted civilization. During the Middle Ages, Europe experienced repeated pandemics of plague. About 30% of the continent's population died during the 14th century plague pandemic. The latest pandemic originated near the end of the 19th century in northern China and spread to other continents by way of rats on steamships. During the Middle Ages, plague was a decisive factor in many military campaigns, weakening besieged cities or attacking armies. During World War II, plague presented a real threat to U.S. military forces in the Mediterranean area and the Orient, but no U.S. military personnel contracted the disease. This was attributed to effective rodent control, DDT for flea control, chemoprophylaxis, and the use of preliminary plague vaccines. Severe ecological disturbances and dislocations of human populations during the Vietnam War led to outbreaks of plague, mainly in native populations. Even though total numbers of human cases of plague has been declining world wide, persistent enzootic foci can still trigger a recurrence of epidemics when war or natural disasters disrupt general sanitation and health services. Presently, the threat of plague to military operations is low in most areas of the world .

Disease Distribution. Plague is enzootic in wild rodents at various places around the world (see Fig. 26). It is currently enzootic in the western U.S. with about 11 new human cases a year. It is also enzootic in central Asia, India, and in certain countries in South America, the Middle East, and eastern Africa (including Madagascar). In Southeast Asia, sylvatic plague is considered to be enzootic in Indonesia, Myanmar and southern Vietnam. Human cases have recently been reported from Indonesia, Laos, Myanmar and Vietnam. Many factors may contribute to maintaining current endemic plague foci, establishment of new foci, and triggering outbreaks. These may include large changes in vegetation, animal (reservoir) populations and distributions, and climate or even shorter but persistent multiple-year modified weather patterns. Most cases of human plague in enzootic situations occur in rural sites. However, significant recent urban outbreaks have occurred in India and Madagascar, and certain cities in other countries (*e.g.*, Odessa, Ukraine; Kinshasa, Democratic Republic of the Congo) have been shown to contain all the elements needed to support a large outbreak if the plague organism were to be introduced there (WHO 2006).

Transmission Cycle(s). Plague is a disease of rodents maintained in nature among wild rodents and their fleas (Fig. 27). This zoonotic cycle is called sylvatic, campestral, rural, or wild plague, and cycles can be very complex, involving many rodent and flea species. At least 76 species of fleas are known from Southeast Asia (See Table 4). At least four of them are of them are reported to be competent plague vectors under natural conditions. Little is known about the biology of most of the wild rodent fleas in the region. Worldwide, over 220 species of rodents have been shown to harbor *Y. pestis*. In addition, camels and goats are sometimes infected with plague bacteria and may play an important role in the spread of human plague when infected animals are butchered for human consumption.

Some rodents are highly susceptible to infection, resulting in high mortality. Large numbers of dead and dying rodents is a good indication of an epizootic of plague, but rodent species that are resistant to infection (or are not readily killed by it) are more important in maintaining the zoonotic cycle. Most cases in military personnel would probably occur as a result of intrusion into the zoonotic cycle during or following an epizootic of plague in wild rodents. Domestic cats and dogs may carry infected rodent fleas into buildings or tents. Cats may occasionally transmit infection by their bites or scratches, or by aerosol when they have pneumonic plague. Troops should not be allowed to adopt cats or dogs as pets during military operations. Wild rodents or their infected fleas entering human habitations can initiate an epizootic among commensal rodents, mainly *Rattus* spp., which are highly susceptible to infection. Close association of humans with large populations of infected commensal rodents can result in an urban cycle of plague. A similar cycle can occur in military cantonments experiencing large infestations of commensal rodents. The most important vector of urban plague worldwide is the Oriental rat flea, *Xenopsylla cheopis*. The human flea, *Pulex irritans*, is a secondary vector in Southeast Asia. The cat flea, *Ctenocephalides felis*, and dog flea, *Ctenocephalides canis*, are both often numerous in cities throughout the region, and both are competent but not very efficient plague vectors. The most frequent route of plague transmission to humans is by the bite of infected fleas. Fleas often exhibit a host preference, but most species of medical importance readily go from one host to another. A lack of absolute host specificity increases the potential for infection and transmission of pathogens. Plague may also be acquired by handling tissues of infected animals or humans, and by person-to-person transmission of pneumonic plague. Additionally, crushed infected fleas and flea feces inoculated into skin abrasions or mucous membranes can cause infection. Not all flea species are competent vectors. The vector competence of the Oriental rat flea is attributed to enzymes produced by the plague bacilli that cause blood to coagulate in the flea's digestive tract. The flea attempts to clear the blockage in its digestive tract by repeated efforts to feed. In the process, plague bacilli are inoculated into the host. Fleas may remain infective for months when temperature and humidity are favorable. *X. cheopis* may require 2 to 3 weeks after an infective bloodmeal before it can transmit plague bacilli.

Figure 26. Reported Worldwide Distribution of Plague.

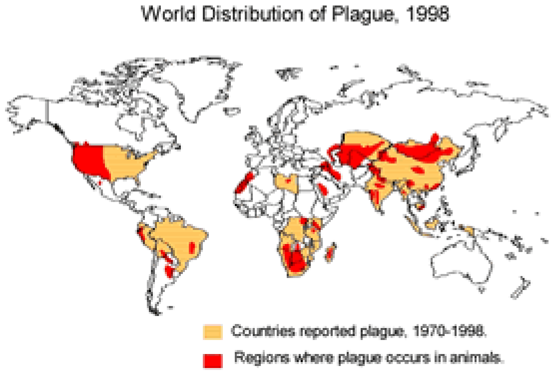
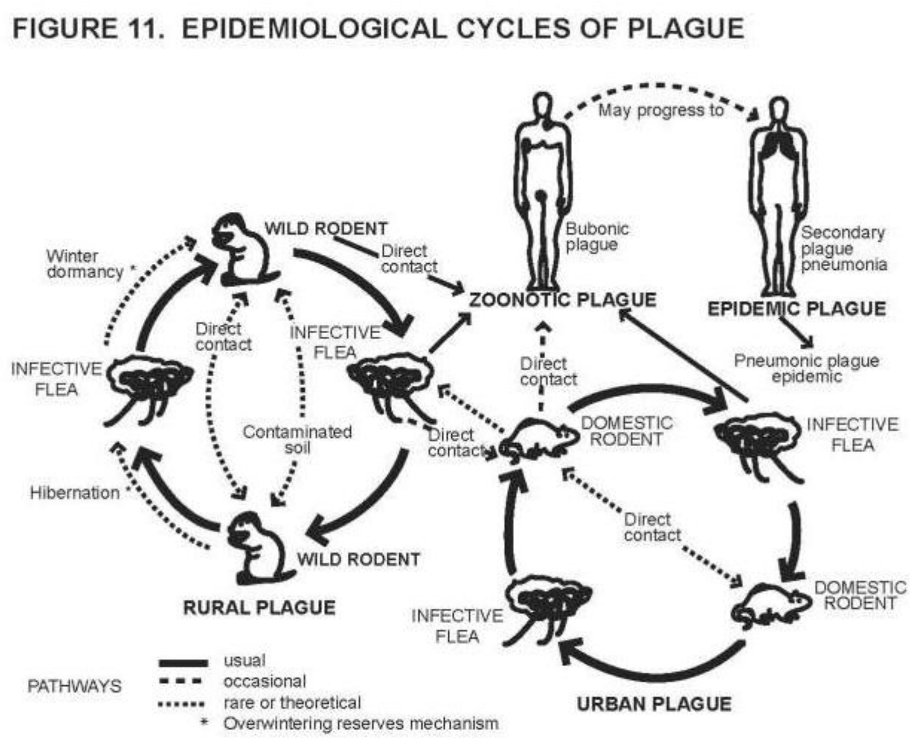


Figure 27. Plague Disease Cycles.



Vector Ecology Profiles.

Xenopsylla cheopis occurs mostly in urban areas, in association with its rodent hosts. However, it may occur sporadically in villages when rats are present. Adult fleas feed exclusively on blood and use blood protein for egg production. After feeding on a rodent, the female Oriental rat flea lays several eggs (2 to 15). Each female may lay hundreds of eggs during lifetime. Oviposition most often occurs on the hairs of the host, but the dry, smooth eggs drop off and hatch in the nest or its environs. In locally humid environments, such as rodent burrows, eggs may hatch in as little as 2 days. Larvae grow rapidly when temperature and relative humidity are above 25°C and 70%, respectively; they live in the nest, feeding on dried blood, dander, and other organic materials. The larval stages can be completed in 14 days (at 30-32°C), or may last 200 days at <15°C or when their food is scarce. Mature larvae pupate in cocoons, loosely attached to the host's nest material. Adults may emerge in as little as 7 days or may take as long as a year. Emergence is stimulated by carbon dioxide or host activity near the cocoon. Adult fleas normally await the approach of a host rather than actively search for one. Fleas feed on humans when people and rodents live close together, but man is not a preferred host. However, if rat populations decline suddenly due to disease or rat control programs, these fleas readily switch and feed on humans. The life span of adult *X. cheopis* is relatively short compared to that of other flea species, often <40 days. Flea populations increase rapidly during warm, moist weather. The human flea, *P. irritans*, occurs mainly among lower socioeconomic groups. It is a secondary vector of plague in Southeast Asia and is most widely distributed in cities. The life cycle of the human flea is similar to that of the Oriental rat flea. Despite its common name, *P. irritans* has a low to moderate preference for humans and is more likely to feed on available rodents, including mice, voles, or gerbils, maintaining the enzootic plague cycle among these hosts. Where swine occur, the human flea prefers them to humans. Domestic pets also serve as hosts. In the absence of preferred hosts, this flea readily feeds on humans and is often found in our homes. *Pulex irritans* can live over one year on its preferred hosts, and can survive unfed for several months.

Vector Surveillance and Suppression. Flea surveillance methods depend on the species of flea, the host, the ecological situation, and the objective of the investigator. Fleas can be collected from hosts or their habitat. The relationship of host density to flea density should be considered in assessing flea populations. It has been common practice for years to use a flea index (average number of fleas per host), in studies of rodent fleas. For *X. cheopis*, a flea index >1.0 flea per host is considered high. The flea index has many limitations, since only adults are considered and then only while they are on a host. Fleas are recovered by combing or brushing the host or by running a stream of carbon dioxide through the fur while holding the host over a white surface. Flea abundance in the environment can be determined by counting the number of fleas landing or crawling in 1 minute on the lower parts of the observer's legs. Trouser legs should be tucked into the socks to help prevent bites. Flea populations can also be estimated by placing a white cloth on the floor in buildings or on the ground in rodent habitat and counting the fleas that jump onto the cloth in a given time. Various flea traps have been devised. Some use light or carbon dioxide as an attractant or stimulant. Sifting and flotation of rodent nest materials or of dust and debris from infested buildings can also be effective flea survey methods.

Serologies of wild carnivores are sensitive indicators of enzootic plague. Fleas and tissues from suspected reservoirs or humans might potentially be submitted for plague analysis to the U.S. Centers for Disease Control and Prevention (CDC), National Center for Infectious Diseases, Division of Vector-borne Infectious Diseases, Fort Collins, **CO**. Before submitting any sample for analyses, it is suggested that interested parties should contact that agency beforehand and should consult TG 103, Prevention and Control of Plague. Control of enzootic plague over large areas is not usually feasible. Control efforts should be limited to pre-selected, manageable foci adjacent to urban areas, military encampments, or other areas frequented by military personnel. If possible, cantonment sites should not be located in wild rodent habitats. Fleas quickly leave dead or dying hosts in search of new ones. Therefore, flea control must always precede or coincide with rodent control operations. Applying insecticidal dusts to rodent burrows can be effective in reducing flea populations, but it is often very labor intensive. Fleas can be controlled by attracting infested rodents to insecticide-treated bait stations. The stations may incorporate an insecticidal dust that rodents pick up while feeding or a rodent bait containing a systemic insecticide that fleas ingest when taking a bloodmeal. Baiting local flea vector hosts with systemic (feed-through) insecticide formulations may work but might pose environmental risks (Mascari et al. 2008).

Urban plague control requires that rodent runs, harborages and burrows be dusted with an insecticide labeled for flea control and known to be effective against local fleas. Insecticide-treated bait stations can be used. Rat populations should be reduced by well-planned, intensive campaigns of poisoning and concurrent measures to reduce rat harborages and food sources. Buildings should be rat-proofed as completely as possible. Domestic rodent control is discussed in TG 138, Guide to Commensal Rodent Control. Some insecticides recommended for flea control are listed in TG 24, Contingency Pest Management Guide, or in current tables on the AFPMB website, www.afpmb.org .

Military personnel, especially those doing rodent control, should use the personal protective measures in TG 36, Personal Protective Techniques Against Insects and Other Arthropods of Military Significance. Active immunization with a vaccine of killed bacteria is available in some countries and can provide protection against bubonic (but not pneumonic) plague in most humans for several months. Booster injections are needed every 6 months. The efficacy of plague vaccine in humans has not been demonstrated in controlled trials, so vaccination should not be relied on as the sole preventive measure.

K. Murine Typhus. (Flea-borne typhus, Endemic typhus, Shop typhus). The infectious agent, *Rickettsia typhi* (formerly *R. mooseri*), causes a debilitating illness with high fever and a maculo-papular rash. The incubation period ranges from 1 to 2 weeks, and clinical symptoms may last up to 2 weeks in untreated cases. Mortality is very low, and serious complications are infrequent. The disease is easily treated with antibiotics. Absence of louse infestation, seasonal distribution, and the sporadic occurrence of murine typhus help to differentiate it from epidemic typhus. Murine typhus is often unrecognized and substantially underreported in most endemic areas. It is not a notifiable disease in most countries.

Military Impact and Historical Perspective. Confusion in diagnosis between murine typhus and closely related diseases may occur. Prior to World War II, murine typhus was not distinguished from the epidemic form, and its importance in prior wars is unknown. During World War II, there were 786 cases in the U.S. Army, with 15 deaths. Only 34 cases were recorded in the China-Burma-India theater. There are few available data on the incidence of this disease during military operations in Korea or Vietnam. During the Vietnam War, murine typhus was concentrated in port cities and incidence seemed low. However, retrospective studies indicate that *R. typhi* was probably responsible for a large proportion of fevers of unknown origin (FOUO) in American soldiers during that conflict. The disease is most common in lower socioeconomic classes and increases when wartime disruptions or mass migrations force people to live in unsanitary conditions along with domestic rodents. However, murine typhus has not been a major contributor to disease rates in disaster situations. Because of its sporadic nature, the real or potential impact of murine typhus is difficult to predict or even quantify. Its potential impact on future military operations in this region would probably be minimal.

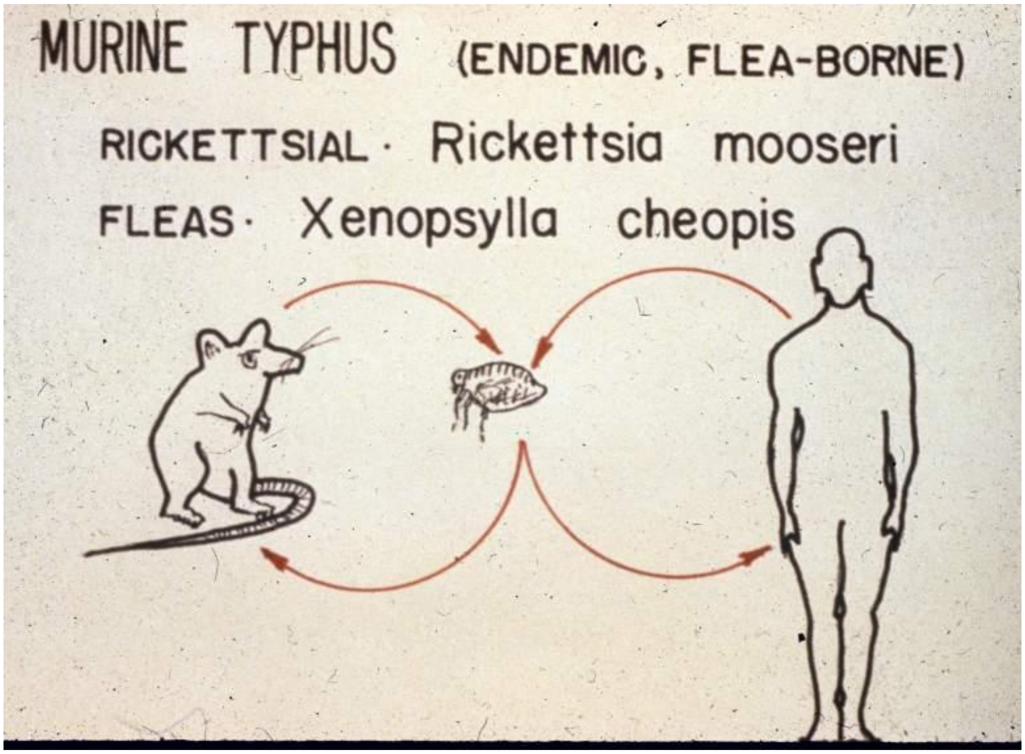


Figure 28. Murine Typhus Disease Cycle.

Disease Distribution. Murine typhus is one of the most widely distributed arthropod-borne infections and is endemic in many coastal areas and ports throughout the world. Human cases occur mainly in urban areas, where commensal rodent infestations are common, although infected rodents have been collected from rural sites. Foci occur wherever rats are common, and transmission is year-round in tropical and subtropical regions. Murine typhus usually occurs in the summer and fall, while epidemic typhus generally occurs during colder months. Only sporadic cases in this region have been reported in recent medical literature. However, a few serological surveys have indicated that a low incidence of infection with *R. typhi* is common in many coastal areas. Human death due to murine typhus is rare, only about 1% if untreated, and prior human infection with *R. typhi* provides long-term immunity to re-infection.

Transmission Cycle(s). Murine typhus is a zoonotic infection associated with domestic rats (*R. rattus* and *R. norvegicus*) and vectored by their fleas and rarely by the spiny rat louse, *Polyplax spinulosa* (Figure 28). The Oriental rat flea, *X. cheopis*, is the most important vector, but the cat flea is also a competent vector. Neither rodents nor their ectoparasites seem to be affected by infection with *R. typhi*. Inoculating crushed fleas or infective flea feces into the skin at a bite site, or an open wound, introduces the disease. Scratching fleabites increases the likelihood of infection, but *R. typhi* is rarely transmitted directly by fleabite. Other routes of infection are inhalation of dry flea feces containing rickettsiae (which may remain infective for months), and ingestion of food contaminated by rodent urine. Murine typhus is not transmitted from person to person. The risk of transmission is year-round but peaks during the warm months in northern latitudes. Although the rat-flea-rat cycle is still the major source of human infection, murine typhus exists in some endemic foci where commensal rodents are absent. In suburban areas of Texas and southern California, the classic enzootic cycle has been replaced by a peri-domestic animal cycle involving free-ranging cats, dogs and opossums and their fleas. In the Dinaric beech-fir forest of southern Slovenia, *Monopsyllus sciurorum* fleas collected from the nests of the fat doormouse, *Glis glis*, were found infected with *R. typhi*. The widespread distribution of this sylvatic flea species and its presence on other mammals and birds suggests that murine typhus may exist in unrecognized enzootic cycles.

Vector Ecology Profiles. The primary vector is the Oriental rat flea, *X. cheopis*. Potential secondary vectors for humans are the cat and dog fleas, *C. felis* and *C. canis*, as well as the human body louse, *Pediculus humanus humanus*. The northern rat flea, *Nosopsyllus fasciatus*, spiny rat louse, *Polyplax spinulosa*, and tropical rat mite, *Ornithonyssus bacoti*, are vectors that may help maintain the enzootic cycle of the disease. The pathogen, *R. typhi*, has been isolated from the rodent fleas *Monopsyllus anisus* and *Leptopsylla segnis* collected from wild rodents in China. Flea biology is discussed under plague. The biology of human body lice is discussed under epidemic typhus. *Polyplax spinulosa*, the spiny rat louse, is closely associated with its rodent hosts. Female lice typically attach eggs to rodent hairs, and all developmental stages live exclusively on their hosts. Lice are mainly transferred from rodent to rodent by direct body contact. These lice feed on rodents but do not feed on, and many will not even bite, humans.

Ornithonyssus bacoti, the tropical rat mite, lives on commensal and other rodents throughout Southeast Asia (essentially world wide) and feeds on blood and other fluids that ooze from its tiny bite wounds. Engorged females start laying eggs within 2 days of feeding and continue to lay groups of eggs for 2-3 days. Eggs hatch in 1-2 days and develop into larvae, followed by protonymphs and deutonymphs. The entire life cycle, from egg-to-adult, requires only 5-6 days. These mites will readily infest humans if their rodent hosts are suddenly eliminated, or if humans live in close association with rodent nests.

The northern rat flea, *N. fasciatus*, occurs where commensal rodents are found, particularly *R. norvegicus* and *R. rattus*. It is widespread in North America, Europe, China, Korea, and Japan, but it is not as common in Southeast Asia or other tropical regions. This flea lays its eggs in its hosts' the nests or burrows. Larvae have the unique habit of attaching to the abdomen of an adult flea and ingesting fecal blood as it passes out from the anus of the adult.

Vector Surveillance and Suppression. See this same section under plague.

L. Epidemic Typhus. Epidemic typhus is a severe disease transmitted by the human body louse, *Pediculus humanus humanus*. The infectious agent is the bacterium *Rickettsia prowazekii*. It causes high mortality, particularly in populations weakened by malnutrition. Case fatality rates normally vary from 10 to 40% in the absence of specific therapy. Onset is usually sudden and marked by fever, headache, and general pains followed by a rash that spreads from the trunk to the entire body. Untreated cases may last up to 3 weeks. Many humans who contract typhus retain some rickettsiae for the rest of their lives. Under certain stressful conditions or reduced immunity, they may relapse and develop a milder form known as Brill-Zinsser disease.

