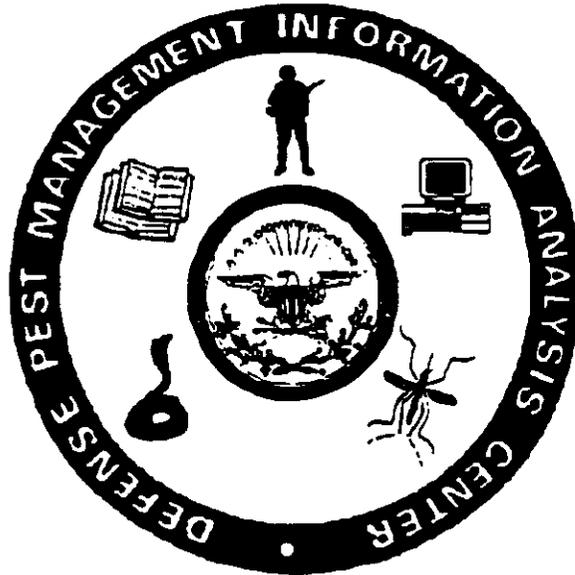


DISEASE VECTOR ECOLOGY PROFILE



THAILAND

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ARMED FORCES PEST MANAGEMENT BOARD
DEFENSE PEST MANAGEMENT INFORMATION
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PREFACE AND ACKNOWLEDGEMENTS

Disease Vector Ecology Profiles (DVEPs) are concise summaries of vector-borne and other militarily significant diseases that occur in specific countries. DVEPs focus on vector-borne diseases and emphasize essential epidemiology, vector bionomics, behavior, and pesticide resistance. Selected bibliographies of pertinent disease and disease vector literature are included.

DVEPs are not meant to serve as scientific documents but rather as synopses of relevant entomological and arthropod-borne disease information. They are compiled from unclassified scientific literature, and are intended to provide a historical profile of arthropod-borne disease epidemiology in the recent past for selected geographical areas. The epidemiology of arthropod-borne disease is dynamic, and incidence and prevalence are constantly changing. This is especially true for Third World countries which are undergoing rapid development and ecological change, and those areas experiencing migrations of large refugee populations as a result of civil strife. These documents should be supplemented with recent information on foreign public health status and medical developments. Component medical department activities may have updated regional information for their areas of responsibility. Current disease risk assessment and additional information on other parasitic and infectious diseases, and other aspects of medical intelligence can be obtained from the Armed Forces Medical Intelligence Center, (AFMIC) Fort Detrick, Frederick, MD 21701 (301-619-7574, DSN 343-7511). Additional information can be obtained from the Navy Preventive Medicine Information System (NAPMIS), which maintains up-to-date Disease Risk Assessment Profiles (DISRAPs) and Disease Risk Assessment Profiles (VECTRAPs) on most countries of the world. DISRAPs and VECTRAPS can be obtained by contacting the Navy Environmental Health Center (NEHC) (804-444-7575 extension 456, DSN 564-7575 ext 456).

DVEPs are designed to complement documents obtained from AFMIC and NEHC. Every effort is made to make them as accurate as possible. Individuals possessing additions, corrections, or suggestions are encouraged to communicate this information to Chief, DPMAIC, for incorporation into future revisions. In addition to DVEPs, DPMAIC can provide bibliographic literature searches of its extensive database on pest management, medical entomology, pest identification and pesticide toxicology. DPMAIC can also conduct online computer searches of other worldwide biomedical databases. DPMAIC (301-295-7479, DSN 295-7479).

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INTRODUCTION

The Kingdom of Thailand (also known as Siam during the periods 1855-1939 and 1946-1949) is located in the heart of Southeast Asia. The country is often described as shaped like an elephant's head because of the peninsular "trunk" which it shares with Burma on its western border. It is this narrow strip of land that forms most of the coast of the Gulf of Thailand and that connects its southern neighbor, Malaysia, to the southeast Asian landmass. Thailand's serpentine eastern border is formed by Laos in the north and Cambodia in the south.

Thailand has an area of 514,000 sq km (198,500 sq. mi.), equivalent in size to California. The Ministry of Health typically divides the country into four regions, as follows:

(1) Central Thailand dominates the country in terms of population, economics, and politics. Because of the vast Chaophraya River system and the rich alluvial plain, this area is agriculturally important and considered a major "rice bowl" of Asia. The capital city of Bangkok and the port of Chonburi are near the mouth of the Chaophraya and together have an official population of about 60 million people. Unofficially, the population in the metropolitan area may be 2-3 times that amount.