Military Impact and Historical Perspective. Epidemics of typhus have changed the course of history. One author stated that the louse has killed more soldiers than all the bullets fired in war. During 1812, in one of the worst disasters in military history, over half of Napoleon's army perished from epidemic typhus during the invasion of Russia. During the first year of World War I, typhus started as an epidemic in the Serbian Army. In 6 months, 150,000 people were dead from the disease, including 50,000 prisoners of war and one-third of Serbian physicians. From the end of the war through 1923, an estimated 30 million cases of epidemic typhus occurred in Russia and Europe with over 300,000 deaths. During World War II, there were severe epidemics of typhus in some endemic areas, including Bucovina, in northeast Romania, and neighboring Moldova. There were also hundreds of thousands of cases in Poland during the war as well as large epidemics in Yugoslavia. From 1941 to 1944, there were over 132,000 cases in urban areas of French North Africa. More than 91,000 cases occurred in Egypt during the same period. Despite this incidence, U.S. Army personnel experienced only 30 cases of typhus with no typhus deaths in the North African-Middle East-Mediterranean zone during the years 1942 to 1945. When Allied forces landed in Italy in 1943, a typhus epidemic in Naples was ravaging the city of 1 million. Death rates reached 80%. An effective delousing campaign, chiefly using DDT dust, was waged. This marked the first time in history that a typhus epidemic did not exhaust itself but instead was terminated by human action. The U.S. Army achieved a remarkable record of low morbidity with no fatalities from epidemic typhus in World War II. This was accomplished by taking effective protective measures against the disease and through the work of the U.S. Typhus Commission, established by the Secretary of War on October 22, 1942. DDT was used extensively during a typhus epidemic in Japan and Korea in the winter of 1945-1946. Over 2 million Koreans and Japanese were treated with DDT dust. Epidemic typhus was not a problem in U.S. military personnel during the Korean War. Body louse infestations in Korean civilian and military personnel, and in prisoners of war, was a major problem for U.S. military entomologists due to resistance of body lice to DDT.

The development of modern antibiotics and insecticides has reduced the threat of this disease to military forces. However, its short incubation period and severe clinical symptoms should be of concern to medical personnel when dealing with large concentrations of refugees or prisoners of war. This pathogen, *R. prowazekii* , has the most serious epidemic potential of all rickettsiae, and the emergence and spread of body lice can be very rapid under favorable conditions. In a refugee camp in Goma, Zaire, all 800,000 refugees became infested within 1 month.

Disease Distribution. Epidemic typhus is most common in temperate regions and at the cooler higher altitudes (>1,600 m elevation) in tropical sites. It is absent from lowland tropics. It usually occurs in mountainous regions where heavy clothing is worn continuously, such as the Himalayas, the highlands of Ethiopia and the northern highlands of Myanmar, Laos and Vietnam. The incidence of epidemic typhus has been steadily declining over the last 25 years. The majority of recent cases have occurred in Africa (mainly Ethiopia), with most other cases occurring in Peru and Ecuador. During 1997, a large outbreak was reported in Burundi in which 100,000 people were infected. A small outbreak was observed in Russia in that same year. During 1998, small outbreaks were recorded in Peru, and an isolated case occurred in Algeria. In the 1980s and 1990s, several outbreaks occurred in Mexico, and there have been several outbreaks in China in the 1930s and 1940s (partly related to World War II). Overcrowding, poverty, and general poor health of large human population groups have usually contributed to these outbreaks. Serological surveys reported in the literature often are difficult to interpret because of extensive cross-reactivity between epidemic and murine typhus. An emphasis on preventive medicine and a general improvement in living conditions nearly always results in a dramatic reduction in incidence of this disease.

Transmission cycle(s). The head louse, *Pediculus humanus capitis*, and the crab louse, *Pthirus pubis*, can transmit *R. prowazekii* experimentally, but epidemics have always been associated with the body louse, *P. h. humanus*. Humans are reservoirs of the pathogen and the only hosts for these lice. Major epidemics have been associated with war, poverty and natural disasters. Persons in cold climates are more likely to acquire epidemic typhus when they live in crowded and unsanitary conditions, and are unable to bathe or change clothes for long periods of time. Lice become infective 5-7 days after a bloodmeal from an infected human. During subsequent bloodmeals, the louse defecates and rickettsiae are excreted in the feces. Louse bites are irritating, and scratching by the host produces minor skin abrasions, which facilitate entry of the pathogen from feces or crushed body lice. *Rickettsia prowazekii* c The pathogen, *R. prowazekii*, can survive desiccation for several weeks. Louse feces are extremely dry and powdery, and infection may also occur by inhaling infective louse feces. The survival of *R. prowazekii* between outbreaks is of interest, since there is no transovarial transmission and lice die from the infection. Individuals who recover from the initial infection and relapse years later with Brill-Zinsser disease are considered the primary long term reservoir. Lice feeding on such patients can become infected and transmit epidemic typhus to other individuals.

A sylvatic cycle of *R. prowazekii* has been recognized in the eastern U.S., where Southern flying squirrels and their ectoparasites (a squirrel flea *Orchopeas howardii*, and a sucking louse, *Neohaematopinus sciuropteri*) are naturally infected. The louse is host specific, but *O. howardii* has an extensive host range, including humans. Sporadic human cases have occurred in houses harboring those flying squirrels. The significance of this finding to the epidemiology of epidemic typhus in other areas is not known.

Vector Ecology Profiles. Human lice spend their entire life cycle (egg, 3 nymphal stages and adult) on their host. Eggs of body lice are attached to clothing at a rate of about 5-8 eggs per female per day. Lice must mate before laying eggs, since females cannot store sperm. At 29-32°C, eggs hatch in 7-10 days. The maximum time eggs can survive unhatched is 3-4 weeks, which is important when considering the survival of lice in infested clothing or bedding. A bloodmeal is required for each of the 3 nymphal molts and for egg production in adults. The nymphal stages are passed in 8-16 days. Louse populations have the potential to double every 7 days. Adults live about 2 weeks and feed daily. Louse infestations cause considerable irritation and scratching, which may lead to skin lesions and secondary infections. Body lice are commonly found in the seams and folds of clothing. Lice tolerate only a narrow temperature range and will abandon a dead host or one with a body temperature of 40°C or above. This contributes to the spread of lice and louse-borne disease. Humidity is also critical because lice are susceptible to rapid dehydration. The optimal humidity for survival is 70-90%. Body lice cannot survive at a relative humidity <40%. They can survive without a host for only a few days and are spread by intimate personal contact or contact with infested clothing or other items.

Vector Surveillance and Suppression. The incidence of head lice has been increasing worldwide. Body louse infestations have declined with higher standards of living, although infestations are still common in some areas of Southeast Asia, especially at remote higher elevations where heavier clothing is worn and bathing is infrequent. The prevalence of body lice reflects the socioeconomic level of the society. The incidence of body lice has increased in some countries due to war or social disruption. Infestations with body lice are increasingly being reported among the homeless and deprived populations in inner cities of developed nations. Military personnel should avoid close personal contact with infested persons and their belongings, especially clothing and bedding.

Surveillance for body lice consists of examining individuals and their clothing for lice or nits (eggs). The population density of body lice may be very high, but usually only a few lice are observed on an individual. Body lice are frequently found around the waistbands of clothing. Heavily bitten areas, such as the base of the thorax, groin and flanks of the body, may become darker. This characteristic skin coloration is often referred to as vagabond's disease. Dry cleaning or laundering clothing or bedding in hot water (55°C for 20 minutes) will kill eggs and lice. Control of epidemics requires mass treatment of individuals and their clothing with effective insecticides. A permethrin-treated uniform is usually extremely effective against lice. Since lice cannot survive away from the human host, application of insecticides to buildings, barracks or other living quarters is not necessary. Mass louse control could be hampered by insecticide resistance. Resistance to common pediculicides, particularly DDT and gamma BHC (lindane), is widespread in much of the world, including Southeast Asia. Pyrethroid lotions and shampoos have been widely used in some areas to control head lice, and reports of pyrethroid resistance are increasing. Compounds such as ivermectin, taken orally to eradicate lice, have been investigated experimentally but are not currently registered for that use.

Production of typhus vaccine in the United States has been discontinued and there are no current plans for further research or development of such a vaccine. Vaccination against typhus is not currently required by any country as a condition of entry. The U.S. military no longer has the equipment to perform mass delousing as it had done in the past. Consult TG 6 for more details about surveillance and control of body lice.

M. Relapsing Fever (louse-borne). Louse-borne (or epidemic) relapsing fever is caused by the spirochete *Borrelia recurrentis*. Symptoms and severity of relapsing fever depend on the immune status of the individual, geographic location, and strain of *Borrelia*. The incubation period in an infected host ranges from 2 to 14 days. The disease is characterized by a primary febrile attack followed by an afebrile interval and 1 or more subsequent attacks of fever and headache. Intervals between attacks range from 5 to 9 days. Mortality is usually low but can reach 40%, untreated. Infection responds well to treatment with antibiotics.

Military Impact and Historical Perspective. Major epidemics of louse-borne relapsing fever occurred during and after World War I in Russia, Central Europe and North Africa. After the war, relapsing fever was disseminated through large areas of Europe, carried by louse-infested soldiers, civilians and prisoners of war. Between 1910 and 1945, there were an estimated 15 million cases and nearly 5 million deaths. Large outbreaks of relapsing fever were common during and after World War II, when epidemics in North Africa produced an estimated 1 million cases and some 50,000 deaths. However, U.S. forces were largely spared. There were only 70 cases reported from the China-Burma-India theater and most of these occurred in China. One death due to louse-borne relapsing fever was reported in U.S. military personnel during the Korean War. During the Vietnam War, outbreaks of louse-borne relapsing fever occurred in the Democratic People's Republic of Vietnam.

Disease Distribution. From 1960 to 1980, louse-borne relapsing fever flourished primarily in the Sudan, Somalia, Ethiopia and Eritrea. Ethiopia reported the highest incidence, estimated at 10,000 cases per year. Relapsing fever is also believed to persist in the Peruvian Andes and the Himalayas. Epidemics usually occur in the cold season, among poor people with inadequate hygiene. There are no recent published reports of louse-borne relapsing fever in Southeast Asia, although sporadic cases may occur.

Transmission Cycle(s). The body louse, *P. h. humanus*, is the vector of *B. recurrentis*. After the louse feeds on infective blood, the spirochetes leave the digestive tract and multiply in the insect's body cavity and other organs. They do not invade the salivary glands or ovaries and are not found in the feces. Bites and fecal deposits cannot transmit the pathogen, and transovarial transmission does not occur. Human infection results when a louse is crushed and *Borrelia* spirochetes are released. The spirochetes may be scratched into the skin or come in contact with mucous membranes, but there is evidence that *B. recurrentis* can penetrate unbroken skin. Since infection is fatal to the louse, a single louse can infect only 1 person. However, the pathogen can survive for some time in a dead louse. Outbreaks of louse-borne relapsing fever require high populations of body lice. Lice leave febrile patients in search of new hosts, and this behavior contributes to the spread of disease during an epidemic. Humans are the only known reservoir, and mechanisms of survival during non-epidemic periods are unknown. The life cycle of the body louse is less than 2 months, and in the absence of transovarial transmission *B. recurrentis* cannot survive in the louse population (see Figure 25).

Vector Ecology Profiles. See this section under epidemic typhus.

Vector Surveillance and Suppression. See epidemic typhus. Also consult TG 6, Delousing Procedures for the Control of Louse-borne Disease During Contingency Operations, for more information on surveillance and control of body lice.

VI. Militarily Important Vector-borne Diseases with Long Incubation Periods (>15 days)

A. Leishmaniasis. This potentially disfiguring and sometimes fatal disease is caused by infection with protozoan parasites of the genus *Leishmania*. Transmission results from bites of infected phlebotomine sand flies. The parasite responsible for The Black Sickness (Kala-azar) or Dum Dum Fever (named for the Indian city of Dum Dum) was described in 1903 by William Leishman on the basis of a case in a British soldier assigned to Dum Dum, India. Also in 1903, Charles Donovan reported the same parasite from a splenic puncture of a British soldier, who had been assigned to troop duty in India and was sick with the Black Sickness. The first identification of an infected sand fly, and the first proven transmission of the parasite by the bite of the sand fly vector, *Phlebotomus argentipes*, were accomplished by military medical personnel in India. All vectors of leishmaniasis in the Old World belong to the sand fly genus *Phlebotomus*. Incubation in humans may take as little as 10 days or more than 6 months.

There are currently four main clinical syndromes caused by *Leishmania* spp., which are usually categorized by their typical symptoms. They include: ulcerative cutaneous lesions (cutaneous leishmaniasis or CL); lesions in the mucosal areas of the mouth and/or nose (mucocutaneous leishmaniasis or MCL); internal pathological manifestations resulting in fever, swollen lymph glands, anemia, enlargement of the liver and spleen, and progressive emaciation and weakness (visceral leishmaniasis or VL); and a macular, maculo-papular, or nodular rash which is a complication of VL after treatment which did not effectively eliminate the parasites in the individual (post-kala-azar dermal leishmaniasis, or PKDL). The lesions of PKDL contain very large numbers of the parasite and are highly infectious for any competent vector which feeds on such a lesion. Those lesions usually appear within 6 months to 3 years after completion of a regimen of treatment for VL.

Cutaneous Leishmaniasis (CL, Baghdad boil, Oriental sore) most commonly caused in the eastern hemisphere by infection with *L. tropica* typically appears as a non-healing ulcer and is often referred to as anthroponotic cutaneous leishmaniasis (ACL). The lesion usually develops within weeks or months of an infected sand fly bite and slowly evolves from a papule to a nodule to an ulcer. Lesions of CL may resolve quickly (2 - 3 months) without treatment or they may become chronic (lasting months to years) and not heal without treatment. Scarring is associated with healing. In CL endemic areas, such scars are common among rural and urban populations.

Life-long immunity to the infecting *Leishmania* species usually results. CL caused by *L. major* is often referred to as zoonotic cutaneous leishmaniasis (ZCL) and typically appears as 1 or more wet-looking non-healing ulcers. The lesion(s) usually develop within weeks after sand fly bites and quickly evolve from papules to open wet sores with raised, reddened edges. Lesions usually heal spontaneously and provide lifetime immunity against that *Leishmania* species.

Kala-azar (VL), almost exclusively caused by either *L. donovani* or *L. infantum*, is a severe form of leishmaniasis, with as much as 95% mortality in untreated cases. It is a chronic disease that, without treatment, is marked by fever (2 daily peaks), weakness and, as the parasites invade internal organs, weight loss coupled with enlargement of spleen and liver that may resemble severe malnutrition. As of November 2007, an estimated 500,000 new cases occur each year world wide, and >50,000 of those people die.

It should be noted that cutaneous lesions may also be seen in human VL cases, but the chronic visceralizing nature of the disease is the main concern. Nearly everywhere it occurs in Asia, VL is mainly a disease of young children and the elderly. The increasing incidence of AIDS has made many people more susceptible to VL and the complications of this and other infectious and vector-borne diseases.

Viscerotropic *L. tropica* has also been reported and was described in veterans of the Persian Gulf War, and several viscerotropic cases of *L. tropica* have been reported from India and Pakistan. The incubation period for VL is usually 4 to 6 months but may be as short as 10 days or as long as 2 years. By the time the disease is diagnosed, patients have usually forgotten any contact with sand flies. Epidemics of VL often follow conditions of severe drought, famine or disruption of native populations by wars that produce large numbers of refugees. In Sudan, between the years 1991 and 1996, there were reports of 10,000 treated cases and an estimated 100,000 deaths from untreated cases of VL due to the shortage of health services.

Military Impact and Historical Perspective. Leishmaniasis is a persistent health threat to U.S. military personnel because troops deploy or conduct military exercises in locations where the disease is endemic. The potential for this disease to compromise mission objectives is significant. Soldiers exposed to sand fly bites while deployed to Southeast Asia are highly susceptible to infection with *Leishmania* spp. Immunity among U.S. military personnel is essentially nonexistent, and recovery from one species of the parasite does not confer immunity to any other species.

Most of the cases of visceral leishmaniasis (34 of 49) during World War II were acquired in India, in or near Calcutta. Accurate information is not available for incidence of CL, since most cases were treated as outpatients. In the Karum River Valley of Iraq, US forces suffered 630 cases of VL in a three-month period during WWII. From 1990 to 91, 12 cases of VL due to *L. tropica* were diagnosed when 697,000 allied soldiers were deployed to the Arabian Peninsula during Operations Desert Shield and Storm. Even though no fatalities were associated with leishmaniasis in this deployment, new lessons were learned that could affect future military deployments.

Before the Persian Gulf War, eastern Saudi Arabia was not known to be endemic for VL, and *L. tropica* had not been convincingly shown to produce VL. More important, the potential for leishmaniasis to cause post-deployment diagnostic problems and threaten blood supplies had not been anticipated. Returnees from the Persian Gulf War were barred from donating blood for up to 2 years, severely impacting blood supplies at the time. Infection with *Leishmania* was even suspected to have been one of the causes of Persian Gulf War syndrome, but no scientific evidence for this association was ever established.

Diagnosis of leishmaniasis is difficult at best, and providing proper care for service members who may have been exposed or infected is a long, costly and complex process. Treatment usually requires at least 20 days and consists of injections with pentavalent antimony (Pentostam). Because this drug is not registered for use in the U.S., it must be administered under an experimental protocol at an approved medical treatment facility. Estimated leishmaniasis-related costs can exceed US $17,000 per patient, with an average of 92 lost duty days per patient. Other important but less quantifiable costs include loss to the unit, personal distress, and delay of career progression.

Disease Distribution. The WHO estimated in 2008 (search on www.who.org), that there are 2 million new cases of CL per year and it is widespread in 88 countries around the world. They estimate that VL is endemic in 62 countries, with 500,000 new cases a year, and the population at risk is at least 120 million. Several species of *Leishmania* and several species of competent vector *Phlebotomus* are endemic and rather widespread in parts of East Asia (*e.g*., China) and large portions of the Indian sub-continent (*e.g*., India, Bangladesh, Pakistan); and both VL, and to a lesser extent CL, are major health threats there. However, both the pathogens (*Leishmania* spp.) and associated competent vector sand flies (*Phlebotomus* spp.) are relatively limited in numbers and distribution in most of Southeast Asia.

At least one fairly common and regionally wide spread sand fly species in Southeast Asia, *P. argentipes*, is known to be a competent vector of *L. donovani* in parts of its geographic distribution. However, it is usually more zoophilic than anthropophilic (*i.e.*, it usually feeds on animals other than humans). Both VL and CL have seldom been reported in Southeast Asia, but two autochthonous (locally acquired) cases of VL caused by *L. donovani* were recently reported from Thailand. Anthroponotic (human-to-human) transmission of CL due to *L. tropica* could possibly occur in urban centers, around ports or airports, or wherever both a suitable pathogen (like *L. tropica*) and an effective vector (like *P. sergenti*) have been introduced and have become established at least temporarily. Zoonotic (rodent to human) CL transmission due to *L. major*, or similar species, may occur in this region. Potentially suitable wild rodent hosts and potential sand fly vector species are present but it has not been documented nor very well studied, so far.

Strains of *L. donovani* resistant to the standard therapeutic agents sodium stibogluconate and pentamidine have been reported in India. Newer anti-leishmanial drugs include amphotericin B, Liposomal amphotericin B, and miltefosine (developed originally as an anti-cancer drug). Both of the amphotericin B regimens are very costly (up to U.S. $ 2,800 per complete treatment), slow (drawn out, about 1 month long) and have significant potentially life-threatening side effects. The WHO announced a May 2007 price reduction of the second regimen to about US$ 200 per complete treatment in endemic countries.

Miltefosine is still considered experimental, although registered in India since 2002, and is considered teratogenic. However, it seems to combine lower cost (US$ 125-200 per treatment course), usually many fewer and less serious side effects, and a shorter treatment regimen; but it requires directly observed treatments and has a short shelf life. Other newer, still considered experimental, anti-leishmanial drugs include paramomycin (aminosidine) and sitamaquine. There has been little or no progress in attempts to develop an effective vaccine against any species of *Leishmania*, so far.

Transmission Cycles. Despite its relative rarity in Southeast Asia, a description of the typical natural cycles of Leishmaniasis could be helpful for understanding and reducing related disease risks and incidence [see Fig. 29 (a, or b ?)]. In urban areas humans might serve as reservoirs of *L. tropica*, and in rural areas, non-human hosts of *L. tropica* may include wild and domestic rodents living in close proximity to humans. Sand fly vectors inhabit the burrows of domestic and wild rodents, moles, hedgehogs and jerboas, and acquire infections while feeding on these reservoir hosts. Amastigotes (the mammalian form of *Leishmania* parasites) ingested with the bloodmeal transform to flagellated promastigotes within the gut of the female fly.

In addition to a bloodmeal, the female consumes sugar in the nectar of nearby plants. These sugars provide needed energy for the flies and help maintain any *Leishmania* in them. Promastigotes multiply within the bloodmeal in the gut of the sand fly and undergo development to infective metacyclic promastigotes. By the time the bloodmeal is digested and the fly is ready to lay its eggs, infective metacyclic promastigotes are ready to be transmitted to the next vertebrate host when the sand fly feeds again.

In human hosts, infective-stage promastigotes (metacyclics) are engulfed by white blood cells or macrophages, in which they transform to amastigotes. Amastigotes proliferate in the macrophage until it ruptures and new macrophages are invaded. At the skin surface, the tiny bite site becomes a small red papule that enlarges and ulcerates, with a raised edge of red inflamed skin, within which macrophages continue to engulf parasites, resulting in additional parasite multiplication. The ulcerated sores may become painful, last for months and, in uncomplicated CL caused by *L. tropica*, eventually heal to form characteristic scars seen on large numbers of people in some endemic areas.

Likely vectors of *L. tropica* in Southeast Asia have not been clearly determined yet. However, *P. sergenti* is a major vector in other parts of its known distribution. This form of CL (sometimes called “dry” sore) is most common in densely populated urban centers and is considered to have a humans-fly-human transmission cycle (called anthroponotic cutaneous leishmaniasis, or ACL), with no recognized sylvatic reservoir.

Vector Ecology Profiles. The only proven vector of *L. donovani* (VL) found in Southeast Asia, so far, is *P. argentipes*. No competent vector of *L. tropica* or any other causal agent of CL, has yet been reported to be established in Southeast Asia, but *P. sergenti* has been implicated as a probable CL vector in urban margins and some rural settings in other nearby countries. Most reported cases of CL in this region have been imported cases, so far. Species of Phlebotomine sand flies reported from Southeast Asia are listed in Table 5.

In general, adult Phlebotomine sand flies rest during the day in dark, humid, protected areas, such as rodent burrows, rock crevices or caves. The preparation of military bunkered ground positions in desert areas provides additional protected daytime resting sites for sand flies. In urban areas, sand fly adults often rest in dark, cool, humid areas of human habitations and animal structures. Abandoned structures and their vegetative overgrowth often become attractive wild or domestic rodent habitats and foci of rural CL. Nectar is important as a sugar source for both male and female sand flies, and sugars are required for development of parasite infections.

After a bloodmeal, eggs are deposited in dark, humid, cryptic areas. They develop into minute caterpillar-like larvae that feed on mold spores and organic debris. The larvae go through 4 instars and then pupate near larval feeding sites. Development from egg to adult typically requires 30 - 45 days, depending on feeding conditions and environmental temperatures. Phlebotomine sand fly eggs, larvae and pupae have seldom been found in nature, despite exhaustive studies and searches. The adult female has been observed to lay her eggs at several separate sites rather than in a single site. The larvae are widely distributed in the environment but are probably below the ground surface in rodent burrows, caves, termite mounds, or cracks and crevices in the soil where temperature, humidity and mold growth provide ideal conditions for larval development.

The dusk-to-dawn movement of adults is characterized by short, hopping flights just above the ground surface which avoids wind. Adult sand flies generally do not travel great distances, and most flights are believed to be <100 m. Sand fly habitats in the region range in altitude from sea level to 3,500 m in the mountains. In temperate climates, adult sand flies are most abundant and active in the warmer months of April-October, especially after rains. However, *P. sergenti* is tolerant of cold winters and is found in the very mountainous (up to 3,500 m) in northern India, Pakistan, Afghanistan and Nepal, and they readily bite humans in cool conditions.

Female sand flies are quiet “stealth biters,” and their bites may go unnoticed by military personnel. Sand flies may also bite during the daytime if disturbed in their secluded resting sites. Areas with some vegetation and cliffs, rock outcroppings, or other geologic formations that allow for suitable hiding places and daytime resting sites are important habitats. Exact information on reservoirs and vectors will require more extensive study in many countries of the region. Most areas of these countries remain unsurveyed for sand fly vectors and disease. When searches have been made, sand fly vectors have often been found in areas from which they had not been previously reported.

Vector Surveillance and Suppression. Because sand flies are small and retiring, specialized methods are needed to collect them. The simplest method is active searching of daytime resting sites with an aspirator and flashlight, but this can be very labor intensive. Human-landing collections are an important method to determine which species are anthropophilic. Sticky traps (paper coated with a sticky substance or impregnated with an oil, such as castor oil, mineral oil or olive oil) are used to randomly capture sand flies moving to or from resting places. Traps can also be placed at the entrances of animal burrows, caves or crevices, in building debris, and in local vegetation where sand flies are likely to rest during the daytime.

Various light traps have been used to collect phlebotomines, but their effectiveness varies with the species of interest and the habitat. Light traps are inefficient in open desert. Light traps used to collect mosquito should be modified with fine mesh netting to collect sand flies. Traps using animals as bait have also been used. Collection of larvae is extremely labor intensive and usually unsuccessful because specific breeding sites are unknown or hard to find and because females usually deposit eggs singly over a wide area. Emergence traps are useful for locating breeding sites. Identification (ID) of sand flies requires a microscope, a good key, and some training; but with a little experience, sorting and field ID to major group (*i.e.*, sand flies) by color and size can be done rather well using minimal magnification (*e.g.*, a 15 – 20X hand lens). For accurate species ID, a lab microscope with 100x magnification is needed.

Because of their flight and resting behavior, Phlebotomine sand flies that feed indoors are very susceptible to control by residual insecticides. When sand flies are exophilic or bite away from human habitations, control with insecticides is impractical, although the application of residual insecticides to a radius of 100 m around encampment sites may be helpful. Some success in reducing vector populations has been achieved by controlling their rodent host populations. Selection of encampment sites without vegetation or rock outcroppings that can harbor rodents is important. Cleanup and removal of garbage and debris that support rodent infestation are necessary for longer periods of occupation. Pets must be strictly prohibited, because any small desert rodent and/or local dog may be infected with Leishmanias or other pathogens.

Sand flies are able to penetrate standard mesh screen used on houses and standard mesh bednets (7 x 7 threads / cm). These items should be treated with permethrin to prevent entry. Fine mesh (14 x 14 threads / cm) bednets can be used to exclude sand flies, but these are uncomfortable in hot, humid conditions because they restrict air circulation. The use of repellents on exposed skin and clothing is the most effective means of individual protection. Insect repellent should be applied to exposed skin and to skin at least 2 inches under the edges of the uniform (or other cloth garment) to prevent sand flies from crawling under the fabric to bite. Using personal protective measures (see TG 36) is the best way to reduce or prevent sand fly-borne disease.

Figure 29-a. Leischmaniasis Disease Cycle.

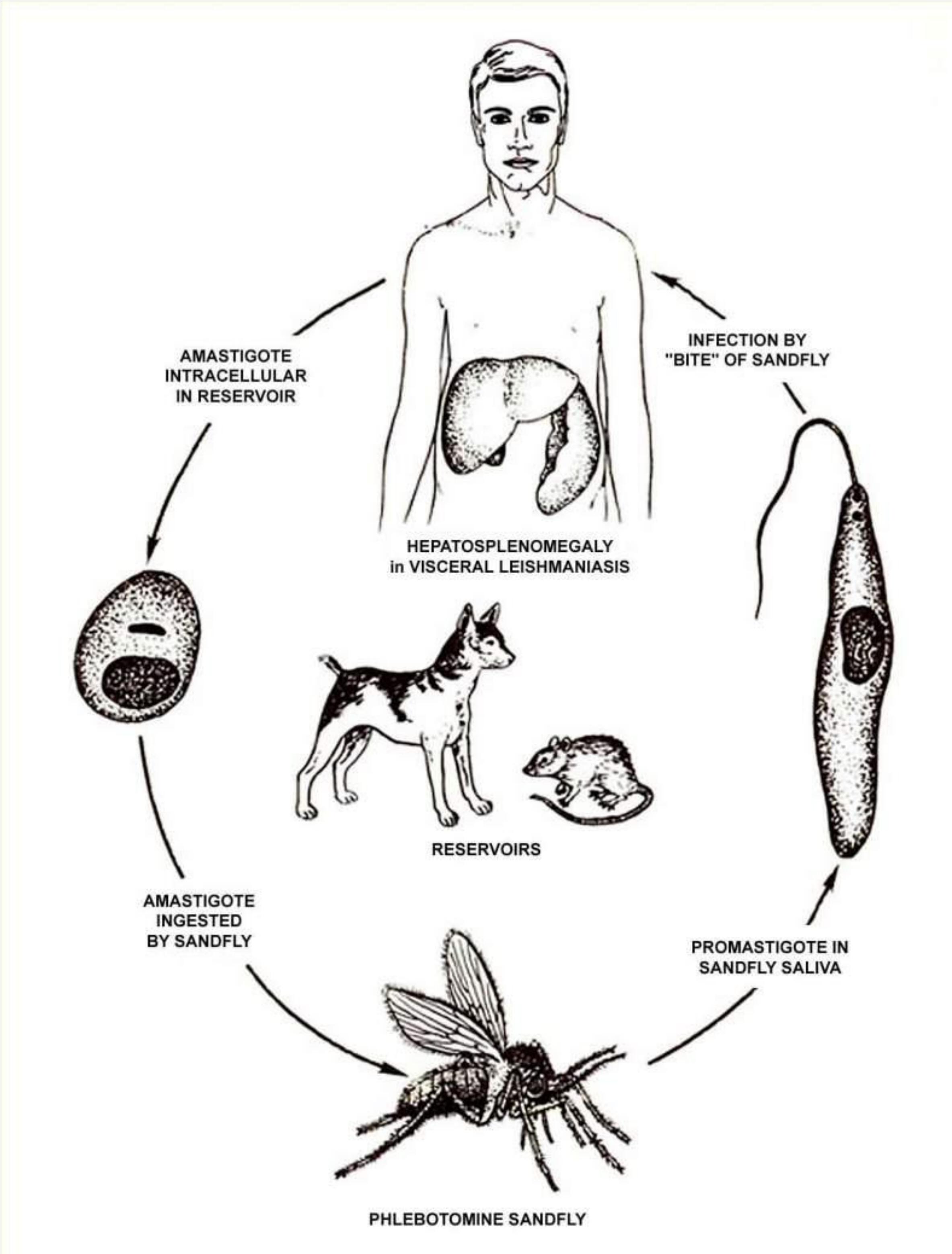
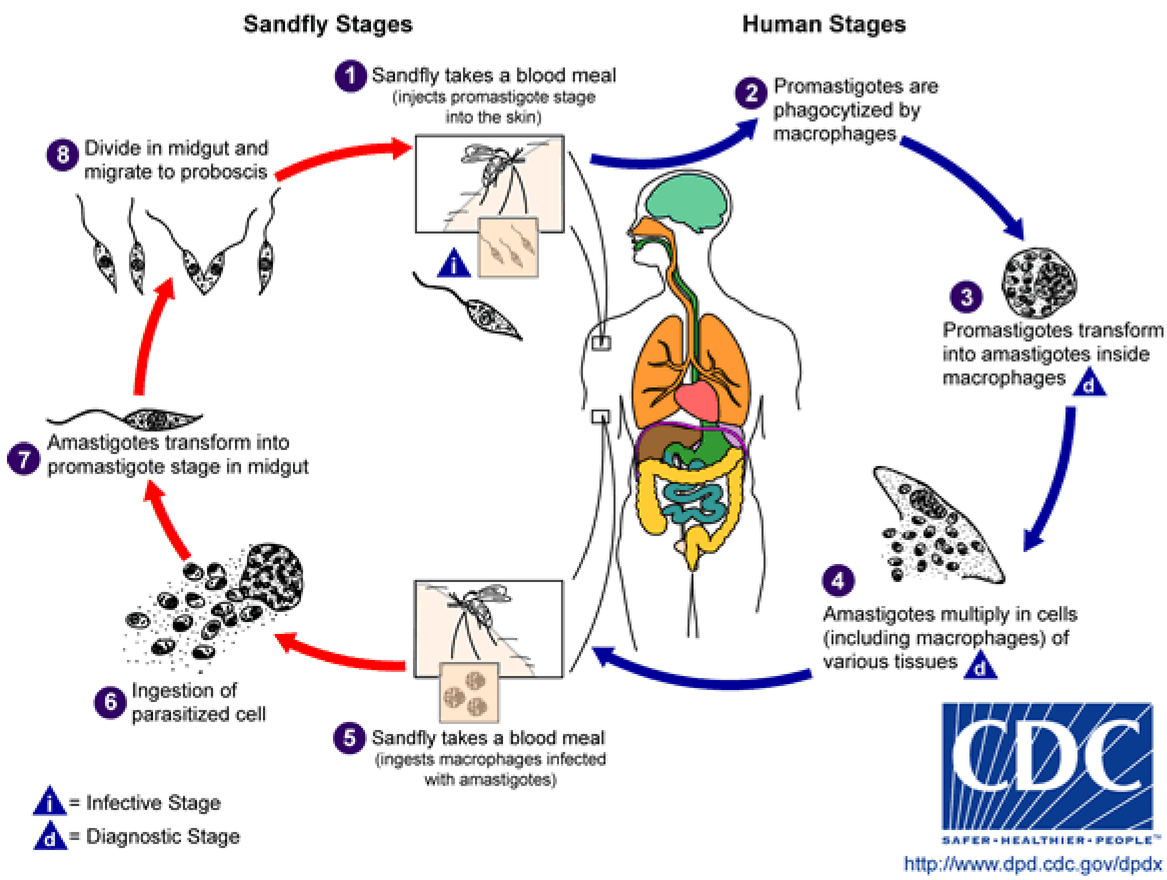


Figure 29-b. Leischmaniasis Disease Cycle (CDC).



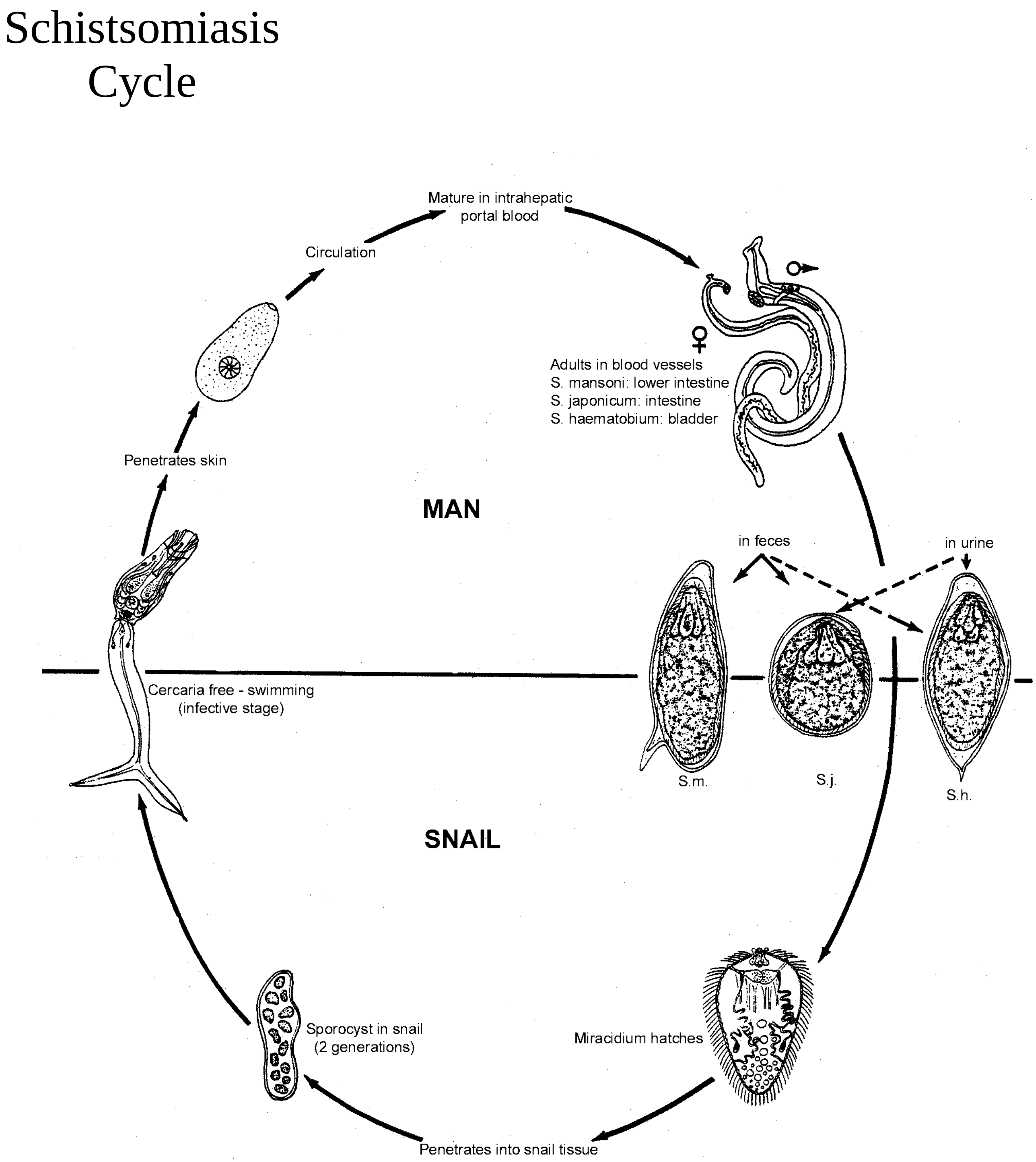
B. Schistosomiasis.

This disease, also known as Bilharziasis or snail fever, is caused by trematodes in the genus *Schistosoma* (blood flukes) that live in the veins of humans and other vertebrates. Eggs from adult worms produce minute granulomata and scars in the organs where they lodge. Symptoms are related to the number and location of the eggs. There are 19 currently recognized species of schistosomes infecting mammals world wide, but the WHO considers that only 5 of them cause significant human disease. *Schistosoma mansoni*, *S. japonicum*, *S. mekongi* and *S. intercalatum* give rise to primarily hepatic and intestinal symptoms. Infection with *S. haematobium* usually produces urinary symptoms. The most severe pathological effects are the complications that result from chronic infection. Symptoms of acute disease appear 2 to 8 weeks after initial infection, depending on the parasite species, and can be intense, especially in nonimmune hosts. Clinical manifestations may include fever, headache, diarrhea, nausea and vomiting. Blood is usually present in the urine of well-established *S. haematobium* cases. The acute stage of schistosomiasis is usually more severe in the Asian forms *S. japonicum* and *S. mekongi* than in *S. mansoni*, *S. intercalatum*, or *S. haematobium*.

Military Impact and Historical Perspective. The first documented cases of schistosomiasis in U.S. military personnel occurred in 1913 in sailors assigned to the Yangtze Patrol in China. Significant portions of the crews on some patrol boats were incapacitated. During World War I, American forces were not deployed in areas endemic for schistosomiasis. However, infection was prevalent among Allied Forces in Mesopotamia and parts of Africa. During World War II, the U.S. Army hospitalized 2,088 patients with schistosomiasis. More importantly, an average of 159 days were lost per admission, almost half a year per case. Over 1,500 cases of acute infection due to *S. japonicum* were reported in U.S. troops during the reinvasion of Leyte in the Philippines. Allied and Axis troops deployed in the North African and Middle East campaigns experienced high rates of infection. During the early 1950s, troops of the People's Republic of China were training along the Yangtze River for an amphibious landing on Taiwan. However, the invasion had to be cancelled when 30,000 to 50,000 cases of acute schistosomiasis, 10 to 15% of the invasion force, occurred. By the time the Chinese army recovered, the U.S. had established the Taiwan Defense Command and had begun routine patrols of the Taiwan Strait. Schistosomiasis was rare among U.S. military personnel during the Vietnam War.

Disease Distribution. Worldwide, about 200 million people are infected with schistosomiasis, 120 million of them show symptoms, and 20 million of these have severe disease. Cycles of natural transmission absolutely depend on the presence of one or more species of suitable snail intermediate hosts. Schistosome species which are mainly zoonotic, also depend on an established population of one or more species of suitable vertebrate reservoir hosts. The widest spread human-pathogenic schistosome in Southeast Asia, *S. japonicum*, is established in Cambodia, Indonesia, Laos, Malaysia, the Philippines, and Thailand. The Mekong River's main channels in northern Cambodia, Laos, and northeastern Thailand constitute the vast majority of the known distribution of *S. mekongi*. Primarily a wild rodent parasite, *S. malayensis* is limited mainly to southern peninsular Malaysia. There are at least 3 species of schistosomes circulating mainly among domestic and wild animal reservoirs in Southeast Asia. Although these seldom cause disease in humans, exposure to their cercariae can produce a temporary, and sometimes severe, dermatitis with an itching rash that usually occurs within hours after exposure. That so called "rice field dermatitis" is an occupational health problem in much of this region.

Figure 30. Schistosomaisis Disease Cycle(s).



Transmission Cycle(s). The life cycles of the various schistosomes infecting man are similar. A generalized life cycle appears in Figure 30. Humans are infected when they are exposed to cercariae in infested fresh water. A single infected snail intermediate host may release 500 to 2,000 cercariae daily. Cercariae are infective for about 12 hours after being released from the snail. After cercariae penetrate the skin and enter the blood or lymph vessels, they are carried to blood vessels of the lungs before migrating to the liver, where they develop into mature adult male and female worms. They mate in the liver and migrate as pairs to veins of the abdominal cavity, usually the superior mesenteric veins in the case of intestinal forms (*S. mansoni*, *S. mekongi*, *S. intercalatum* and *S. japonicum*) or the venous plexus of the urinary bladder in the case of *S. haematobium*.

Four to 6 weeks after initial penetration of the skin, adult females begin laying eggs. Female worms can deposit from 300 to 2,500 eggs per day. Adult worms live 3 to 7 years, but life spans of 30 years have been reported. Only about 50% of the eggs produced reach the bladder or intestine, where they are excreted in the urine and feces. The rest become lodged in the liver and other organs. The immunological reaction to the eggs is the primary cause of both acute and chronic clinical symptoms. The degree of chronic disease is directly related to the number of eggs deposited in the tissues.

After excretion in urine or feces, a schistosome egg hatches in fresh water, releasing a single miracidium that infects an appropriate species of snail. The miracidium can survive as an infective free-living entity for less than a day. Miracidia undergo a complicated, asexual cycle of development and multiplication in the snail, but after 30 to 60 days each successful miracidium gives rise to several hundred infective cercariae. Humans are the principal hosts for both *S. mansoni* and *S. haematobium*, but natural infections of *S. mansoni* have been found in rodents and other mammals in Egypt.

Vector Ecology Profiles.

General Bionomics. The most important schistosome intermediate host snails (sometimes called vector) are focally distributed in rural and urban areas, usually associated with slow-moving streams, irrigation canals, oases, cisterns, and aqueducts. New or expanded irrigation and long-term urban development projects in several countries in Southeast Asia have increased the habitats for such snails which support human-pathogenic schistosome species. Concrete-lined, covered canals are usually poor habitats, but the soil-lined canals that are much more common in all but strictly urban areas throughout Southeast Asia allow lots of emergent and marshy vegetation to grow and provide excellent snail habitats.

Tidal areas are not suitable snail habitats. Snails can survive dry seasons by burrowing into riverbeds, soil banks, or under moist stones. Snails may be transported by man and sometimes by birds. Self-fertilization is common among these hermaphroditic snail species, and can enhances their dispersal, since only a single founder is needed to establish a new population. The movement of military equipment from a snail-infested area can export snails of significant medical and economic importance to other regions (see TG 31).

Specific Bionomics. The main snail hosts of *S. japonicum* are *Oncomelania* spp., which are amphibious and can live in a fairly dry environment for several months at a time and can maintain the larval parasites very well between rainy periods. Suitable hosts for *S. japonicum* include at least 30 different species besides humans, in 7 mammalian orders, including nearly all domestic species in this region which are known to develop patent infections and then shed eggs into surface waters. The main snail hosts of *S. mekongi* are *Tricula* spp. or *Lithoglyphopsys* spp., which are mainly limited to the larger, fairly slow-moving tributaries of the upper drainage tree of the Mekong river. The main reported snail hosts of *S. malayensis*, which mainly infect wild rodents on lower peninsular Malaysia, are *Robertsiella* spp.

Vector Surveillance and Suppression. The most important preventive measure in reducing the incidence of schistosomiasis is to avoid fresh water containing infective cercariae. Assume that all fresh water in endemic areas is infested unless proven otherwise. The absence of snails in an area does not preclude infection, since viable cercariae can be transported considerable distances in water. Combat commanders and troops must be instructed in the risk of infection and measures to prevent schistosomiasis.