(2) Northeastern Thailand, or the Korat Plateau, makes up one third of the country. The Mekong River forms the country's border here between Thailand and its eastern neighbors, but the land itself is poor and suffers from alternating conditions of drought and floods. Because of its climate, topography and position, this portion of the country has been plagued by poverty and a flood of refugees who have fled the political excesses and economic deprivation of Laos, Cambodia, and Vietnam.

(3) Northern Thailand is an area of mountains and deep river valleys, representing the beginnings of the Himalayan foothills. Because of the climate and fertility, this area is a major source of timber, rice, and substantial but declining illegal opium production. Chiang Mai, Thailand's second largest city, is also in the north.

(4) Southern or peninsular Thailand is essentially a 450-mile isthmus which is only 10 miles wide at its narrowest point. Once covered with rain forests, today it is mostly covered with rubber, coconut, coffee, and pineapple plantations. These products, along with ores, are the major exports of the region.

Thailand has a tropical monsoon climate, high in humidity and temperature. In most areas, there are three seasons: rainy (May to October), characterized by drenching rains; dry (November to February), when the monsoon pattern reverses; and hot (March to April), when "summer" temperatures may exceed 100° F. rainfall varies but is generally heaviest in the south and southeast, where the yearly average is 150 inches, and lightest in the northeast.

Based on a 1987 population estimate of 54 million with an annual growth rate of 1.6%, Thailand's population is estimated to be close to 56 million. The largest population center is the Bangkok – Chonburi urban area where at least 15% of the country's citizens are located. Because of a desire for urban employment, education, and more arable and available farmland, population shifts occurred in the 1970s which resulted in about 70% of the country's population being concentrated in the central and northeast regions. Except for Bangkok and a few other urban areas, such as Chiang Mai in the north and Nakhon Ratchasima (Korat) in the northeast, the Thai people primarily are engaged in agriculture. The government, knowing that the country could not withstand the unchecked population growth that occurred in the sixties, sponsored a voluntary program of family planning. This program was proved successful, and a future goal is to keep the annual growth rate below 2%.

Thailand's people are relatively homogeneous. More than 85% share a common ancestry, speak a dialect of Thai, and consider themselves Theravada Buddhists. The largest minority group is the Chinese (12%), followed by the Malay-speaking Muslims in the south, the Khmer, and the Mon. These groups are considered to be assimilated into Thai culture and society. Small groups of Vietnamese and hill tribes (e. g. Hmong) also have integrated into the mainstream of Thai culture.

Close relations exist between Thailand, the U. S. and other free-world countries. The country prides itself on never having been under European domination and is considered stable among the countries of Southeast Asia. The system of government is a constitutional monarchy, with a king as the formal head of state. A freely elected House of Representatives and an appointed Senate make up the legislative National Assembly. The government has, until recently, been heavily dominated by military interests.

The Ministry of Public Health is responsible for health and sanitation, and through the ministry a close working relationship has been maintained between Thailand and organizations such as the World Health Organization (WHO) and the U. S. Agency for International Development (AID).

DISEASE SUMMARY

MALARIA: Malaria is a major threat for deployed personnel in mountainous and wooded areas throughout the country, but especially in the eastern, northeastern, northern and western parts of the country. Transmission is year-round in most areas, with peak transmission occurring during post-monsoon, dry and pre-monsoon months (October-May). *Plasmodium falciparum* dominates over *P. vivax* in most regions, except central and peninsular Thailand, where the two species have similar rates of infection. Multiple drug-resistant strains of falciparum malaria exacerbate the problem. The mosquito vectors are all night-biters and are usually found in rural areas.

DENGUE: Dengue also is a major threat for deployed personnel. It occurs in both urban and rural areas, with highest risk during the monsoon months of May through November. Large outbreaks occur about every 4 weeks and appear to be related to a shift in the dominant serotype. All four dengue serotypes occur, and the hemorrhagic fever form of dengue appears to be most prevalent when two or more sequential outbreaks of differing serotypes take place. The mosquito vectors are day-biting species which, because of peridomestic habits, can cause intense foci of transmission.