No topical repellent is currently available that provides long-term protection against cercarial penetration. Experimental studies have shown the insect repellent *N*,*N*-diethyl-m-toluamide (long known as DEET; its chemical name was recently changed to N,N-diethyl-3- methyl-benzamide) to provide a significant level of protection. However, the beneficial effects of DEET last only a few minutes because of its rapid absorption through the skin or loss from the skin surface by washing. New repellents containing picaridin [2-(2-hydroxyethyl)-1-piperidinecarboxylic acid 1-methylpropyl ester], and IR3535 (3-[N-Butyl-N-acetyl]-aminopropionic acid, ethyl ester), have each been proven effective against mosquitoes and certain other blood-feeding insects, but they have not yet been tested against schistosomal cercariae.

When DEET is experimentally incorporated into liposomes (called LipoDEET), its activity is prolonged for >48 hrs after a single application. Commercial formulations that can protect against cercarial penetration may soon be made available. Cercariae penetrate the skin rapidly, so efforts to remove them after exposure by applying alcohol or other disinfectants to the skin have limited value. Standard issue field uniforms offer substantial protection against penetration, especially when trousers are tucked into boots. Rubber boots and gloves can provide additional protection for personnel whose duties require prolonged contact with water containing cercariae.

Cercarial emergence from snails is periodic, and the numbers found in natural waters vary with the time of day. Light stimulates cercarial release for *S. mansoni* and *S. haematobium*. Minimal numbers of cercariae are present early in the morning and at night. Restricting water contact during peak cercarial density may reduce risk of infection. Avoid water contact in mid- to late morning except where *S. japonicum* is endemic and in the Caribbean where *S. mansoni* is endemic. In those areas, noctural rodents are the primary hosts and their peak activity is in the late afternoon and early evening.

Stepping on and crushing an infected snail will release thousands of cercariae. Cercariae are killed by exposure for 30 minutes to concentrations of 1 ppm of chlorine (typically hypochlorite). Treating water with iodine tablets is also effective. Heating water to 50^{o} C for 5 minutes or allowing it to stand for 72 hours will render it free of infective cercariae. Water purification filters and reverse osmosis units are effective in removing cercariae.

Molluscicides may be applied area-wide or focally by preventive medicine teams to eliminate snails from aquatic areas likely to be used by military personnel. Consult TG-23, A Concise Guide for the Detection, Prevention and Control of Schistosomiasis in the Uniformed Services, and TG-24, Contingency Pest Management Guide, for suggested prevention actions, potentially effective molluscicides, and related application techniques. There is little evidence that snail intermediate hosts have developed resistance to commonly used molluscicides like niclosamide. In field research clinical trials in Brazil in the 1990s, this chemical showed considerable promise as a topical liquid formulation to kill cercariae of *S. mansoni* before they could penetrate human skin, and this effect lasted for >48 hrs.

C. Filariasis.

Bancroftian filariasis is caused by the nematode *Wuchereria bancrofti*, which normally resides in the lymphatic systems of infected humans. Eight to 12 months after infection, adult female worms release thousands of microfilariae (prelarval filarial worms) into the circulatory system. Acute reaction to infection includes swelling of lymph nodes, fever and headache, and allergic reaction to metabolic products of filariae. However, many individuals are asymptomatic in the early stages of infection.

Female nematodes continue to produce microfilariae over the next 15 to 18 years. Chronic filariasis develops slowly, with recurrent episodes of fever and lymph gland inflammation. Microfilariae can obstruct the lymphatic system, causing the legs, breasts or scrotum to swell to grotesque proportions, a chronic condition known as elephantiasis. This occurs only after repeated infections.

Nearly half of all infected humans are clinically asymptomatic, but they have microfilariae circulating in their blood and usually have hidden damage to their lymphatic and/or renal systems. The death of numerous microfilariae resulting from drug therapy may cause severe immune reactions. Brugian filariasis is caused by the nematodes *Brugia malayi* and *B. timori*. Clinical details are similar to those of Bancroftian filariasis, except that the recurrent acute attacks of filarial fever and lymph gland inflammation are more severe, and elephantiasis is usually confined to the legs below the knees.

Military Impact and Historical Perspective. Microfilariae of *W. bancrofti* were first discovered a patient's blood in Brazil in 1866. This was the first discovery of a pathogen transmitted by insects. Over 70 million people worldwide are estimated to be infected with *W. bancrofti*, resulting in serious economic cost to developing countries. The long incubation period and requirement for repeated infections before chronic clinical symptoms appear render Bancroftian filariasis of little medical significance to military operations. However, military personnel moving into an endemic area from one that is free from filariasis may develop acute symptoms such as swelling of the lymph glands, headache and fever months before larvae become mature.

From 1942 to 1944, American military forces in the Samoan-Ellice-Wallis Islands rapidly developed swollen lymph glands and swollen extremities following repeated exposure to infected mosquitoes. Acute filariasis is the primary military concern, because its symptoms develop fairly rapidly and may be severe enough to cause removal of troops from their duties. Clinical manifestations of filariasis often occur with no demonstrable circulating microfilariae (occult filariasis). Of several thousand cases involving American military personnel during World War II, microfilariae were found in only 10 to 15 patients. In addition, the sight of people with grotesque deformities caused by chronic infection can have an adverse psychological impact. Medical personnel should be aware that troops with brief exposure to infection are often not diagnosed until after they return from deployments.

Disease Distribution. *Wuchereria bancrofti* occurs in most tropical and some subtropical regions, including Latin America, Africa, Asia and the Pacific islands (Figure 31). Mass migrations of infected humans are usually required to introduce the disease to new areas. The nocturnally periodic form of *B. malayi* occurs in rural populations living in open rice growing areas or near open swampy areas in Asia, from India to Japan.

The subperiodic form of *B. malayi* is associated with swampy forests of Malaysia, Indonesia and the Philippines. Infections with *B. timori* occur on Timor and other southeastern islands of Indonesia. In 2006 the WHO estimated that >1.25 billion people are at risk of acquiring filarial infection, >600 million of them are in Southeast Asia. Worldwide, >125 million people in at least 83 countries are currently infected with some form of filariasis, and >42 million of these are seriously incapacitated and disfigured by the disease. Ninety percent of infections worldwide are caused by *W. bancrofti*, and most of the remainder by *B. malayi*. Primary endemic areas of filariasis appear in Figure 31.

Lymphatic filariasis (LF) caused by *W. bancrofti* is endemic throughout most of Southeast Asia, but incidence varies from country to country. Brunei Darussalam has a few cases annually, but there appears to be no need for any Mass Drug Administration (MDA) program there.

Thailand has greatly reduced its LF burden through five rounds (so far) of an aggressive MDA using diethylcarbamazine citrate (DEC) plus albendazole (or ivermectin plus albendazole) usually via DEC-fortified salt as recommended by the WHO. Indonesia, Myanmar, and Timor-Leste have shown progress with their MDA program results, but each still has significant numbers of cases and LF morbidity. Cambosia, Malaysia, the Philippines, and Vietnam are currently implementing MDA programs.

Figure 31. Distribution of Lymphatic Filariasis in WHO's Southeast Asia Region.

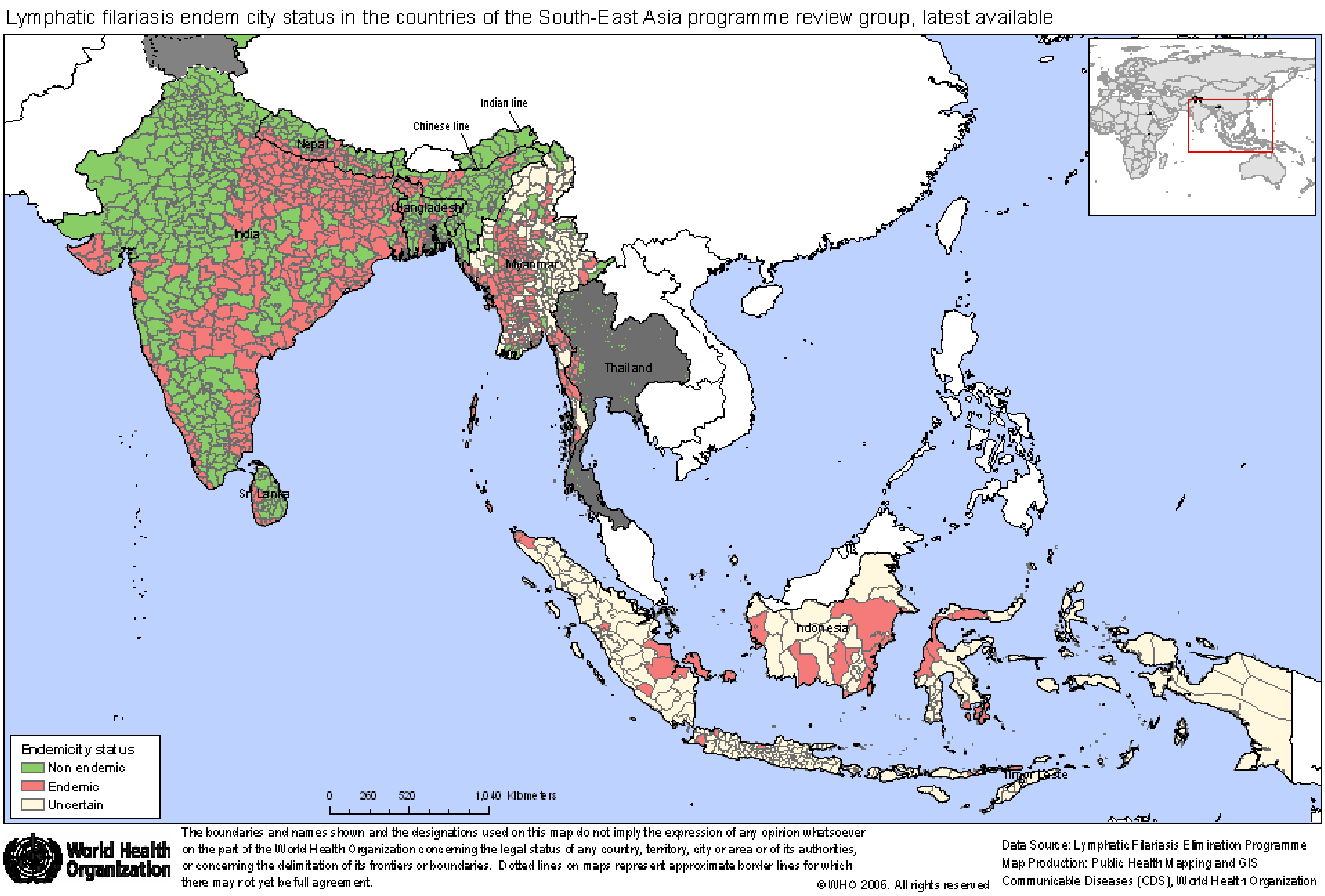
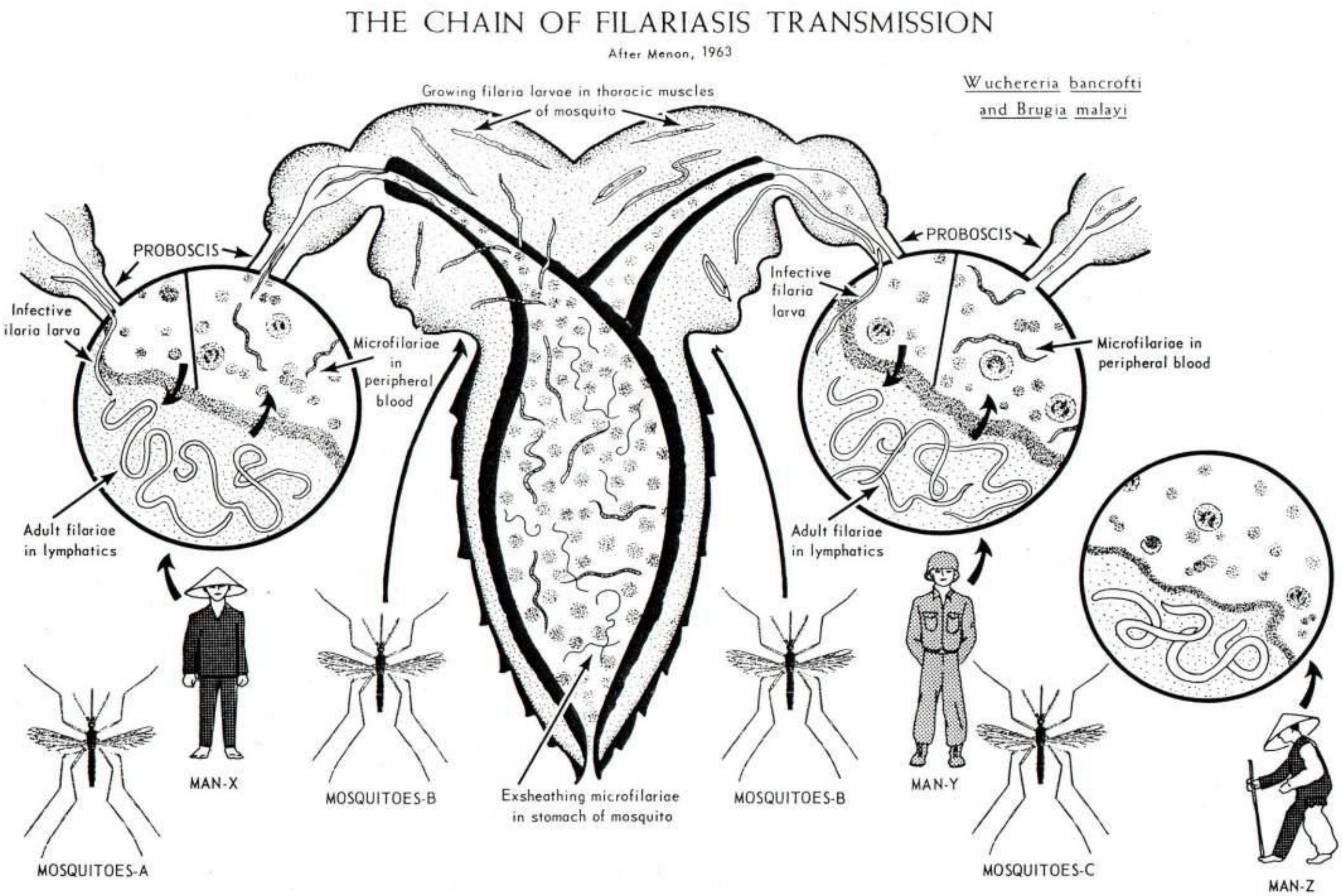


Figure 32-a. Cycles of Filariasis caused by *Wuchereria bancrofti* and *Brugia malayi*.



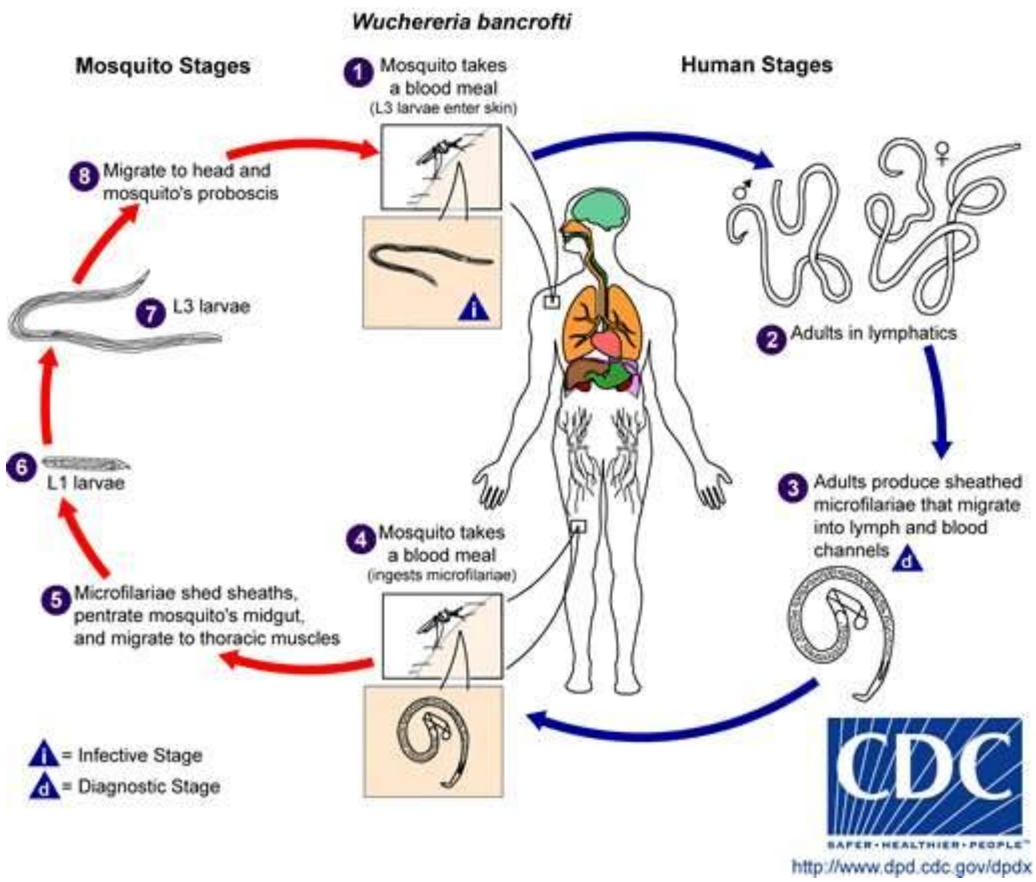
Explanatory notes: –

Infective vector mosquitoes (A) repeatedly inoculate Man "X" who becomes a symptomless microfilaria carrier in about a year or more; he infects numerous vector mosquitoes (B) which in turn inoculate Man "Y" who also becomes a microfilaria carrier and passes on the infection to still more vector mosquitoes (C).

A symptomless carrier (Man "X" or "Y"), continually exposed to further bites of infected vectors, may later develop filarial disease (Man "Z") with the onset of disease, his peripheral blood usually becomes free from microfilariae so that he is no longer a carrier.

Prepared by Harald George Scott, Ph.D., and Margery Borom

Figure 32-b. Cycles of Filariasis caused by *Wuchereria bancrofti*.



Transmission Cycle(s). Microfilariae circulating in human blood are ingested by mosquitoes and undergo several days of development before the vector can transmit infective stages of the nematode. Infective larval parasites enter the bloodstream directly during a mosquito bite. A few nematode larvae may also be deposited on the skin and may enter the host through skin abrasions. In humans, larvae develop to adults that produce microfilariae for many years.

Over most of the geographic range of this disease, including Southeast Asia, *W. bancrofti* microfilariae exhibit pronounced nocturnal periodicity and consequently are ingested by night-biting mosquitoes (Figure 32a and 32b). Peak abundance of microfilariae in the blood occurs between 2300 and 0300 hours. *Culex quinquefasciatus* is the most common urban vector. In rural areas, transmission is mainly by *Anopheles* spp. and *Culex* spp. There are no known animal reservoirs of *W. bancrofti* and no significant animal reservoirs for nocturnally periodic forms of *B. malayi* or *B. timori*.

The subperiodic form of *B. malayi* infects humans, monkeys, wild and domestic cats, and pangolins (scaly anteaters). The zoonotic and epidemic life cycles of subperiodic *B. malayi* usually do not overlap. In Brugian filariasis, *Mansonia* spp. serve as the major vectors, but in some areas anopheline mosquitoes are responsible for transmitting the infection.

Vector Ecology Profiles. Vectors of filariasis are widespread in the region and include *Culex quinquefasciatus*, *Mansonia annulifera*, *Ma. indiana*, and *Ma. uniformis*. *Culex quinquefasciatus* is the primary vector of *W. bancrofti*, while *Ma. annulifera* is a secondary vector. Several *Mansonia* species, including *Ma. annulifera*, *Ma. indiana*, and *Ma. uniformis* are good vectors of periodic *Brugia* parasites because their peak biting activity nearly coincides with the nocturnal abundance of microfilariae in human blood. *Brugia timori* is mainly transmitted by *Mansonia* spp., but also by *An. barbirostris* and *An. stephensi*. The bionomics of *An. barbirostris* and of *An. stephensi* are discussed in the (earlier) section on malaria.

Culex quinquefasciatus is the primary vector of *W. bancrofti* because it is highly anthropophilic, and it feeds actively from 2200 to 0300 hours, which coincides with the nocturnal periodicity of the microfilariae in human blood. This species is widespread and abundant throughout the region. Adults feed mainly on birds but also readily feed on humans or large animals like cattle or goats. They often feed early in the evening, within 2 hours of sunset, but feeding may continue throughout the night. Adults are strong fliers and will travel 3 to 5 km from breeding sites to find a blood meal.

This species is an annoying biter and produces a high-pitched buzzing sound that can easily be heard. They feed and rest indoors or outdoors. Before and after feeding indoors, they rest behind or under furniture and draperies, or in closets. Adults are more endophilic in the late fall, from November through December. Three or four days after a bloodmeal, a *Cx. quinquefasciatus* female deposits rafts of 75-200 eggs each on a water surface. Common oviposition sites include cisterns, water troughs, irrigation spillovers, wastewater lagoons, and swamps.

Eggs hatch 2 to 4 days after deposition. Larvae of *Cx. quinquefasciatus* generally prefer ground pools with high concentrations of organic matter or swamps with emergent vegetation and polluted water from septic systems is ideal. Slums with poor sanitation and urban construction sites provide many breeding sites for this species. Larval development takes 7-9 days at 25 to 30°C. At lower temperatures, larval stages may require 15-20 days.

The pupal stage lasts about 2 days. Adults of C*x. quinquefasciatus* occur from May to October in most of Southeast Asia, although they may be found practically year-round in southern parts of the region or where sewage effluent keeps breeding sites warm. Adults usually have two yearly population peaks, from April to May and again from October to December.

Mansonia annulifera is a highly anthropophilic species and is widespread in Southeast Asia. This species is most abundant in the monsoon months of August to October, with a population peak in September. It is a strong flier (>5 km) that feeds primarily indoors. It is a persistent biter and frequently occurs in large numbers. It feeds on man in strong preference to cattle or other animals. Its feeding activity increases steadily as the night progresses, displaying 2 peaks, one at 2400 to 0100 hours, and the other at 0400 to 0500 hours.

Eggs are laid in sticky compact masses, often arranged as a rosette, and are glued to the undersurfaces of floating vegetation. Typical habitats include more or less permanent bodies of water with floating or submerged vegetation, primarily grasses, such as swamps, ponds, and fallow or active rice fields. *Mansonia* larvae are easily recognized: they have specialized pointed air siphons adapted for piercing aquatic plants to get air. Pupae also get oxygen from plant tissues by inserting their pointed, modified respiratory trumpets into plant stems.

Mansonia uniformis is not as common or as anthropophilic as *Ma. annulifera*. It is a persistent biter but is more zoophilic (feeding on cattle) than *Ma. annulifera*. Its peak biting activity is within the first hour after dusk, falling off steadily after that, with virtually no biting after 0300 hours. It is a strong flier, which can fly 5 km or more, and is primarily exophagic and exophilic.

Mansonia indiana is a relatively common species throughout the region, but is found mostly in lowlands. Its period of greatest abundance is usually from August to October with a peak in September. This species tends to feed and rest indoors and outdoors in nearly equal numbers. It feeds on man and animals but prefers cattle to humans. *Mansonia indiana* has 2 peak biting periods during the night, one between 2000 to 2100 hours, and a second, smaller peak between 0300 and 0400 hours. Larvae of *Ma. uniformis* and *Ma. indiana* are found in the same habitats as *Ma. annulifera*.

Vector Surveillance and Suppression. Light traps are used to collect night-biting mosquitoes, but not all mosquito species are attracted to light. The addition of the attractant carbon dioxide, or octenol, or a focal heat source, or any combinations of these, to light traps increases the number of species collected. Traps using animals, or even humans, as bait are useful for determining feeding preferences of mosquitoes collected (use of humans as bait must be conducted under approved human-use protocols). Adults can be collected from indoor and outdoor resting sites using a mechanical aspirator and flashlight. Systematic larval sampling with a long-handled white dipper provides information on species composition and population dynamics, which is used when planning control measures.

Mosquitoes can be individually dissected and examined for filarial infection. Large numbers of mosquitoes can be processed more quickly by crushing them in a saline solution and removing filarial worms with a sieve. The parasites can then be concentrated by centrifugation. Careful identification is required so as to not confuse medically important species of filarial worms with those that chiefly infect nonhuman hosts.

Application of residual insecticides to the interior walls of buildings and sleeping quarters is an effective method of interrupting filarial transmission when local vectors feed and rest indoors. Nightly dispersal of ultra low volume (ULV) aerosols can temporarily reduce exophilic mosquito populations. Larvicides and biological control with larvivorous fish can reduce larval populations before adults have an opportunity to emerge and disperse. However, it is necessary to maintain vector density at low levels for prolonged periods to control filariasis. Hence chemotherapy of infected persons has been the chief tool to control the disease in endemic areas.

Some insecticides labeled for mosquito control are listed in TG-24, Contingency Pest Management Guide. Chemical control may be difficult to achieve in some areas. After decades of insecticide use, many species of the *Cx. pipiens* complex are now resistant to many insecticides. Sanitary improvements, such as filling and draining areas of impounded water to eliminate breeding habitats, should be used whenever possible. Placing non-toxic expanded polystyrene beads (2 to 3 mm in diameter) into pit latrines and cess pits to completely cover the water surface with a 2 to 3 cm thick layer prevents *Culex* spp. from laying eggs in such places. A single application can persist for several years and give excellent control.

Mansonia mosquitoes are usually controlled by removing or killing the aquatic weeds upon which the larvae and pupae depend for their oxygen requirements. If insecticides are used to control *Mansonia* larvae, granules or pellets are more suitable than liquid formulations because they can penetrate the vegetation layer and sink to the bottom of breeding places to release chemicals toxic to the larvae.

Proper use of repellents and other personal protective measures is detailed in TG 36, Personal protective techniques against insects and other arthropods of military significance. The use of bednets impregnated with a synthetic pyrethroid, preferably permethrin, is an extremely effective method of protecting sleeping individuals from mosquito bites. The interior walls of tents can also be treated with permethrin. Buildings and sleeping quarters should be screened to prevent entry of mosquitoes and other blood-sucking insects.

VII. Other Diseases of Potential Military Significance.

A. Leptospirosis. This disease is also known as Weil's disease, Canicola fever, hemorrhagic jaundice, mud fever, or swineherd disease. The spirochete *Leptospira interrogans* is the causal agent of this zoonotic disease, with >200 serovars of this bacterial species identified, and classified, just as a matter of convenience, into 23 serogroups based on serological relationships. Common clinical features are fever with sudden onset, headache, and severe muscle pain. The severity of leptospirosis varies greatly and is determined to a large extent by the infecting serovar and health of the individual. The usual incubation period is 10-12 days after infection.

Clinical illness can last from a few days to 3 weeks or longer. There are usually two phases, a febrile (leptospiraemic) phase of 4-9 days, and a convalescent (immune) phase of 6-12 days. Recovery can take months, in untreated cases, and serious complications can occur. Infection of the kidneys and renal failure is the cause of death in most fatal cases. The case fatality rate can be as high as 20% in cases with jaundice and kidney damage who are not given dialysis treatments. In some areas of enzootic leptospirosis, most infections are mild or asymptomatic.

Disease Distribution. Leptospirosis is one of the most widespread zoonoses in the world, being found in all except polar regions. It occurs in urban and rural areas of both developed and developing countries. Leptospirosis is regarded as focally enzootic throughout Southeast Asia, and at least sporadic human cases are reported from most countries due to occupational exposure. The highest incidence of leptospiral antibodies is usually found in persons frequently exposed to stagnant, polluted, or flood waters; like rice farmers, sewage or sanitation workers, veterinarians, animal husbandry workers, and military personnel.

An EcoChallenge Race in Malaysian Borneo (Sabah and Sarawak) from August 20 to September 3, 2000, drew 304 participants (76 teams; 4 person each; from 26 countries). There were 8 events, from jungle trekking to swimming to spelunking. A total of 155 athletes based in the U.S. constituted about 51% of the participants, and nearly 45% of them were symptomatic (febrile) and 15% required a brief hospital stay for antibiotic therapy. Multiple cases were laboratory confirmed from at least one European country and Canada.

Transmission Cycle(s). *Leptospira* spp. infect the kidneys and are transmitted in the urine of infected animals. Humans become infected through contact of skin or mucous membranes with contaminated water, moist soil or vegetation. *Leptospira* survive only in fresh water, and they are not shed in the saliva; therefore, animal bites are not a source of infection. Although infected humans shed *Leptospira* in urine, person-to-person transmission is rare.

Infection may occasionally occur by ingestion of food contaminated with urine from infected rodents. Infection from naturally infected meat or milk is low. Spirochetes disappear from whole milk within a few hours. Because of its prevalence in rodents and domestic animals, leptospirosis has usually been an occupational hazard to farmers, sewer workers, veterinarians, animal husbandry workers, slaughterhouse workers, and rice and sugarcane field workers.

Numerous wild and domestic animals act as reservoirs, including rodents, swine, cattle, sheep, goats, buffalo, horses and even elephants. Cats and dogs are frequently infected but are probably insignificant as sources of infection to humans. Dogs are a good indicator of the distribution of different leptospiral serovars in the environment. Many small mammals are involved in the epidemiology of leptospirosis in this region.

Bandicoot rats, *Bandicota indica* and *B. bengalensis*, are important reservoirs in Southeast Asia in addition to domestic rodents. Both species of bandicoots have become common commensals of humans. One, *B. indica* is also common in lowland rice fields. In recent years, the incidence of leptospirosis has increased in flood-prone areas, and in areas where irrigation and year-round rice cultivation provide food and cover to host rodents. Close association of humans, animals, soil and water facilitates the spread of leptospirosis to humans.

Disease Prevention and Control. To prevent leptospirosis, control domestic rodents around living quarters and food storage and preparation areas. *Leptospira* are readily killed by detergents, desiccation, acidity, and temperatures above 60^{o} C. Good sanitation reduces the risk of infection from commensal rodents. Troops should be educated about modes of transmission and instructed to avoid swimming or wading in potentially contaminated waters. Leptospirosis can be a problem following flooding of contaminated streams or rivers.

Vaccines have been effective at protecting workers in veterinary medicine, and immunization has been used in some Asian and European countries to protect against occupational exposure to specific serovars. Specific vaccines are currently available in China, Japan and Vietnam. Short-term prophylaxis may be accomplished by administering antibiotics. Doxycycline was recently reported to have been effective in preventing leptospirosis in U.S. military personnel in Panama.

B. Hantaviral Disease. This disease is known by many names including: epidemic hemorrhagic fever; Korean hemorrhagic fever; Nephropathia epidemica; hemorrhagic nephrosonephritis; hemorrhagic fever with renal syndrome (HFRS); hantavirus pulmonary syndrome (HPS). Hantaviruses are a closely related group of zoonotic viruses that infect rodents. The genus *Hantavirus*, family Bunyaviridae, comprises at least 14 viruses, including those that cause HFRS and HPS.

Syndromes in humans vary in severity but are characterized by abrupt onset of fever, lower back pain, and varying degrees of hemorrhagic manifestations and renal or pulmonary involvement. Depending in part on which hantavirus is responsible for illness, HFRS can appear as a mild, moderate or severe disease. Severe illness is associated with Hantaan virus (HTN) and Seoul virus (SEO), primarily in Asia and the Balkans. The case fatality rate is variable but is about 5% in Asia and somewhat higher in the Balkans. Convalescence takes weeks to months.

A less severe illness caused by Puumala virus (PUU) and referred to as nephropathia epidemica predominates in Europe. Dobrava-Belgrade (DOB) virus has caused severe HFRS cases in several countries surrounding Turkey with mortality rates up to 20%. HPS, caused by several hantaviruses, have been reported throughout North and South America.

Military Impact and Historical Perspective . Prior to World War II, Japanese and Soviet authors described HFRS along the Amur River in Manchuria. An epidemic of “trench nephritis” during World War I may have been due to hantaviral infection. Thousands of cases of this illness, considered an entirely new disease, were noted on both sides of the front. During World War II, more than 10,000 cases of a leptospirosis-like disease were recorded during the 1942

German campaign in Finnish Lapland. When the snow melted, great numbers of lemmings and field mice invaded German bunkers.

In 1951, HFRS was recognized among United Nations troops in Korea and has been observed there in both military personnel and civilians since then. Hantaviral disease is an emerging medical threat to military forces operating in many areas of the world.

Over 20 acute PUU infections were documented in U.S. Army personnel during a 1990 field exercise in southern Germany. Several outbreaks of hantaviral disease occurred in 1995 as a result of the civil war in the states of the former Yugoslavia. Over 300 patients, most of them soldiers exposed in the field, were hospitalized in the Tuzla region (northeast Bosnia) with acute hantaviral disease, and outbreaks occurred around Sarajevo and Zenica. Croatia reported over 200 cases from several localities. Over 100 cases were reported in northern Montenegro. Hantaviral infections also occurred during the fighting in Kosovo.

Advanced diagnostic techniques have led to increasing recognition of new hantaviruses and hantaviral infections globally. New outbreaks with novel hantaviral strains are still being discovered. The distribution of new and old hantavirus strains presents a complex and confusing epidemiological picture of this emerging disease, but the military threat is highly significant.

Disease Distribution. At least 200,000 cases of HFRS involving hospitalization are reported annually world wide. Hantaan virus claims 40,000 to 100,000 victims in China, and another 1,000 in South Korea annually. The SEO virus is associated with the commensal Norway rat and occurs in more urban areas. Many clinical cases are reported from the Balkans. Little published information is available about the hantaviruses that may be circulating in Southeast Asia.

Transmission Cycle(s). Virus is present in the urine, feces and saliva of persistently infected, asymptomatic rodents. Aerosol transmission to humans from rodent excreta is the most common mode of infection. Human-to-human transmission of HFRS is considered rare, but the viruses have been isolated from the blood and urine of patients. Hantaviruses have caused laboratory-associated outbreaks.

Each hantavirus appears to have a single predominant murid reservoir. HTN is commonly associated with the field mouse, *Apodemus agrarius*, in open field or unforested habitats. The red bank vole, *Clethrionomys glareolus*, inhabits woodland or forest-steppe environments and is a primary reservoir for PUU. The Norway rat, *R. norvegicus*, is the reservoir for SEO worldwide. The common European vole, *Microtus arvalis*, appears to be the primary reservoir of TUL.

Hantavirus infection is apparently not pathogenic in its rodent reservoir and produces chronic and probably lifelong infection. Hantaviruses may be spread by infected rodents that infest ships, thereby reaching ports worldwide. Transmission is highest in warm months when rodent reservoir populations are abundant. Military personnel are usually exposed to infection when working, digging or sleeping in fields infested by infected rodents.

Disease Prevention and Control. Prevent rodent access to buildings. Store food in rodent-proof containers or buildings. Disinfect rodent-contaminated areas with dilute bleach or other antiviral agents. Do not sweep or vacuum rodent-contaminated areas, use a wet mop moistened with disinfectant. Eliminate wild rodent reservoirs before military encampments are established in fields. Do not disturb rodent droppings or sleep near rodent burrows.

Military personnel should not handle or tame wild rodents. Rodents frequently urinate or bite when handled. Detailed information on surveillance and personal protective measures when working around potentially infected rodents can be found in TG 40, Methods for trapping and sampling small mammals for virologic testing (usually via PCR), and in TG 41, Protection from rodent-borne diseases with special emphasis on occupational exposure to hantavirus.

C. Avian Flu. Avian flu is caused by a virus (influenza A, H5N1) which occurs naturally and is widespread in many and very diverse taxa of birds around the world. It occurs as either a low virulence or high virulence form, with the low virulence form causing mild or minimal symptoms even when there are large numbers of wild and/or domestic birds infected. Some highly pathogenic strains of this virus emerged in Asia in 2003, and have since caused several epizootic outbreaks in domestic and wild birds.

Migratory species, like geese and ducks have been found infected and may be responsible for carrying this virus between countries or continents. Humans have apparently become infected via direct contact with live or recently slaughtered domestic birds, like chickens or ducks or with physical items comtaminated by their excretions. There has been only limited potential for spread from person to person, so far. Human cases have occurred mainly in Southeast Asia, but also in Europe, Africa and the Near East. Infected birds have been more common and more widely distributed.

Military Impact and Historical Perspective. The highly virulent strain of this virus (Influenza A, H5N1) was first noted in 2003, but the low virulence strain had been known for many years to cause a highly contagious illness in various wild and domestic species of birds. Clinically ill cases in humans are still rare, but more than 50% of persons who show severe symptoms have died in 21 days or less after symptoms first appeared. Military personnel can be educated to the nature of H5N1 and its prevention, and they can avoid contact with infected bisrds and their excretions. The numbers of potential military members affected by this virus should be very limited. Its impact on military operations in Southeast Asia should be minimal.

Disease Distribution. This virus has so far been documented in birds in several countries in Southeast Asia, Eastern Asia, Europe, Africa, and the Near East. Continuing surveillance will continue to detect and document its actual distribution, which may still be expanding.

Transmission Cycle(s). This virus is transmitted by direct contact, fecal-oral routes between birds. Documented human infections have apparently occurred in a similar manner. Details of incubation time, species-to-species transmissibility, and virulence are still under study.

Disease Prevention and Control. Based on case reports since 2003, once humans develop a suite of serious symptoms due to H5N1, more than half of them usually die. Transmission is primarily via direct contact with an infected bird, or its excretions or secretions. So far, direct secondary transmission from human to human has not been carefully documented, but a few reports have strongly implied that may have happened.

This virus, like many influenza A viruses, seems to change its genetic and behavioral characteristics and rapidly adapts to different hosts. If its transmissibility to and between humans increases, it could lead to a pandemic. Currently available antiviral medications have been reported to apparently be able to eliminate or cure infections by this virus. Onset of illness is very rapid (1-3 days) and early human symptoms usually including respiratory symptoms, fever, headache, myalgia, and coughing.

A number of recent H5N1 outbreaks have occurred in Southeast Asia, with human cases and deaths in several countries including: Indonesia in 2006, and 2008; Thailand in 2004; and Vietnam in 2004, 2005, 2006, and 2009. For current information on avian flu and outbreak updates, go to: www.cdc.gov or www.who.org , and then search by appropriate topic or links.

VIII. Noxious/Venomous Animals and Plants of Military Significance

A. Arthropods. Annoyance by biting and stinging arthropods can adversely affect troop morale. The salivary secretions and venoms of arthropods are complex mixtures of proteins and other substances that can be allergenic. Reactions to arthropod bites or stings range from mild local irritation to systemic reactions causing considerable morbidity, including rare but life-threatening anaphylactic shock. Insect bites can be so severe and pervasive that they affect the operational readiness of troops in the field. Bites and their discomfort have been a major complaint by soldiers deployed in many parts of the world.

Entomophobia, the irrational fear of insects, and the related arachnophobia, fear of spiders, are two of the most common human phobias. The fear is usually not limited to obvious threats, such as scorpions Anxiety produced in a fearful individual by a potential encounter with an insect can range from mild aversion to panic. The degree of negative response to encounters with insects or spiders is important in assessing the difference between common fear and true phobia. Common fear is a natural extension of human experience and is appropriate in situations that involve potential danger or require caution. Phobias, however, are characterized by persistent, high levels of anxiety in situations of little or no real threat to the individual.

Many individuals may express a fear of insects or spiders, but few are phobic to the extent that their ability to function in a normal daily routine is impaired by their fear. The term delusory parasitosis refers to a mental disorder in which an individual has an unwarranted belief that insects or mites are infesting his or her body or environment. This psychiatric condition is distinct from entomophobia or an exaggerated fear of real insects. Extreme entomophobia and delusory parasitosis require psychological treatment. The following groups of noxious arthropods are those most likely to be encountered by military personnel operating in countries of Southeast Asia:

1. Acari (ticks and mites).

Scabies is the most important disease caused by mite infestation of humans. It is initiated almost exclusively by direct contact with a currently infested person. Infestations have been common during past military conflicts. Scabies infestations, their diagnosis, treatment and prevention are almost always best dealt with in the clinical medical realm, along with individual education, and taking personal avoidance or preventive measures. They are not disease vectors nor are they typically spread by vectors, and seldom even via contaminated fomites. Scabies will not be further addressed herein, but more detailed information is available on the CDC or WHO website, and in certain medical references, like Heymann (2005).

Chiggers, the common name for larvae of the mite family Trombiculidae, also called harvest mites, or scrub itch mites, are parasites of mammals and birds. Over 3,000 species have been described worldwide but only about 30 of these are known to feed on humans. Larvae are very small, only about 0.25 mm long, and are often called red bugs. Females lay their eggs in damp, high-humus soil. The eggs hatch into six-legged larvae that congregate near the tips of grass and fallen leaves and attach to passing animals that brush against the vegetation. Larvae cluster in the ears of rodents and around the eyes of birds.

On humans they most often attach where the clothing is tight, around the waist or genitals. Chiggers do not burrow into the skin as commonly believed, nor do they feed on blood. Larvae remain on the skin surface and use digestive fluids to form a feeding tube (stylostome) that enables them to feed on cellular material for several days. Fully fed larvae drop to the ground to continue their complex life cycle. In the nymphal and adult stages, they are believed to prey on the eggs and larvae of other arthropods. Feeding by chiggers can cause an intense itchy dermatitis with pustules and sometimes to secondary infection. Most temperate zone chiggers have one generation a year.

Ticks of certain species can cause tick paralysis, a potentially fatal but easily cured affliction of man and animals. It is almost exclusively associated with hard ticks (family, Ixodidae) and is caused by injection of neurotoxin(s) in the tick’s saliva. The toxin, which may be different in different species, disrupts nerve synapses in the spinal cord and blocks neuromuscular junctions.

Worldwide, nearly 50 species of hard ticks have been associated with tick paralysis, although any ixodid tick may be capable of producing this syndrome. Certain species (*e.g.*, *I. holocyclis* in Australia, and *D. andersoni*, in the U.S.), tend to cause this syndrome more often than others.

A tick must be attached for 4-6 days before symptoms appear. This condition is characterized by an ascending, flaccid paralysis, usually beginning in the legs. Progressive paralysis can cause respiratory failure and death. Diagnosis involves finding the attached tick, usually at the base of the neck or the scalp. After tick removal, symptoms resolve within hours or days. However, if paralysis is advanced, recovery can take weeks. No known drugs are effective as treatment, but anti-inflammatory products either taken orally or applied topically, can often reduce itching. Species of ticks reported from Southeast Asia are listsed in Table 3.

2. Araneae (spiders). More than 35,000 species of spiders have been described worldwide. All spiders, with the exception of the family Uloboridae, are venomous and use their venom to immobilize or kill prey. Most spiders are harmless to man because their chelicerae cannot penetrate our skin, or they have venom of low toxicity to humans. Only about 12-15 species have been reported to cause severe systemic envenomation in humans, but as many as 500 species may be able to inflict significant bites.

Those that can bite humans are rarely seen or recovered for identification, so physicians need to be able to recognize signs and symptoms of common venomous spider bites to administer appropriate therapy. In Southeast Asia, certain of the widow spiders, *Lactrodectus* spp. (family, Theridiidae), and the sac spiders, *Chiracanthium* spp. (family, Clubionidae), are responsible for serious local and systemic envenomations. The brown widow, *L. geometricus*, and black widow, *L. mactans*, are widespread throughout the region. Members of this family are also referred to as hourglass, shoe button, or po-ko-moo spiders. There is a lot of variation in coloration and markings between species, and between immatures and adults.

Widow spiders are found in various protected habitats such as crawl spaces under buildings, holes in dirt embankments, or in piles of rocks, boards, bricks or firewood. Indoors, they prefer dark areas behind or underneath appliances, in deep closets and cabinets. They commonly infest outdoor privies, and preventive medicine personnel should routinely inspect such sites. Widow spiders spin a crude web and usually will not bite unless provoked.

Some *Latrodectus* spp. can inject a potent neurotoxin when they bite. The bite itself is usually mild and most patients don't remember being bitten. Significant envenomation may cause severe systemic symptoms, including painful muscle spasms, a rigid board-like abdomen, and tightness in the chest. Human mortality has been estimated at 1-5%, for untreated bites by *L. mactans*. Most envenomations by this group respond quickly to calcium gluconate given IV. Antivenins may be commercially available and are usually effective.

Sac spiders of the genus *Chiracanthium* have a cytolytic venom that produces mild to moderate cutaneous necrosis in humans, it is usually not as severe as that caused by envenomation by *Loxosceles* spp. Some species may have neurotoxic components in their venom. Over 150 species of sac spiders have been recorded worldwide. Symptoms of their bites may include severe local pain, fever, swelling and redness, with a small slow-healing open wound at the bite site.

3. Ceratopogonidae (biting midges, no-see-ums, punkies). Ceratopogonidae is a large family containing nearly 5,000 species. A list of *Culicoides* spp. reported from Southeast Asia is included in Table 6. These extremely small flies can easily pass through standard window screens and mosquito netting, although most species feed outdoors. Their small size is responsible for their being called "no-see-ums."