JAPANESE ENCEPHALITIS: Japanese encephalitis is highly endemic in the northern, northeastern, and central parts of the country. Like dengue, its peak period of transmission occurs in the monsoon months. Although most infections are inapparent, clinical cases are often fatal. It is fairly uncommon except among those who live near pigs, which serve as amplifying hosts of the virus. The mosquito vectors are rice-field breeders. They are strong fliers in the early evening hours and are capable of flying several miles to find human hosts. Although primarily rural in distribution, some cases occur in suburban areas as well. Personnel deployed for over two weeks in rural areas during the transmission season should be protected by vaccination.

SCRUB TYPHUS: Scrub typhus is considered a low to moderate risk for deployed forces and is distributed throughout Thailand, with highest endemicity in recent years reported from northern and northeastern provinces. Scrub typhus outbreaks tend to be highly focal, in consonance with the distribution of chigger vectors. Most foci occur in disturbed forest habitats, associated with second growth forests, rubber plantations, orchards, and tall grassy areas. Seasonally cases appear most commonly during rainy months.

CHIKHUNGUNYA: This arbovirus disease occurs in rare, but usually intense, outbreaks, with long interepidemic cycles of 10 to 20 years. Although the vectors are the same as for dengue, and the disease is therefore primarily urban, it also has rural area vectors, leading to occasional rural outbreaks. The risk for deployed forces is considered very low in most years.

OTHER VECTOR-BORNE DISEASES: Filariasis (Malayan and Bancroftian) and schistosomiasis occur in very limited areas and are of little risk to deployed forces. Murine typhus, while having a somewhat wider distribution, is primarily a threat to lower socioeconomic groups, especially refugee populations. West Nile fever and Sindbis, while both present, are considered low risks. Plague, which has not been reported for many years in Thailand, is not a risk at present.

MILITARILY IMPORTANT DISEASES

MALARIA

INFECTIOUS AGENTS: *Plasmodium vivax* and *P. falciparum* occur in about a 20/80 ratio in the north and a 50/50 ratio on the peninsula. *Plasmodium malariae* occurs at very low frequency. Mixed infections are not uncommon. Some studies in Thailand have found that vivax malaria will develop in a third of the patients treated for acute falciparum malaria, although less than 1% of these were reported to have a mild infection upon admission.

RESERVOIR: Humans are the only important reservoir of human malaria.

MODE OF TRANSMISSION: From the bite of an infective female Anopheles mosquito, or from an infectious blood transfusion.

CLINICAL FEATURES:

Incubation Period – Usually 12 to 14 days; in some cases *P. vivax* may have a protracted incubation period of up to 10 months.

Symptoms – Acute febrile illness characterized by chills, fever, headache, sweating, muscular ache and general malaise. *P. falciparum* symptoms may include severe anemia, jaundice, renal failure, shock, loss of orientation, convulsions and coma. Symptoms are most severe in *P. falciparum* malaria. Case fatality rates among non-immune adults and children may approach 10%. Relapses are common with improperly treated *P. vivax* and may occur irregularly for years.

Thailand probably has the worst multiple-drug resistance problem in the world. Some surveys have found nearly 100% of the falciparum isolates are resistant to chloroquine. Resistance to Fansidar (sulfadoxine-pyrimethamine) is also widespread, and resistance to quinine, proguanil, halofantrine, and mefloquine is common along the eastern and western borders. Primaquine-tolerant *P. vivax* has been reported from southern Thailand.

GEOGRAPHIC DISTRIBUTION: The malaria risk is present year-round in rural areas, especially forested and hilly areas. The large urban areas, including Bangkok and Chiang Mai, and most coastal resort areas are considered malaria-free. Malaria is particularly common in villages of semi-forested areas. A reduction in the incidence of malaria resulted from deforestation for cassava cultivation. However, much of the natural forest habitat of the primary vector *Anopheles dirus* that was destroyed by farming is now being replaced with orchard. This ecological change may reintroduce malaria to a wide area. Risk is particularly high close to Thailand's international borders with Malaysia, Burma, Laos, and Cambodia, where malaria is a major cause of morbidity in refugee areas (Fig. 1).

SEASONAL DISTRIBUTION: The seasonality of malaria in Thailand is complex. Peak transmission usually occurs from October to December in the north and northeast, November to February in the west and northwest, and February to March in the peninsula. Efficient dry season transmission is well documented in eastern and northwestern Thailand. A second transmission peak occurs in May or June, especially in eastern and northeastern Thailand.

INCIDENCE/PREVALENCE: Malaria was the leading cause of death in 1947, with a mortality rate of 297 per 100,000, but control programs reduced the mortality rate to less than 8 per 100,000 by 1982. However, malaria remains a major public health problem in Thailand. In 1991, the annual parasite incidence was 3.96 cases per 1,000, but five primary border provinces (Trat, Tak, Mae Hong Son, Ranong, and Chantaburi) had an AP exceeding 21 per 1,000 and another 5 provinces (Kanchanaburi, Surat, Thani, Krabi, Prachuab, and Chumphon) had an API of 11 to 20 per 1,000.

VECTORS AND VECTOR BIOLOGY

Primary Vector: *Anopheles dirus*, formerly known as *An. balabacensis* s.l., now is recognized as a complex of 5 species, with the exact vector status of all but *An. dirus* s.s. still under investigation. This is the most important vector in most areas, particularly in the provinces along the eastern border with Cambodia. Normally a mosquito that inhabits hilly, forested areas, it has adapted well to areas where natural forests have been replaced with orchards, tea, and rubber plantations.

An. dirus breeds in shallow pools of fresh water along forest margins in hilly areas. It does not normally occur in rice-growing or urban plains. Heavy concentrations occur where human or animal activity is most intense along forest margins. Pools are generally located near streams or rivers that contain some organic debris in relatively clean water. Most sites are in areas of deep shade and may include puddles formed by tire tracks, hoof prints, and gem pits. *An. dirus* is a highly efficient, exophilic vector, with a peak biting period from 2100 to 0300 hours. Biting occurs earlier in the evening during cool period of the year. Its flight range is estimated at 1-3 kilometers. Adult rest in trees or other nearby vegetation after feeding.

SECONDARY VECTORS: Thailand has many potential vectors of malaria. Those documented as significant vectors include:

An. minimus. This complex of three species (A,B, and C) is found in forested and semi-forested foothill regions, where it breed at the edges of clean, clear, slow moving streams. Peak populations in the Pakchong district, Nakhon Ratchasima Province, occurred from September to November. Adults feed on man both indoors and outdoors, but prefer animals to man and tend to be exophilic. Biting activity occurs during the early part of the night (1800-2200 hours). Flight range is estimated to be less than four kilometers.