Many species in this family attack and suck fluids from other insects. Most species that suck vertebrate blood belong to the genera *Culicoides* (1,000 species) or *Leptoconops* (about 80 species). In Southeast Asia these insects do not transmit any known human diseases, but they are vectors of some diseases of veterinary importance. Many Ceratopogonid species are widespread in the region, but little is known about their biology. Many Southeast Asian species of *Culicoides* are zoophilic, and *Leptoconops* are usually more likely to be a major nuisance to man in this region. Certain species breed near beaches and can seriously affect tourists in parts of Indonesia, Malaysia, Thailand and the Philippines.

Only the females suck blood, and human-biting species mainly feed and rest outdoors, entering houses only in small numbers. *Leptoconops* are active during the day; *Culicoides* may be either diurnal or nocturnal. Diurnal species of both genera prefer early morning and late afternoon periods. Despite their small size, they often cause local reactions severe enough to make a military unit operationally ineffective.

In sensitive people bites may blister, exude serum and itch for several days, or be complicated by secondary infections from scratching. Enormous numbers of these tiny flies often emerge from breeding sites, causing intolerable annoyance. Some species can fly 2-3 km without the aid of wind. Ceratopogonidae are most troublesome under calm conditions, and the number of flies biting declines rapidly with increasing wind speed.

Breeding habits vary widely from species to species. Larvae are mainly aquatic or semiaquatic, occurring in the sand or mud of fresh, salt, or brackish water habitats, notably salt marshes and mangrove swamps. Many species occupy specialized habitats such as tree holes, decaying vegetation, or cattle dung. Most species remain within 500 m of their breeding grounds. In militarily secure areas, encampments should be located in the open, away from breeding sites, to avoid these insects. Larvae are difficult to find, but adults are easily collected while biting and with light traps.

Environmental management (reduction or elimination of larval habitat) is the best control for larvae, but this may be impractical in extensive or diffuse habitats. Adult control typically includes applying residual insecticides to fly harborages, treating screens and bednets with pyrethroids, and using repellents. Ultra low volume (ULV) application of aerosols may produce temporary control, but treated areas are soon invaded from nearby untreated areas. Ceratopogonids have difficulty biting through clothing because of their short mouthparts, so even an untreated uniform can provide considerable protection.

4. Chilopoda (Centipedes) and Diplopoda (Millipedes).

Centipedes in tropical countries can attain large size. At least some species in the genus *Scolopendra* can be >25 cm long and can inflicting painful bites, with discomfort lasting 1-5 hours. Several species of this genus known to bite man occur in Southeast Asia. *Scolopendra cingulata* is a widespread tropical species in this region, and has been incriminated in human bites. Specimens up to 12 inches long have been collected Vietnam and Indonesia. Its bite produces severe local pain and burning.

Smaller centipede species have been reported to occasionally bite humans in this region. Centipedes use their first pair of trunk appendages (modified legs, called maxillipeds) which have evolved into sharp, claw-like structures with associated venom glands and ducts. Two puncture wounds at the site of attack are usually characteristic of a centipede bite. Neurotoxic and hemolytic components of these centipedes' venom usually cause only a local reaction, but systemic symptoms like vomiting, irregular pulse, dizziness and/or headache may occur. Most centipede bites are uncomplicated and self-limiting, very rarely serious and seldom ever human-lethal, but secondary infections can also occur at a bite wound.

Centipedes are dorso-ventrally flattened with 1 pair of legs per apparent body segment. Some relatively long and slender species may have nearly 100 pairs of legs. They are fast-moving, nocturnal predators of small arthropods. During the day, they hide under rocks, boards, bark, stones and leaf litter, but occasionally they find their way into homes, buildings, and tents. They are not aggressive and seldom bite unless molested. Most centipede bites occur when the victim is sleeping or when putting on clothes in which centipede becomes trapped. Troops should be taught to inspect clothing and footwear operating in the field in this region.

Millipedes are similar to centipedes, but they have two pairs of legs per apparent body segment and are usually more rounded or cylindrical instead of flattened in their body's cross section. Most species feed on decaying organic matter and are more abundant during the wet season. When disturbed they coil up into a tight spiral.

They do not bite or sting, but some species, such as the Haase millipede, *Otostigmus ceylonicus*, secrete defensive body fluids containing quinones and cyanides that may cause discoloration and painful blistering of the skin. An initial yellowish-brown tanning turns to deep mahogany or purple-brown within a few hours of exposure. Blistering may follow in a day or two. Eye exposure may require medical treatment. A few species from the genera *Spirobolida*, *Spirostreptus*, and *Rhinocrichus* can squirt their secretions 80 cm or more.

5. Cimicidae (bed bugs). There are >90 species in the family Cimicidae. Most are associated with birds and/or bats and rarely bite humans. The common bed bug, *Cimex lectularius*, has been associated with humans at least for centuries and is cosmopolitan. The tropical bed bug, *Cimex hemipterus*, also feeds on humans and is similar in appearance to *C. lectularius*. It is common in tropical areas of Asia, Africa and Central and South America. Bed bug infestations are typical of cluttered and unsanitary conditions, but greatly improving sanitation alone will not significantly reduce their numbers. They can be found in many developed countries and seem to be spreading and increasing in number wherever they occur. There is currently no verifiable evidence that bed bugs transmit any human pathogens. Humans' reactions to bed bugs' bites is individual and usually increases in severity with greater numbers, or more frequent, or repeated bites. Bite reactions may be immediate or delayed (up to 18 days), or an individual may have both an immediate and delayed reaction to any given bed bug bite (or biting incident). Bites can be very irritating, prone to secondary infection after scratching, and may develop into hard swellings, welts, or even blisters (papules). Bed bugs feed at night while their hosts are sleeping but will feed during the day if conditions are favorable or if they become very hungry. During the day they typically hide in cracks and crevices, under or in mattress seams, spaces under baseboards, or loose wallpaper. Chronic exposure to bed bugs may result in insomnia, nervousness and fatigue. Some studies have found that a high percentage of asthmatic patients had positive skin reactions to *Cimex* antigen. There are 5 nymphal instars and each must take a bloodmeal to develop to the next stage. Adults have been reported to live 3-12 months in an untreated household situation. A given undisturbed bug may take 3-15 minutes to take a full bloodmeal depending on its life stage. They can survive long periods of time without feeding, reappearing from their hiding places when hosts again become available. They have special scent glands and often emit a characteristic odor that can usually be detected in heavily infested sites. Dark fecal spots on bedding or "bedclothes," pearly-white eggs (1 mm long), and papery yellowish cast "skins" are other signs of infestation often found in cracks or crevices. Infestations of bed bugs in human habitations are not uncommon in many areas of South Central Asia. Bed bugs can be introduced into barracks on infested baggage, bedding and belongings. They may pass from the clothing of one person to another on crowded public vehicles. In contingency situations, old dwellings should be surveyed for these and other pests before they are occupied. Both *C.*

lectularius and *C. hemipterus* commonly feed on poultry in many parts of the region, so poultry houses should be avoided by military personnel.

6. Dipterans Causing Myiasis. Myiasis refers to the condition of fly maggots infesting the organs or tissues of people or animals. Worldwide there are 3 major families of myiasis - producing flies: Oestridae, Calliphoridae and Sarcophagidae. The Oestridae contains about 150 species known as bot flies and warble flies. They are all obligate parasites, primarily on wild or domestic animals. Members of the genera *Cuterebra* and *Dermatobia* commonly infest humans in the Americas. The Calliphoridae, known as blow flies, are a large family composed of over 1,000 species. At least 80 species, mostly in the genera *Cochliomyia*, *Chrysomya*, *Calliphora* and *Lucilia*, have been recorded as causing cutaneous myiasis. Flies in the genus *Lucilia* are known as greenbottle flies due to their metallic or coppery green color. *Lucilia sericata* and *L. cuprina* are the most common species infesting wounds of humans. *Calliphora* flies are commonly called bluebottle flies because of their metallic-bluish or bluish-black color. The abdomen is usually more shiny than the thorax. The family Sarcophagidae, known as flesh flies, contains over 2,000 species, but its only important genera in terms of myiasis is *Wohlfahrtia* and *Sarcophaga*. The abdomen of flesh flies is often marked with squarish dark patches on a grey background, giving it a checkerboard appearance. Females are larviparous and deposit first-instar larvae instead of eggs. The larvae are deposited in batches of 40-60 on decaying carcasses, rotting food and animal or human feces. Myiasis is also classified according to the type of host-parasite relationship, and specific cases of myiasis are clinically defined by the affected organ, *e.g.*, cutaneous, enteric, rectal, aural, urogenital, ocular, *etc*. Myiasis can be accidental when fly larvae occasionally find their way into the human body. Accidental enteric myiasis occurs from ingesting fly eggs or young maggots on uncooked foods or previously cooked foods that have been subsequently infested. Other cases may occur from the use of contaminated catheters, douching syringes, or other invasive medical equipment in field hospitals. Accidental enteric myiasis is usually a benign event, but larvae may survive temporarily, causing stomach pains, nausea, or vomiting. Numerous fly species in the families Muscidae, Calliphoridae, and Sarcophagidae are involved in accidental enteric myiasis. A common example is the cheese skipper, *Piophila casei* (family, Piophilidae), which infests cheese, dried meats and fish. Facultative myiasis occurs when fly larvae infest living tissues opportunistically after feeding on decaying tissues in neglected wounds. Considerable pain and injury may be experienced as fly larvae invade healthy tissues. Facultative myiasis has been common in wounded soldiers throughout military history, and numerous species of Muscidae, Calliphoridae, and Sarcophagidae have been implicated. Species of these families are widespread throughout Southeast Asia. Surgeons used maggots that feed only on necrotic tissue to clean septic battle wounds until about 1950. Maggot therapy has been used in recent years to treat chronically infected tissues, especially osteomyelitis. Myiasis is obligate when fly larvae must develop in living tissues. This constitutes true parasitism and is essentially a zoonosis. Obligate myiasis is a serious pathology. In humans, obligate myiasis results primarily from fly species that normally parasitize domestic and wild animals.

The Old World screw-worm fly, *Chrysomya bezziana* (family, Calliphoridae), is a fairly common myiasis-producing fly in Southeast Asia. Adult *C. bezziana* only oviposit on live mammals, depositing 150 to 500 eggs at wound sites or in body orifices (ears, nose, mouth and urogenital openings). The larvae hatch in 18 to 24 hours, molt once after 12 to 18 hours, and a second time about 30 hours later. They feed for 3 to 4 days and drop to the ground to pupate. The pupal stage lasts 7 to 9 days in tropical conditions. *Chrysomya megacephala* is common in India and is often called the Oriental latrine fly because of its habit of breeding in feces as well as on carrion and other decomposing organic matter. It can occur in large numbers around latrines and become a nuisance in open-air meat and fish markets. The larvae can cause a secondary myiasis of wounds in man and animals. Myiasis is rarely fatal, but troops living in the field during combat are at a high risk of infestation. Good sanitation can prevent most cases of accidental and facultative myiasis. To prevent flies from ovipositing on them, exposed foodstuffs should not be left unattended. Fruits and vegetables should be washed prior to consumption and examined for developing maggots. Extra care should be taken to keep wounds clean and dressed. Avoid sleeping in the nude, especially outdoors during daytime when adult flies are active and likely to oviposit in body orifices. At field facilities, proper waste disposal and fly control can reduce fly populations and the risk of infestation. Several other species of flies commonly cause myiasis in cattle (*e.g*., *Hypoderma* spp.) And in horses and donkeys (*e.g*., *Gasterophilus* spp.), and their larvae sometimes infest humans. The larvae of most species of flies are extremely difficult to identify. Geographic location and type of myiasis are important clues to identity. It is particularly helpful, if possible, to rear larval specimens so that the adult can be used for identification.

7. Hymenoptera (ants, bees and wasps).

Most wasps and some bees are solitary or subsocial insects that use their stings to subdue prey. These species are not usually involved in stinging incidents, and their venom generally causes only slight and temporary pain to humans. The social wasps, bees and ants use their sting mainly as a defensive weapon, and their venom causes intense pain in vertebrates. The 3 families of Hymenoptera responsible for most stings in humans are the Vespidae (wasps, hornets, and yellow jackets), the Apidae (honey bees and bumble bees), and the Formicidae (ants). Wasps and ants can retract their stings after use and can sting repeatedly. The honey bee stinging apparatus has barbs that hold it so firmly that the bee's abdomen ruptures when it tries to pull the stinger out of the skin. The bee's poison gland, which is attached to the stinger, will continue injecting venom after separation. Scraping the skin after a bee sting is important to remove the stinger and attached venom sac. Honey bees and social wasps (family, Vespidae) account for most stings requiring medical treatment in Southeast Asia. Wild species of honey bees (genus, *Apis*) can often be more aggressive than the European honey bee, *Apis melifera* (including several different domesticated "forms") maintained by bee keepers in many countries around the world. *Apis cerana* is a common cavity-nesting honey bee that is widespread in Southeast Asia, from Myanmar to Indonesia. One of the world's largest honey bee species, *Apis dorsata*, has been reported from Southeast Asia. It occurs from Thailand to Indonesia and parts of the Philippines. The nests of *A. dorsata* are harvested by local people for honey and wax, and sometimes brood, which are eaten in several cultures. Its nests are typically built under tree limbs and cliffs. These bees aggressively defend their nests and sometimes pursue attackers >100 m. The world's smallest honey bee, *Apis florae*, occurs from Myanmar to Indonesia, and is relatively abundant in Southeast Asia.

Ants can bite, sting and squirt the contents of their poison gland through the tip of their abdomen as defensive secretions. The components of the venom are complex and vary with the species of ant. Formic acid is a common substance discharged as a defensive secretion. Certain ant species in the subfamily, Ponerinae have caused hypersensitive reactions in humans. Some protein-feeding ants such as the Pharaoh ant, *Monomorium pharaonis*, have been incriminated as mechanical vectors of pathogens in hospitals.

Hymenoptera venoms have not been fully characterized but contain complex mixtures of allergenic proteins and peptides as well as vasoactive substances, such as histamine and norepinephrine. These are responsible for the pain at the sting site, irritation, redness of the skin, and allergic reactions in sensitized individuals. There is no allergic cross-reactivity between honey bee and vespid (wasp) venoms, although cross-reactivity may exist to some extent between different wasp venoms. Therefore, a person sensitized to one vespid venom could have a serious reaction to the sting of another member of the same family.

Reactions to stings may be grouped into 2 categories, immediate (within 2 hours) or delayed (more than two hours). Immediate reactions are the most common and are subdivided into local, large local, or systemic allergic reactions. Local reactions are nonallergic responses characterized by erythema, swelling, and transient pain (often very intense) at the sting site that subsides in a few hours. Stings in the mouth or throat may require immediate medical assistance. Multiple stings in a short period of time may cause systemic symptoms such as nausea, malaise and fever. It has been estimated that it takes 500 or more (domesticated) honey bee stings to kill an adult human by the toxic effects of the venom alone.

The toxicity of Africanized honey bee venom is roughly equivalent to the toxicity of the venom of domesticated honey bees. Large local reactions are characterized by painful swellings at least 5 cm in diameter and may involve an entire extremity. Systemic reactions vary from mild urticaria to more severe reactions, including vomiting, dizziness and wheezing. Severe allergic reactions are rare but can result in anaphylactic shock, difficulty in breathing, and death within 30 minutes. Emergency kits should be provided to patients who have experienced anaphylactic reactions to stings. Commercial kits are available that include antihistamine tablets and syringes preloaded with epinephrine. Sensitive individuals should also consider wearing a Medic-Alert tag to alert medical personnel of their allergy in case they lose consciousness.

Venom immunotherapy for sensitive individuals will reduce but not eliminate the risk of anaphylactic reactions. The frequency of sting hypersensitivity is probably less than 1% of the population, but still usually results in >20 human deaths per year in the U.S. Delayed reactions to Hymenoptera envenomization are uncommon but usually present as a large local swelling or, rarely, as systemic syndromes.

Individuals can take a number of precautions to avoid stinging insects. Avoid wearing brightly colored floral-pattern clothes. Do not go barefoot in fields where bees and wasps may be feeding at ground level. Avoid the use of scented sprays, perfumes, shampoos, suntan lotions, and soaps when working outdoors. Be cautious around rotting fruit, trash containers, and littered picnic grounds, since large numbers of yellow jackets often feed in these areas. Avoid drinking sodas or eating fruits and other sweets outdoors, since bees and yellow jackets are attracted to these items. Bees and wasps are most aggressive around their nests, which should not be disturbed.

8. Lepidoptera (medically important, and significant nuisance, moths and caterpillars). Caterpillars of certain moths have urticating hairs that can cause dermatitis. The hairs are usually connected to glands that release poison when the hair tips break in human skin. The intensity of irritation varies with the species of moth, sites and extent of exposure, and the sensitivity of the individual, but usually the symptoms are temporary.

Certain species of the genus *Lonomia* have caused a number of human fatalities, but that genus is limited to the tropical Americas, and none of the species of Lepidoptera reported from Southeast Asia which cause urticating effects has ever been reported to cause death in humans except persons truly allergic (hypersensitive) to that particular venom. Hairs stimulate the release of histamine, and resultant skin rashes last about a week. The irritation is more severe when the hairs reach mucous membranes or the eye, where they can cause nodular conjunctivitis.

Urticating hairs can also become attached to the cocoon when the larva pupates, and later to the adult moth. Hairs readily become airborne. If inhaled, detached caterpillar hairs can cause labored breathing; if ingested, they can cause mouth irritation. The hairs of some species retain their urticating properties long after being shed. Hairs and setae may drop into swimming pools and irritate swimmers.

Scratching and rubbing the affected parts of the body should be avoided to prevent venomous hairs from penetrating deeply into tissues. Running water should be used to wash the hairs out of the lesion. Light application of adhesive tape and stripping it away will remove many of the hairs or spines from the skin. Acute urticarial lesions usually respond to topical corticosteroid lotions and creams, which reduce the inflammatory reaction. Oral histamines may help relieve itching and burning sensations. Caterpillars of the families Bombycidae and Saturniidae have been implicated in cases of urticarial dermatitis in Southeast Asia.

Lachrymal feeding. Some adult moths frequently ingest liquids (lachrymal seretions, or tears) from the mucous membrane margins of the eyes of domestic or wild animals, and sometimes eye exudates, and even sweat, from humans. This activity is most common during dry periods of the year. And it has been observed mainly in Southeast Asia (including: Cambodia, Indonesia, Laos, Malaysia, and Thailand), but a number of cases have also been reported from Africa, China, and the U.S. (at least one case in Arkansas; Selman 1972). The moths mainly limit this activity to evening or early night hours, and very rarely during the day in deeply-shaded forest or jungle sites. So far, this behavior has been reported for >100 moth species, representing at least 25 genera, in at least 6 families (including: Geometridae, Noctuidae, Notodontidae, Pyralidae, Sphingidae, and Thyatiridae). This activity can be a serious nuisance to the animal and might spread ocular pathogens, as well.

Blood feeding. Adults of several of the previous group of moths will feed on blood or other fluids which is seeping from any open sore, scratch or wound. Unique to Southeast Asia (at least in Indonesia, Laos, Malaysia, and Thailand), a number of species of the Noctuid genus *Calyptra* can, and often do, directly pierce the unbroken skin of animals or humans and ingest fresh blood. Animal from which they have been observed to take blood have included: elephants, Malayian tapir, deer, water buffalo, rhinosceros, antelopes, mules, and pigs. At least five species of this genus (*C. bicolor*, *C. fasciata*, *C. ophideroides*, *C. parva*, and *C. pseudobicolor*) have been reported to feed on humans. Only the males pierce animals' skin and take blood. Their associated females pierce the rather tough skin of certain fruits, and apparently feed only on the juices of those fruits (Banziger 1986, 1989; Banziger and Fletcher 1988; Mullen and Durden 2002).

9. Meloidae (blister beetles), Oedemeridae (false blister beetles) and Staphylinidae (rove beetles). Blister beetles are medium-sized (10-25 mm long), soft-bodied insects that have cantharidin in their body fluids. Cantharidin is a strong vesicant that readily penetrates human skin. Handling or crushing the beetles causes blistering within a few hours of skin contact. There is a large variation in individual susceptibility to such blistering. Blisters are usually not serious and clear in 7-10 days without scarring.

If blister beetles are ingested, cantharidin can cause nausea, diarrhea, vomiting, and abdominal cramps. Blisters that occur on the feet where they will be rubbed may need to be drained and treated with antiseptic. Cantharidin was once regarded as an aphrodisiac, and a European species of blister beetle was popularly known as the Spanish-fly. Troops should be warned against using blister beetles or cantheridin for this purpose, since it is highly toxic when taken orally.

About 1,500 species of the family, Oedemeridae occur worldwide. They are slender, soft-bodied beetles, 5-20 mm long. Adults of most species feed on pollen and are often found on flowers. These beetles also contain cantharidin. Although there are few references in the medical literature, blister beetle dermatitis caused by oedemerids may be more common and widespread than currently recognized. During a training exercise on the North Island of New Zealand in 1987, 74 (14%) of 531 soldiers developed blisters after exposure to *Thelyphassa lineata*. Adult Oedemerids are usually attracted to light.

Some species of Staphylinidae, or rove beetles, produce a strong vesicating substance that causes blisters. Rove beetles are active insects that run or fly rapidly. When running, they frequently raise their abdomen tip, somewhat like scorpions. They vary in size, but the largest are about 25 mm long. Some larger rove beetles can inflict a painful bite when handled. Many species are small (<5 mm) and can get under clothing or into eyes.

Members of the genus *Paederus* are widespread throughout the world. They have a toxin, paederin, that can cause dermatitis, painful conjunctivitis and temporary blindness after eye contact. Normally, rove beetles must be crushed to release their vesicating agent. Like true blister beetles (Meloidae), rove beetles are attracted to light and can be a hazard to soldiers at guard posts. Rove beetles often emerge in large numbers after rains and can cause outbreaks of dermatitis. The staphylinid *Paederus fuscipes* was identified as the cause of hospital outbreaks of dermatitis. Beetles were attracted by hospital lights at night and entered open windows.

10. Scorpionida (scorpions). These arthropods have a stout cephalothorax, 4 pairs of legs, a pair of large anterior pedipalps with enlarged claws, and a tail tipped with a bulbous poison gland and stinger. Some species carry the tail above the dorsum of the thorax, while others drag it behind. Of over 1,500 described species worldwide, fewer than 25, all in the family Buthidae, have venom that can often be lethal to humans. Scorpion species reported from Southeast Asia are listed in Table 7.

Scorpions inject the venom with a stinger on the tip of their abdomen, and some species can inflict a painful pinch with their pedipalps (claws, pincers). They usually feed at night on insects, spiders and other arthropods. During the daytime, scorpions hide beneath stones, logs or bark, loose earth or among manmade objects. Indoors, scorpions often hide in shoes or clothing. Scorpions use their sting to capture prey, for defense against predators and during mating.

A scorpion can regulate how much venom is injected with each sting, if any. Some scorpions may not inject any venom while stinging. Scorpion venom is a complex mixture of substances that may include several neurotoxins, histamine, seratonin, enzymes and other unidentified components. The venom of most species has never been analyzed. Some scorpion venoms are among the most toxic substances known; fortunately, only a small amount is injected, probably less than 0.5 mg. There is evidence that the toxicity of any species’ venom is highly variable across its geographic range. Thus, a species that is dangerous in one area may not be hazardous in another. There are numerous scorpions in Southeast Asia.

Two medically important species have been reported form Southeast Asia, *Mesobuthus occitanus* (Amoreaux) and *Mespobuthus martensii* (Karsch). They are responsible for many scorpion stings of humans. A list of scorpions reported from Southeast Asia appears in Table 7. Most stings are to the lower extremities, arms and hands. Among indigenous populations, stings most often occur at night, while scorpions are actively hunting prey. Scorpion stings can occur year round in tropical and subtropical areas. In colder higher elevations of mountains of Myanmar and Vietnam, most stings occur during warm months (March to October).

Scorpions can sting multiple times, and if trapped, as with a person in a sleeping bag, will readily do so, as long as the victim is active. Common places where stings are encountered by military personnel include the boots and under or around piled clothing. Scorpion stings broadly affect nearly all body tissues, and they present a mixture of hemolytic, neurotoxic and cardiotoxic effects. All stings should be considered potentially dangerous.

The severity of scorpion stings can be categorized as follows: 1) patients with initial sharp pain, numbness, and localized swelling dissipating in 1 to 3 hours with no systemic findings; 2) those who, in addition to pain, have 1 or 2 mild systemic manifestations, such as local muscle spasm, dry mouth, increased salivation, or runny nose; 3) those who have more severe systemic manifestations but no central nervous system manifestation or general paralysis; and 4) those who have severe systemic reactions, including central nervous system involvement, such as confusion, convulsions, and coma, with or without general paralysis. They may also develop uncoordinated eye movements, penile swelling, or cyanosis.

The most severe manifestations occur in children, who are more susceptible to the effects of venom because of their small body mass. Those with type 1, 2, or 3 manifestations can be managed by applying ice to slow the spread of the venom, and supporting the patient with fluids and antihistamines. However, those with type 4 manifestations require intensive medical treatment, especially during the first 24 hours following the sting.

Antivenin therapy is important for severe cases. For this treatment to be effective, the stinging scorpion must be captured so it can be properly identified. To prevent scorpion stings, military personnel should be instructed to empty boots before putting them on, carefully inspect clothing left on the ground before putting it on, and keep sleeping bags tightly rolled when not in use. Troops must be cautioned that scorpions can cause painful reactions requiring medical treatment and should never be kept or handled as pets.

11. Simuliidae (black flies, buffalo gnats, turkey gnats). Black flies are small (3-5 mm long), usually dark, stout-bodied, hump-backed flies with short wings. Despite their appearance, black flies are strong flyers that are capable of dispersing many kilometers from their breeding sites. Only females suck blood. They can emerge in large numbers and be serious pests of both livestock and humans. Black fly (females only) bite during the day and in the open. Some species have a bimodal pattern of activity, with peaks around 0900 hrs in the morning and 1700 hrs in the afternoon, but in shaded areas biting is more evenly distributed throughout the day. The arms, legs and face are common sites of attack, and a favorite site is the nape of the neck.

Black fly bites may be itchy and slow to heal. Systemic reactions, characterized by wheezing, fever or widespread urticaria, are rare but require medical evaluation and treatment. Numerous species of anthropophilic black flies are distributed throughout Southeast Asia and have been a significant source of human discomfort. A list of black fly species reported from Southeast Asia is included in Table 8.

12. Siphonaptera (fleas). Flea bites can be an immense source of discomfort. The typical fleabite consists of a central spot surrounded by a reddish (erythematous) ring. There is usually little swelling, but the center may be elevated into a papule. Papular urticaria is seen in persons with chronic exposure to fleabites. In sensitized individuals, a delayed papular reaction with intense itching may require medical treatment.

Fleas are extremely mobile, jumping as high as 30 cm. Biting often occurs around the ankles when troops walk through flea-infested sites. Blousing trousers inside boots is essential to provide a barrier, since fleas will crawl under blousing garters. Fleas may be encountered in large numbers shortly after entering an abandoned dwelling, where flea pupae may remain in a quiescent state for long periods of time. The activity of anyone entering such premises will stimulate a mass emergence of hungry adult fleas.

The most common pest fleas encountered in Southeast Asia are the cosmopolitan cat and dog fleas, *Ctenocephalides felis* and *C. canis*, the Oriental rat flea, *Xenopsylla cheopis*, the related *X. astia*, and the human flea, *Pulex irritans*. Flea species reported from Southeast Asia are listed in Table 4.

13. Tabanidae (deer flies and horse flies). Tabanids are large, stout-bodied flies with well-developed eyes that are often brilliantly colored. More than 4,000 species have been described worldwide. Relatively little surveillance for Tabanids has been done in this region, their medical importance here is limited mainly to nuisance biting, and data sources are rather scattered, so no compiled listing has been attempted herein.

The larvae develop in moist or semiaquatic sites, such as pond margins, salt marshes or damp earth. The immature stages are unknown for most species. Mature larvae migrate from their muddy habitats to drier areas of soil to pupate. Larval development is usually relatively slow, and many species spend 1-2 years as larvae. In temperate regions the entire life cycle can take >2 years to complete.

Horse fly larvae are carnivorous and cannibalistic, whereas deer fly larvae feed on plant material. Consequently, deer fly populations can reach considerably higher numbers in the same area. Carnivorous tabanid larvae occasionally bite humans, such as military personnel walking barefoot in rice fields or other areas containing such larvae. These bites can be quite painful. Deer flies, typically 8-15 mm long, are about half the size of horse flies, which range from 20 to 25 mm long. The most common tabanid genera containing man-biting species are *Chrysops* (deer flies), and *Tabanus* and *Haematopota* (horse flies). *Chrysops* and *Tabanus* have a worldwide distribution. *Haematopota* spp., also called clegs or stouts, are common in Southeast Asia.

Only female tabanids bite (take a bloodmeal), and nearly all species feed on mammals. Males feed on flower and vegetable juices. Tabanids are diurnal and are most active on warm, sunny days with low wind speeds, especially during the early morning and late afternoon. Adults are powerful flyers with a range of several kilometers. They are very persistent biters, and their painful bites are extremely annoying. They locate their hosts mainly by sight (color and movement), although olfactory stimuli like carbon dioxide and other host odors are involved.

Tabanids lacerate the skin with scissor-like mouthparts and ingest the blood that flows out into the wound. Their mouthparts are large enough to penetrate many types of clothing. Some species can consume as much as 200 mg of blood. The feeding wound usually continues to ooze blood after the fly has fed. Tabanid bites often become secondarily infected, and systemic reactions may occur in hypersensitive individuals.

The mouthparts and feeding behavior of tabanids are well suited to mechanical transmission of blood-borne pathogens, and these flies have been incriminated in the transmission of tularemia. Because their bites are painful, tabanids are frequently disturbed while feeding and move readily from host to host. In Southeast Asia, tabanids are not reported vectors of any human disease, so far, but are serious pests of livestock and transmit several diseases of veterinary importance.

Tabanids are difficult to control. Larval control is impractical due to the difficulty in locating breeding places. Since larvae of most species live below the surface of the soil, insecticides would not penetrate the soil and vegetation and contact the immature stages. ULV aerosols are generally ineffective against adults. Localized control can be achieved around military encampments using a variety of simple traps. The skin repellent DEET is only moderately effective against tabanids.

B. Venomous Snakes of Southeast Asia. There are 60 species of venomous terrestrial snakes and at least 19 species of venomous sea snakes reported from Southeast Asia. Of these, however, only a small number are commonly encountered and likely to inflict a venomous bite. For a more complete list of venomous snakes and their distribution in Southeast Asia, see Table 9. The families of venomous snakes present in the region include: Colubridae, Elapidae, Hydrophiidae, and Viperidae (including both vipers and pitvipers). The biology and distribution of only some of the most important species from each family will be detailed here. For more details about other snakes listed in Table 9, please search (by species, or by country) the LHD on the AFPMB website, at: www.afpmb.org .

1. Colubridae. Most species in this family are aglyphous (*i.e*., have no fangs), but some species, and certain whole genera, have enlarged and grooved rear fangs and factors in their saliva which may have relatively potent effects on other animals if they are introduced (injected) in even small amounts. At least two rear-fanged genera widespread in Southeast Asia have been repeatedly reported to have such potent saliva (essentially a mild venom). These are the cat snakes, genus: *Boiga*, and the keelbacks, genus: *Rhabdophis*. The venom of most of these snakes is rarely lethal, but human fatalities caused by this species have been reported.

The mangrove snake, *Boiga dendrophila*, is a large fairly slender snake (2-2.5 m long) with a large head and mouth (an adult specimen can swallow a squirrel), with relatively large, fixed rear fangs. The body color is usually glossy-black with bright yellow bands, yellow lips and throat, and a black-and-yellow belly. Its eyes are grey with vertical pupils. This species is mainly active in late afternoon and evening, often basks in the sun in trees 15 ft or higher above ground. They eat mainly birds (and their eggs) or small mammals, but also lizards, frogs, and other snakes.

They often "hang on" when they bite, and may inject significant amounts of venom from their rear fangs. A female may lay 4-15 eggs per clutch in a tree hollow or suitable site on the ground. A given specimen usually becomes mature at about 6-7 ft. body length. Their venom and bite effects have not been well studied, but effects in small mammal pets and human children have included: drooping eyelids, reduced muscle tone near the bite, poor coordination, depressed heart rate, respiratory distress, swelling and discoloration of skin a considerable distance from the bite.

Human fatalities reported to have been due to envenomation by this species have not been well documented and may have actually been due to bites by misidentified kraits (*Bungarus* spp) native to the same areas. This is a closely related species to the Brown Tree Snake (BTS), *Boiga irregularis*, which sometimes bites people, especially young children, and has devastated populations of wild native birds and other native animals on Guam.

The tiger keelback, *Rhabdophis tigrinus*, has been a popular species in the pet trade in Europe and the U.S. for a number of years, despite several well-documented fatalities of careless human handlers. Tiger keelbacks are medium-sized, fairly slender, cylindrical, freshwater snakes with keeled dorsal scales and ungrooved enlarged upper rear fangs. Adults are usually 50-60 cm long (max. 70 cm). Their body color varies from almost a uniform greenish-brown with a pale belly, to a striped pattern with black bands on a reddish or greenish-brown background.

These are found mainly in lowland brush-covered or grassy fields adjacent to streams, ditches, or paddies in eastern and Southeast Asia. They are mainly nocturnal but are often active in daytime, and are semi-aquatic. When threatened, a keelback will rear the forepart of body, and laterally flatten its neck (displaying a sort of "hood"). This reveals very bright yellow (sometimes orange) underlying skin between all its scales. These are usually reluctant to bite unless seriously molested or restrained. They mainly prey on frogs and toads, or fish. Females are oviparous, usually laying 18-25 eggs per clutch.

2. **Elapidae**. <u>Cobras</u> are the dominant group of terrestrial elapid snakes throughout Southeast Asia. The king cobra, *Ophiophagus hannah*, is the most feared of the cobras in the region. It normally grows to 3.5-4.3 m long (rarely to 5.5 m). This olive-green snake, with a yellow throat, can raise its body one-third of its length off the ground. Unlike other cobras in the region, it has only a relatively narrow hood, which is not very obvious even when fully spread. This snake hunts other snakes, mainly during the day. It lives in jungles, mangrove swamps, and plains with heavy rainfall, and is most active during the monsoon season.

The female lays 20-40 eggs in a nest of dead leaves and twigs and remains coiled around the nest for 60-90 days until the eggs hatch. The young are 0.5 m long and black when born. The king cobra's neurotoxic venom is not as potent as that of many other cobras. However, the large quantity of venom often injected during a bite causes high mortality in people and large animals, including elephants.

Despite its massive size and fierce reputation, the king cobra is not very aggressive. Much more deliberate in its actions than the smaller, more excitable cobras (*i.e*., *Naja* spp.), it will quickly crawl away if given the opportunity. King cobras can be aggressive while defending a small territory around their nest containing eggs.

Typical hooded cobras include the diocellate cobra (*Naja naja*), and the monocled cobra (*N. kaouthia*). These can be distinguished by the markings on their hoods. The monocled cobra has a single round spot, called the ocellus (plural, ocelli), on its hood while the diocellate cobra has two ocelli on its hood. None of these snakes is more than half the length of a fully grown king cobra but each is usually much more excitable.

A cobra cannot strike upward, only downward, and rather slowly compared to many species of vipers. They usually lay their eggs in rat burrows, termite mounds, or other sheltered places. They feed at night on rats and mice. Snake charming is a street entertainment in India and several other Asian countries. Some snake charmers perform using normal, fully lethal snakes. Others protect themselves by removing the snake's fangs, tying shut its venom ducts, or sewing its lips closed. Others use normal snakes, but train them not to strike. The cobra follows the motion of the flute and is not actually "charmed" by the music.

Kraits are the next most prominent group of elapid snakes. They have a characteristic appearance of hexagonal scales and striking whitish or yellowish bands on the body. They are small snakes (1.0-1.7 m) and are usually mostly blue or black in color. The mouth and fangs are small. The shape of the tail ranges from pointed to blunt. Kraits are most active at night and hunt other snakes, rodents or lizards. These snakes are generally timid unless disturbed.

Their venom is neurotoxic and sometimes fatal but, unlike cobras, there is no swelling or burning at the bite site. The most common snakes in this group are the Malayian or blue krait (*Bungarus candidus*), the banded krait (*B. fasciatus*), the many banded krait (*B. multicinctus*), and the Sri Lankan krait (*B. ceylonicus*). Of these kraits, the bite of *B. multicinctus* is most likely to be fatal.

Coral snakes are another group of elapid snakes that are closely related to kraits. They are small and often brightly colored. Their bodies are slender and often have a pinkish coral color on their bellies. The most prominent coral snakes are *Callophis melanurus* (slender coral snake), *C. nigrescens* (striped coral snake), and *C. beddomei* (Beddome's coral snake). Although their venom is very toxic, they have small mouths and short fangs, requiring them to chew the venom into their prey.

The Malayian or blue krait, *Bungarus candidus*, is medium to large, with adults usually 1.2-1.4 m long (max. about 1.5 m); 15 longitudinal dorsal rows of smooth scales at midbody, a distinct mid-dorsal ridge, 19-30 black alternating with white or yellowish dorsal crossbands speckled with black on body and tail; belly pure white, head not distinct from neck, tail ends in a sharp tip. This species is most common in lowland forests and moist areas in Cambodia, Indonesia (Java, Sumatra, Bali, Salawese), Malaysia, Singapore, Thailand, and Vietnam.

This species is nocturnal and usually very timid (especially in daytime). They become active at dusk and after dark. They will not usually bite unless stepped on. These are often found near human habitations and on trails at night. They mainly eat other snakes, their eggs, and available other small animals. Females are oviparous, with a probable clutch size of 3-12 eggs. This species has potent neurotoxic venom. Most victims are bitten while asleep in huts at night. Local symptoms of envenomation are generally minimal and may include abdominal discomfort, headache, and giddiness. Neurotoxic symptoms may include ptosis, facial paralysis, and inability to open the mouth, or extrude the tongue. Human fatalities have been reported but are rare.

The banded krait, *Bugarus fasciatus*, is a medium to large-sized, terrestrial, smooth scaled snake, with one pair of upper fixed front fangs, adults are usually 1.0-1.2 m long (max. reported is 2.1 m). They have a pattern of alternating light and dark bands circling their body. Light bands are pale to bright canary yellow; dark bands are usually black, and wider. Their tail is blunt, and they have a distinctive light spear-shaped mark, bordered by black, on top of their head, and a distinct vertebral ridge for most of their body length.

This species is most commonly found in grassy fields, meadows, and cultivated areas, often adjacent to streams, rivers, or lakes. Banded kraits have been found up to 1,500 m elevation in Burma (Myanmar), Brunei Darussaam, southern China, India, and Indonesia (most of Southeast Asia). They are normally terrestrial and mainly nocturnal, but may prowl in the daytime during and soon after a rain. This species is usually inoffensive and secretive. They will hide their head beneath their body if disturbed. They may twitch or writhe spasmodically but seldom attempt to bite even when molested.

Females are oviparous (as are all kraits) with usually 8-11 eggs per clutch. They have potent neurotoxin, which causes minimal local pain, redness, or edema. Systemic symptoms of envenomation by this species usually develop slowly and include general achiness, various degrees of paralysis, shock, and respiratory failure. Bites of humans are rare, but human fatalities due to envenomation by this species have been reported.

The many-banded krait, *Bungarus multicinctus*, is a medium to large-sized snake, with smooth scales, a distinct vertebral ridge, and one pair of upper fixed front fangs. Adults are usually 0.8-1.0 m long (max. reported was 1.8 m). their body is usually black or bluish-black, with 21-30 white or creamy white cross bands (plus 7-11 whitish bands on their pointed tail), and 15 longitudinal dorsal rows of scales at midbody. Their belly is usually white or dirty-white.

This species is most commonly found in open woodland, grassy fields, and bamboo groves adjacent to water, such as ditches, rice paddies or streams. They may also be found in villages and suburban areas. This species is fairly geographically wide spread, and has been found up to 1,300 m elevation in southern China, Burma, Indonesia, and (less frequently) throughout most of Southeast Asia. This species is terrestrial, strongly nocturnal, sluggish by day, and more active at night. They eat mainly other snakes, but also available lizards or amphibians.

Many-banded kraits have extremely potent neurotoxic venom. There are usually few or no local symptoms of envenomation. Their bite is usually felt as a pin-prick followed by slight itching, numbness, or redness, and any local swelling is usually minimal. Systemic symptoms of envenomation may include nausea, vomiting, ptosis, inability to speak, swallow, or open the mouth, chest tightness, and breathing difficulties. A number of human fatalities due to bites by this species have been reported.

A third group of elapids in Southeast Asia are the <u>Asian Coral Snakes</u> in the genus: *Calliophis* (which now includes the former genus: *Maticora*). They are closely related to the kraits, but are usually smaller, often brightly-colored, and usually have less potent venom. At least five species are reported from this region. The most widespread and best known species include: the long-glanded (Asian) coral snake, *Calliophis bivirgatus*; the brown long-glanded coral, *Calliophis intestinalis*; and MacClelland's coral snake, *Sinomicrurus (* formerly *Calliophis) macclellandi*. More details of their biology, behavior and distribution are available via a search of the LHD on the AFPMB website.

3. Viperidae. Snakes in the family Viperidae have fangs that are long and tuck into the roof of the mouth when not in use. There are 2 prominent venomous subfamilies in this region, the Viperinae (true vipers), and the Crotalinae (pit vipers). A third subfamily: Azemiopinae, includes only one species, *Azemiops feae*. The toxicity of it's venom to man is unknown. It is a relatively small snake (<1 m long) seldom encountered by humans.

a. Subfamily: Viperinae. Russell's viper (*Daboia russelli*) is the only species of true vipers in Asia, but it is very wide spread and significant in terms of encounters with humans and resultant lethal envenomations. It has a V-shaped mark pointing forward on top of its broad, flat, triangular head. Individual specimens may grow to 1.3 m in length, and each has 3 longitudinal rows of reddish-brown spots or rings, but only the dorsal row is complete. The body color varies among 3 different forms of this species, but the pattern of rings is consistent.

Russell's viper inhabits plains and hills up to 1,000 m and prefers open plains and bushy or abandoned rocky areas, where it hunts lizards, toads, and small mammals at night. It is extremely aggressive during encounters with humans and often inflicts a lethal envenomation. The young are produced viviparously, 20-60 per litter. When threatened, this snake produces a strong hissing sound.

b. Subfamily: Crotalinae. The pitviper subfamily, Crotalinae, includes at least 20 different species in Southeast Asia. Most of them have flat, somewhat triangular heads, relatively slender bodies, and usually relatively short tails. Unlike most other snakes, pit vipers have a heat-sensing pit located between each eye and its nearest nostril. Many of these species also have a distinctly different body color and pattern as juveniles than as adults. Most of these are mainly terrestrial, but some are almost exclusively arboreal (*e.g*., several species of the "tree," or "bamboo," vipers), and most of these are mainly nocturnal. Some of these species are aggressive when disturbed (*e.g*., *Protobothrops mucosquamatus*, the mangrove or shore pitviper), but others are very docile (*e.g*., Wagler's temple pitviper, *Tropidolaemus wagleri*). They live in a wide range of habitats, varying by species. One or more species of these may often be encountered in fruit, tea, or other agricultural plantations, usually resting or hunting under shrubs or leaf litter. Some of the most common, important, and wide spread species in this region include:

The Malaysian pitviper, *Calloselasma rhodostoma*, is moderately stout, terrestrial, with smooth scales. It typically has 19-31 dark triangular marks along each side of its body which point toward or meet at its dorsal midline. Its background body color is light to dark reddish or purple-brown. It prefers fairly dry, forested lowlands (but is found up to 2000 m elevation), but it is most active after dark, when the surrounding air is very humid. It has a upturned, somewhat pointed snout, and a distinct latero-dorsal ridge from each eye to its snout. A female usually lays 13-30 eggs per clutch, then guards them during their 5-7 week incubation. Juveniles usually have bright yellow tails, sometimes used to lure prey closer. They hunt via ambush and eat available toads, frogs, birds, rodents, and even other snakes.

The white-lipped green tree (or bamboo) pitviper, *Trimeresurus albolabris*, is a fairly slender, arboreal pitviper with keeled scales, green dorsally and whiutish or yellowish-green ventrally. Its prehensile tail is partly or completely reddish-brown. It is wide spread in Southeast Asia, and prefers fairly open country below 400 m elevation, but it is often found in urban areas, too. It rests in vegetation above ground during the day and hunts mainly at night. It usually blend into surrounding vegetation very well. Females are ovoviviparous, usually bearing 7-16 live young per litter, They usually hunt available mice, lizards, birds and frogs on the ground at night. This species is responsible for a number of human bites and envenomations every year in the region.