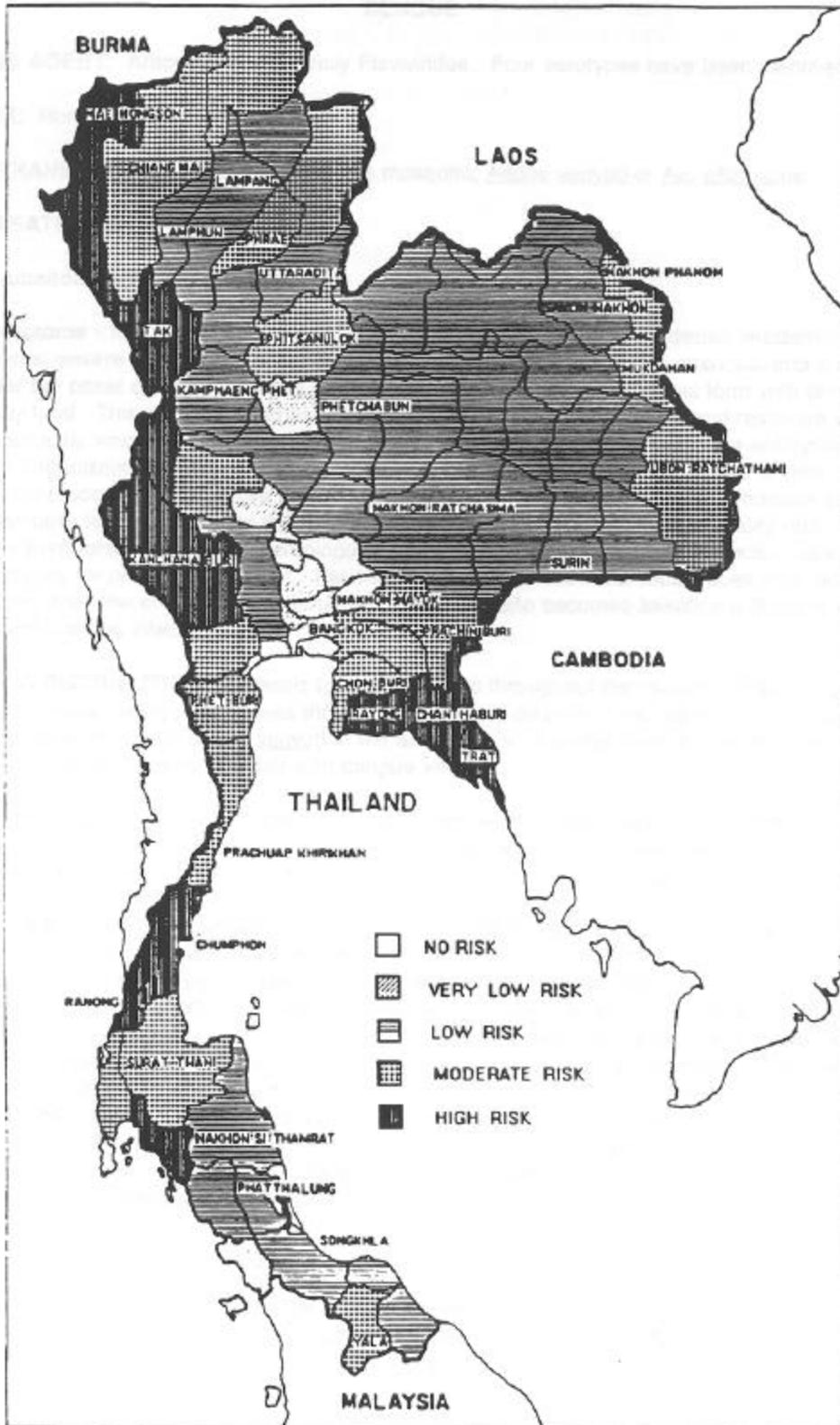
An. maculatus. This complex of seven species have an uncertain role in the epidemiology of malaria in Thailand. Years ago, *An. maculatus* s.s. was found to be positive for sporozoites in the south of Thailand, and has occasionally been ELISA-positive, but without sporozoites, in northern Thailand. Another complex member *An. pseudowillmori*, has been found gland-positive in Tak Province. These species tend to breed in sunlit stream margins, seepages, springs, and rice fields with slow running water. Adults feed on man both indoors and outdoors, but prefer cattle and tend to be exophilic. Feeding activity peaks between 210 and 2400 hours.

An. sundaicus. This is an important vector along coastal areas, where larvae bred in brackish water, salt marshes, lagoons, and salt water fish ponds. This primarily anthropophilic species feeds indoors or outdoors. It has an estimated flight range of up to two kilometers.

An. conitus. This species commonly breeds in rice fields, but larvae are also found in lakes, ponds, swamps, and various impoundments. Sporozoites have only been reported once in this species, although it is regularly ELISA-positive. It is primarily a zoophilic species that also feeds on man. Its flight range is estimated be less than two kilometers.

Other species that reportedly have been found ELISA-positive, but without sporozoites observed in the salivary glands, include *An. nivipes*, *An. sinensis*, *An. barbirostris*, *An. annularis*, *An. hyrcanus* group, and *An. sawadwongpomi*.

FIG. 1. MALARIA RISK BY PROVINCE BASED ON MINISTRY OF HEALTH MORBIDITY REPORTS (1990).



DENGUE

INFECTIOUS AGENT: Arbovirus of the family Flaviviridae. Four serotypes have been identified.

RESERVOIR: Human, rarely monkeys.

MODE OF TRANSMISSION: Bite of an infective mosquito, *Aedes aegypti* or *Ae. albopictus*.

CLINICAL FEATURES:

Incubation Period – 4 to 6 days.

Symptoms – Include sudden fever of 3-5 days (rarely more than 7), intense headache, pain behind the eyes, severe muscle and joint pain, prostration, gastrointestinal disturbances, and a rash from 3-4 days after the onset of fever. Dengue may progress to a severe hemorrhagic form with shock, which can be rapidly fatal. This appears to be associated with an enhanced immunological response which follows individuals who have had sequential dengue infections, usually with different serotypes. The World Health Organization estimates that during any outbreak, between 150-200 cases of mild or silent dengue infections occur for every case of dengue hemorrhagic fever/dengue shock syndrome seen in hospitals. Mortality is rare except for the hemorrhagic form which may produce a fatality rate of up to 5% . Recovery from infection provides homologous immunity of long duration, but protection against different serotypes of only a few months. Patients are usually infective for mosquitoes from one day prior to one day after the end of the febrile period. The mosquito becomes infective 8-30 days after the blood meal and remains infective for life.