4. Hydrophiidae. Sea snakes are all venomous and possess fixed upper front fangs like their close relatives the elapids. There are currently 19 species in the family: Hydrophiidae reported from Southeast Asia. Some authorities still consider these to be only a separate subfamily under Elapidae. There are distinct biological and behavioral differences between true sea snakes and sea kraits (addressed below). All sea snakes must come to the surface to obtain air. Their nostrils are located dorsally on the snout and have valves that they can close to keep out water. Their bodies are laterally compressed, and their paddle-like tails make them excellent swimmers. Sea snakes can dive up to 160 m, although generally they all usually inhabit much shallower water, seldom deeper than about 30 m. Sea snakes feed on fish, crustaceans, or other marine life, with some highly specialized and others more general feeders.

Sea snakes in the subfamily Hydrophiinae are so specialized for sea life that they are virtually helpless on land. They give birth to living young. Sea snakes are most numerous and are most often encountered by people during the monsoon season in Southeast Asia, when they may move into rivers and close along the coast. They are commonly encountered by fishermen, who are frequently bitten as they handle fish in their nets.

The yellow-bellied sea snake, *Pelamis platurus,* is the most widely distributed of all sea snakes and frequently goes into freshwater rivers for extended periods, sometimes months. It also is found at the surface of the open ocean as it drifts with currents. This snake requires tropical waters where the average monthly temperature is at least 20^{o}C. Unlike most sea snakes, it frequently occurs in large numbers in water slicks along the sea surface where it preys upon fish. This species will frequently go into a feeding frenzy and bite anything in its surroundings. Skin shedding is frequent and may occur as often as every 12 days.

The venom of nearly all sea snakes is mainly neurotoxic, and is quite potent. People are rarely envenomated by the yellow-bellied sea snake because it is necessary for these small-mouth snakes to get very close to a victim before they can inject enough venom to cause serious or human-lethal effects. Reportedly, only about 3% of persons envenomated by this species have actually died. Death has usually been caused by toxicity at neuromuscular junctions, resulting in respiratory failure.

Sea kraits are in the sub-family: Laticaudinae in the family Hydrophiidae, herein, but some authorities grant them the rank of a separate family. The yellow-lipped sea krait, *Laticauda colubrina*, is the most widespread of three species of sea kraits found in marine coastal waters in Southeast Asia. This is a rather large, fairly thick-bodied sea krait, with adults usually 0.9-1.2 m long (max. about 1.4 m). Their body is usually bluish-gray with black crossbands which often encircle the whole body. Their belly is usually whitish to cream (with expanded scales or scutes). The front of their head has a broad cream or whitish band from one eye around to the other, which includes both lips. Their tail is laterally flattened and "oarlike."

This species is mainly found in marine waters and (sometimes) on adjacent land along nearby coasts, mainly in the regions of the eastern Indian and the southwestern Pacific Oceans. This species is very docile and seldom ever attempts to bite even when handled. They eat eels (*e.g*., moray, zebra & conger eels) almost exclusively.

These snakes are very agile while crawling over land (usually at night), for considerable distances. They typically hunt prey in marine waters, and come ashore (or onto rocks or pilings) to mate, lay eggs, digest their meals and drink fresh water. Females are oviparous and usually lay 4-20 eggs per clutch. Their venom is mainly neurotoxic with one or more myotoxic factor(s). They produce and inject a rather small volume of venom in any given bite. Bites of humans are rare but a few have been reported. No significant human envenomations or fatalities caused by this species have been documented, so far.

The reported species and distributions of venomous snakes in Southeast Asia are listed in Table 9. Antivenoms, their suggested use, and/or their current procurement and sources are beyond the scope of this DVEP. Current information on these and closely related topics must be sought through medical sources, possibly including a search of certain publicly accessible websites, such as: the Toxinology website, www.toxinology.com/; the WHO sub-page on animal sera and antivenoms, http://www.who.int/bloodproducts/animal_sera/en/; the U.S. CDC sub-page on venomous snakes (limited to U.S. species, but includes good general prevention and first aid advice), http://www.cdc.gov/niosh/topics/snakes/.

C. Medical Botany.

1. Plants that Cause Contact Dermatitis. Plant dermatitis is a problem of enormous magnitude. Categories of dermal injury caused by plants include mechanical injury, immediate or delayed contact sensitivity, contact urticaria, phototoxicity and photoallergy, primary chemical irritation, or some combination of these. Some of the most common plants which have been reported to cause contact dermatitis in Southeast Asia are listed in Table 10.

Members of thegenus *Rhus* (poison ivy, oak, and sumac) are usually among the most frequent causes of acute allergic contact dermatitis wherever they occur. About 70% of the U.S. population is sensitive to urushiol in the sap of these plants. Any part of the skin surface of a sensitized individual may react upon contact with *Rhus* spp. Urushiol remains active for up to 1 year and is easily transferred from an object to a person, so anything that touches poison ivy (clothing, tools, animal fur, sleeping bags) can become contaminated with urushiol and later cause dermatitis in a sensitive person who touches the object. Even smoke from the burning plants (any parts) can produce a severe allergic response. Barrier creams have been developed to prevent contact dermatitis in people sensitive to urushiol but they are only limitedly effective.

Allergy to poison ivy, oak and sumac may also mean a person is allergic to related plants in the same family (Anacardiaceae), including cashews, pistachios, mangos and Chinese or Japanese lacquer trees (*Toxicodendron verniciflua*). A thick viscous sap from the bark of the Japanese lacquer tree is often used for varnishing furniture and many other objects. Once applied, the lacquer may retain its allergenicity for many years. The ginkgo tree, *Ginkgo biloba*, is native to western China but is widely planted along streets and in gardens in many countries. Its fruit contains compounds similar to urushiol that can cause a contact dermatitis resembling poison ivy dermatitis.

Contact urticaria may result from immunological or non-immunological host responses, although the latter is more common. Nettles, such as *Urtica* spp. and *Laportea* spp., are examples of plants that cause non-immunological contact urticaria. These plants have hollow stinging hairs that introduce a chemical after they penetrate the skin. A burning sensation and pruritis usually occur almost immediately. Urticaria from contact with the hairs of some plants can be severe, persisting for days or weeks.

A number of cultivated plants of the carrot and rue families sensitize the skin to long-wave ultraviolet light (causing phytophotodermatitis). Within 6 to 24 hours of contact with the plant and exposure to sunlight or certain wavelengths of fluorescent light, the area of contact will selectively burn. In some cases, hyperpigmentation may persist for several months. Several *Heracleum* species contain phototoxic furcocoumarins.

Some plants contain primary chemical irritants that produce skin damage resembling that from contact with a corrosive acid. The reaction depends on the potency of the irritant. The most serious reactions involve the eye. *Daphne* spp. and *Mucuna* spp. are examples of plants containing chemical irritants. The latex (milky sap) of numerous *Euphorbia* spp. is highly irritating and some kinds may cause blindness if they contact the eyes.

Mechanical injury by splinters, thorns, spines and sharp leaf edges can produce visual impairment or introduce fungal and bacterial infections at the wound site. Various plant thorns and spines may introduce infective microorganisms, including the causal organism of tetanus, *Clostridium tetani*, into the skin and/ or subcutaneous tissues. Some dried seeds are hygroscopic and can cause severe discomfort due to swelling of the plant tissues when lodged in the auditory canal or certain other body cavities.

Many bulbs and some plants, notably *Dieffenbachia*, the popular house plant known as dumb cane, contain calcium oxalate crystals in their sap. This water-insoluble salt forms bundles of needle-like crystals that can cause severe irritation with they become embedded in the skin or mucosae, usually puncturing many of their surface cells (which later die and slough off). Plant juice containing calcium oxalate usually causes severe pain when splashed into the eyes, and calcium oxalate crystals may penetrate the cornea.

2. Systemic Toxicity from Ingestion of Plants. Most wild plants contain toxic components, and military personnel must be instructed not to consume local plants unless necessary for survival. Wild plants are usually difficult to identify and poisonous plants can easily be mistaken for plants with parts safe to eat. Military personnel will be forced by necessity to consume wild plants during survival operations. To avoid accidental poisoning, they should be thoroughly trained to recognize common edible plants in the region. Local inhabitants may be knowledgeable about poisonous plants in the area.

The cashew nut, *Anacardium occidentale*, is extremely toxic if eaten uncooked, and the plant's resin can cause severe dermatitis. The cashew nut shell, but not the kernel, contains a brown oily juice that is a strong contact allergen. Roasting the shell liberates irritating vapors. Wherever cashews are grown commercially, cashew nut dermatitis often affects thousands of workers. Cashews are found mainly in tropical climates but are not widely grown in Southeast Asia.

Many plants have fruiting bodies or have attractive parts that appear edible. *Ricinus communis*, the castor bean plant, has highly ornamental, oval seeds. Castor oil is derived from the seeds. The plant is native to Asia and may be grown commercially in some tropical areas of Southeast Asia. All parts of the plant, especially the seeds, contain ricin, one of the world's most toxic substances. If the beans are swallowed whole, the hard coat reduces or prevents absorption and therefore inhibits poisoning, but 2 to 6 beans could be lethal to an adult human if well chewed. One or 2 seeds could be lethal to a child. The fruit of the ginkgo tree, *Ginkgo biloba*, contains a nut that has a sweet taste when roasted. However, it is surrounded by a foul-smelling fleshy layer that can cause gastroenteritis if eaten.

Seeds of *Abrus precatorius* (also called rosary pea, precatory bean, prayer vine or crab's eye) possess one of the most powerful plant toxins known. One or two seeds, if thoroughly chewed, are capable of killing an adult human. The proteinaceous toxin, abrin, is similar in toxic effects to that of ricin. It is readily absorbed through the digestive tract and causes serious and often fatal clotting in the bloodstream. The attractive seeds are part scarlet-red and part shiny black. They may be used in making rosary necklaces or other costume jewelry in some countries, although this practice is illegal in the U.S.

All species of *Datura*, particularly the jimson weed, *Datura stramonium*, contain belladonna alkaloids. The entire plant is toxic, including the nectar, but the berries are involved in most accidental poisonings. Only about 5 grams of leaves or seeds, or just a few berries, can be lethal for a child. *Daphne* spp. are widely planted as ornamentals. The fragrant flowers of these small shrubs bloom in the early spring before the leaves appear. They are among the oldest plants recognized to be poisonous. Of all the *Daphne* species, *D. mezereum* is the most deadly.

Some military personnel may be tempted to consume plants because they are used locally for various purposes. Local lore may claim medicinal qualities, psychotropic or aphrodisiac effects to native plants. Betel nut, *Areca catechu*, is chewed in many Southeast Asian countries, mainly in rural areas. The plant contains an alkaloid, arecoline, with many pharmacological properties. Serious illness can be associated with its use, including asthma exacerbation, cholinergic crisis, cardiac arrhythmias, acute psychosis, milk-alkali syndrome, and mouth or throat tumors from long-term use. Betel nut may be mixed with other substances, depending on local customs.

Medical personnel and combat commanders must be aware that some troops will be tempted to experiment with native plants. Military personnel should not chew on any part of any unfamiliar plant or use unfamiliar plants for fuel or cooking materials. In most cases of poisoning, care is usually symptom driven. The age and medical condition of the patient influence toxic response and medical treatment. Special monitoring and specific drug therapy are indicated in some instances. Because life-threatening intoxications are rare, military medical personnel may have little experience in management of plant poisoning. It is inappropriate to assume that the toxicity exhibited by a single member of a genus will apply to all other species of that genus or that all toxic members of a genus will have similar effects.

Most toxic plants, regardless of their ultimate effects, induce fluid loss through vomiting and diarrhea. This is important when military personnel are operating in hot, arid areas. Plant toxicity varies with the plant part, maturity, growing conditions, and genetic variation (among other factors). USACHPPM Tech Guide 196, Guide to Poisonous and Toxic Plants, provides information on toxic plants common in the U.S. that also occur in other regions of the world. It includes a list of state and regional poison control centers, which may be helpful in the U.S. and some adjacent or nearby countries. For additional information, contact ISD, AFPMB. The web site: "www.toxinology.com" may offer potentially helpful additional information or advice.

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"Link for Rick Vetter's web site, Brown Spider (recluse) stuff" at: http://spiders.ucr.edu/"

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Appendix A. Links to Tables (XL Files) cited in the body of this DVEP.

Table 1 - Southeast Asian Mosquitoes

Table 2 - Southeast Asian Malaria Vector I

Table 3 - Ticks of Southeast Asia

Table 4 - Fleas reported Southeast A

Table 5 - Phlebotomine Sand Fl

Table 6 - Culicoides Sand Flies - Southeas

Table 7 - Scorpions of Southeast Asia

Table 8 - Black Flys of Southeast Asia

Table 9 - Venomous Snakes of Southeast

Table 10 - Hazardous Plants of Southeast A

Appendix B. Pesticide Resistance in Southeast Asia.

Vector-borne diseases are an increasing cause of death and suffering in many areas of the world. Efforts to control these diseases have historically been founded on the use of chemical pesticides. However, the spread of resistance among arthropods has rendered many pesticides ineffective, while few substitute pesticides are being developed. Resistance has been reported to every class of insecticides, including microbial agents and insect growth regulators.

Resistance is formally defined by the WHO as "the development of an ability in a strain of some organism to tolerate doses of a toxicant that would prove fatal to a majority of individuals in a normal population of the same species." Resistance has a genetic basis and is the result of a change in the genetic composition of a population as a direct result of the selection effects of the pesticide.

Early detection and monitoring are vital to resistance management. Historically, standardized methods, test kits and insecticides were provided by WHO. The simplest method of detecting resistance is the diagnostic dose test. The diagnostic dose is a predetermined insecticide dose known to be lethal to a high proportion of susceptible individuals, but that a high proportion of resistant individuals can tolerate. A list of recommended diagnostic doses of many insecticides for a number of arthropod vectors is available from WHO via a search of their website, www.who.org". For terrestrial and/or adult stages, the insecticide is either applied topically or insects are exposed to a pretreated surface. For aquatic stages, insecticide is added to water at given predetermined concentrations.

New approaches use rapid biochemical tests to detect resistance and determine resistance mechanisms. These methods permit rapid multiple assays of a single specimen. Worldwide application of biochemical assays will require production of standardized kits similar to the insecticide bioassay kits supplied in the past by WHO. The choice of method to test for resistance is of great importance in order to determine resistance mechanisms. Consult TG 189, Procedures for the Diagnostic Dose Resistance Test Kits for Mosquitoes, Body Lice, and Beetle Pests of Stored Products. To inquire about test kits and additional recommendations for resistance testing contact:

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Pesticide resistance can be classified into 2 broad categories: physiological and behavioral. There are many mechanisms of physiological resistance, including reduced penetration of insecticides through the cuticle, presence of enzymes that detoxify the insecticide, and reduced sensitivity of the target site of the insecticide. Physiological resistance can confer cross-resistance to structurally related insecticides of the same chemical class or related classes. Some vector populations have acquired several resistance mechanisms providing multiple resistance to a variety of insecticide classes. Many vector control programs have reached a stage where resistance is so great that few chemical alternatives are available.

In recent years, synthetic pyrethroids have replaced widely used classes of insecticides such as organophosphates, carbamates, and chlorinated hydrocarbons. These pyrethroids have shown great promise for vector control due to their low mammalian toxicity and ability to quickly immobilize and kill arthropods at low dosages. Unfortunately, resistance has been detected in several medically important arthropods. An issue of concern in vector control is whether DDT resistance confers cross-resistance to pyrethroids as a result of similar resistance mechanisms. Increasing pyrethroid resistance is of particular concern to the U.S. military because of the widespread use of permethrin and other pyrethroids on uniforms, bednets, and in vector control programs. Studies indicate that resistance appears rapidly in areas where treated bednets are used to reduce mosquito-borne disease transmission.

Changes in behavior that result in reduced contact with an insecticide include a reduced tendency to enter treated areas or an increased tendency to move away from a surface treated with insecticide once contact is made. These are population-based changes in a species' genetics resulting from the selection pressure of insecticide use. Avoidance behavior is widespread but poorly understood. Some form of behavioral avoidance has been documented for virtually every major vector species. Methods to detect and determine behavioral resistance have not been standardized and are difficult to interpret.

Pesticide resistance will be an increasing problem for vector control personnel. More than 90% of all pesticides are used for agricultural purposes. Insecticide resistance in at least 17 species of mosquitoes in various countries has occurred because of indirect selection pressure by agricultural pesticides. The agricultural use of insecticides in rice paddies has greatly contributed to the development of resistance in several species of *Anopheles* and *Culex* in many areas of Southeast Asia.

Innumerable genetic, biologic and operational factors can influence the development of insecticide resistance. A pesticide use strategy that will prevent the evolution of resistance has not been developed. Tactics to manage or delay the development of resistance include: 1) using nonchemical methods of control as much as possible, 2) varying the dose or frequency of pesticide application, 3) using local rather than area-wide application, 4) applying treatments locally only during outbreaks of vector-borne diseases, 5) using less persistent pesticides, 6) treating only certain life stages of the vector, 7) using mixtures of pesticides with different modes of action, 8) using improved pesticide formulations, 9) rotating pesticides having different modes of action, and 10) using synergists.

Reports of resistance must be interpreted carefully. Many reports of resistance for a vector species are based on single data sets from a single point within a country and may be years if not decades old. Resistant populations tend to revert to susceptible status once insecticide selection pressure has been removed. Isolated reports of resistance, although recent, may indicate local resistance that has not become widespread. Vector control personnel frequently assume that resistance in a particular species occurs throughout their control area but, in reality, insecticide resistance is focal. The length of time an insecticide has been used at a location may not be helpful in predicting the presence of resistance. Vectors in some countries have never developed resistance to DDT, despite decades of use in malaria control. Only appropriate resistance monitoring can guide the vector control specialist in the selection of a suitable insecticide.

The newest strategie(s) for detecting and quantifying resistance to insecticides involve characterizing specific genetic markers (indicative of genes or their function) for a particular vector species, then using precise molecular techniques (PCRs) to detect the presence and prevalence of these in representative samples of field populations of that species. The whole genomes of several important vector species (*e.g.*, *Anopheles gambiae*, *s.s.*) have recently been characterized in scientifically peer reviewed journal articles. These efforts still rely on fairly expensive and limitedly available equipment, reagents, and qualified technicians which are seldom readily available in developing countries or remote sites.

Appendix C - Cyclone Nargis: Myanmar - Snakebite Emergency Management

Cyclone Nargis: Myanmar - Snakebite Emergency Management

Key Medically Significant Species: Russell's viper (85% of bites) (Haemotoxic + shock + renal failure), Green Pit Vipers (Haemotoxic), Monocled Cobra, Kraits (Neurotoxic)

First Aid:
No tourniquets, cutting and or sucking.
Reassure the patient, Immobilise whole patient especially the bitten limb, Get to Hospital fast, Tell the doctor about signs such as bleeding, shock or drooping eyelids that develop on way to hospital.

Treatment: Assess Patient for at least 24 hours

Give antivenom (AV) ONLY if:

1. Incoagulable blood measured by 20 Minute Whole Blood Clotting Test (20WBCT) in NEW, CLEAN, DRY, GLASS test tube or vessel (see below).
2. Low blood pressure (less than 90 mmHg systolic) and/or shock. With lyophilised antivenom the reconstitution time will enable 20WBCT to be available.
3. **Visible neurological signs such as ptosis/ respiratory impairment**

AV Initial Dose:

1. Incoagulable blood 4 vials Myanmar* Anti-Viper, Russell's Viper AV over 1 hour
2. Neurotoxic signs 6 vials Myanmar* Bivalent *Daboia russelii*, *Naja kaouthia* AV over 1 hour

Myanmar Pharmaceutical Factory: Anti-Viper AV is effective ONLY for Russell's viper; Bivalent AV is effective ONLY for cobra. If not available, Thai monovalent Russell's viper (Initial Dose 5 vials) and Cobra (Initial Dose 10 vials) antivenoms may be used. Indian polyvalent antivenoms are NOT effective.

Anaphylactic Reaction to AV
0.5 mg Adrenaline IM (Adults); 0.01mg/kg (juveniles) thigh muscle
Wait 10-15 minutes if symptoms not improved repeat same dose
Support with 100mg Hydrocortisone and H1 Antihistamine
One or two doses of adrenaline will solve problem, then AV is restarted.

If Neurotoxic:
Measure single breath count i.e. ask patient to count aloud for the duration of one breath and record the number reached.
0.6 mg atropine given IV FOLLOWED BY 1.5 mg neostigmine given IM,
Repeat single breath count every 10 minutes for 1 hour
If it improves, give atropine as required followed by 0.5mg neostigmine every 30 minutes until recovery, if no improvement, stop atropine and neostigmine.

Monitor patient for 1-2 hours, if symptoms do not improve, or worsen i.e. paralysis descends repeat dose of 6 vials of AV. **Maximum 12 vials.**
If patient is unable to raise the head and shoulders off the bed, prepare for respiratory support with assisted ventilation by endotracheal tube, nasopharyngeal mask airway or tight fitting face mask.

If the patient is to be transported to another hospital for mechanical ventilation then use a resuscitation bag and, if available, improvise nasopharyngeal airways with size 5 rubber endotracheal tubes cut to the length of the distance between the nostril and the tragus. These will not trigger the gagging reflex and will provide more effective ventilation with flaccid paralysis.

If Haemotoxic: Monitor coagulation every 6 hours and repeat dose of 4 vials until blood becomes coagulable **Maximum 8 vials**

20WBCT is essential and measurement of haemoglobin concentration or haematocrit are important to detect occult bleeding and careful monitoring of urine output and measurement of blood urea/creatinine and potassium are important as renal failure is a high risk. If possible, move patient to a hospital with lab facilities and/or renal support after first dose of ASV.
If severely hypotensive, give fluid/ blood transfusion after first dose of ASV.

20 minute whole blood clotting test (20WBCT)

1. Place a few mls of freshly sampled venous blood in a small glass vessel.
2. Leave undisturbed for 20 minutes at ambient temperature
3. Tip the vessel once
4. If the blood is still liquid (unclotted) and runs out, the patient has incoagulable blood. In the South East Asian region, incoagulable blood is diagnostic of a viper bite and rules out an elapid bite

Warning! If the vessel used for the test is not made of ordinary glass, or if it has been used before and cleaned with detergent, or is wet, its wall may not stimulate clotting of the blood sample in the usual way and test will be invalid

If there is any doubt, repeat the test in duplicate, including a "control" (blood from a healthy person).