GEOGRAPHIC DISTRIBUTION: Endemic to hyperendemic throughout the country. Risk is higher in urban areas. Although dengue once was thought of as a rural disease, it has been primarily an urban disease since the introduction of *Ae. aegypti* in the early 1900. Surveys have shown most villages, as well as urban areas, are heavily infested with dengue vectors.

SEASONAL DISTRIBUTION: The highest densities of the vector usually occur during the rainy seas (May through October) with dengue outbreaks frequently following two months later. In areas where rainfall is not markedly seasonal (i. e. southern Thailand), cases may occur year-round.

INCIDENCE/PREVALENCE: Dengue hemorrhagic fever (DHF) was first reported in Thailand in 1958 when 2,500 cases occurred in the Bangkok area. The pattern of disease during the next 30 years can be divided into 3 phases. During the first period (1958-1967), outbreaks occurred every other year with a median incidence of 10/100,000. DHF was prevalent only in Bangkok, Thonburi and a few other large municipalities. During the second period (1968-1977), outbreaks occurred in four-year cycles, with two years of high incidence followed by two years of low incidence (the median incidence during this period was 23/100,000). DHF had spread to most municipalities of every province. DHF continued to spread during the third period (1978-1987), when large outbreaks occurred every three to four years with a median incidence of 54/100,000. In 1987, over 175,000 cases of DHF were reported, making it the worst epidemic on record. Northeastern Thailand was the hardest hit region. In 1990, another extensive outbreak of nearly 112,000 cases occurred.

VECTOR: *Aedes aegypti*, the primary vector of dengue, is perfectly adapted to its role because of its domesticated habits and close association with man. This is a synanthropic species that breeds in artificial containers such as tires, cans, rain barrels, or cisterns. Eggs are laid on moist surfaces and remain viable for many months after they have dried. The eggs hatch when flooded. Adults prefer to feed on humans during the day and will also feed on cats, dogs, or other domestic animals. Biting activity is usually highest for 2 hours after sunrise and 2 hours before sunset, although patterns may vary by season and locale. The entire life cycle usually takes place near or in human dwellings. The adult flight range is frequently no more than 100 meters from the breeding site.

Ae. albopictus is an important secondary vector of dengue. Its behavior and habits are very similar to *Ae. aegypti* except it prefers natural breeding sites such as treeholes, coconut shells and bamboo stumps, as well as manmade water-holding containers. It occurs around habitations, but mostly in more rural areas. Rubber plantations nearly all have high densities of this species, and it is notably abundant wherever good larval habitats abound.

PREVENTION/CONTROL: Vector control includes good sanitation and the elimination of mosquito breeding places and/or adulticiding measures. Source reduction is the most efficient means of control. Personal protective measures include screening and use of repellents, especially where mosquito control is difficult. However, since the vectors are primarily daytime feeders, use of repellents is the most important personal protective measure. Permethrin-treated uniforms should be worn in conjunction with repellent application. Proper wearing of the uniform (i.e. socks and bloused boots) affords considerable protection to military personnel.

JAPANESE ENCEPHALITIS

INFECTIOUS AGENT: Arbovirus of the family Flaviviridae

RESERVOIR: The natural cycle involves wild aquatic birds, including herons and egrets. Young pigs develop high viremias and function as important amplifying hosts. Water buffalos during their first year of life also may serve as amplifying hosts. Humans and chickens produce levels of virus in the blood too low to infect mosquitoes. Consequently, man, like most domestic animals, is a dead-end host.

CLINICAL FEATURES:

Incubation period – 5-15 days.

Symptoms – Only about one of every 300 persons infected develops clinical encephalitis, but about 25% of clinical cases die, and up to half the survivors are left with permanent neural sequelae. Severe infections are marked by acute onset, headache high fever, and meningeal involvement, which may lead to convulsions, coma and death.

GEOGRAPHIC DISTRIBUTION: Japanese encephalitis is the most common cause of epidemic encephalitis in the Orient. In Thailand, the virus is transmitted throughout the country, but cases of human encephalitis are concentrated in northern, central, and eastern provinces. Risk is greatly reduced in coastal areas and southern provinces (Fig. 2).

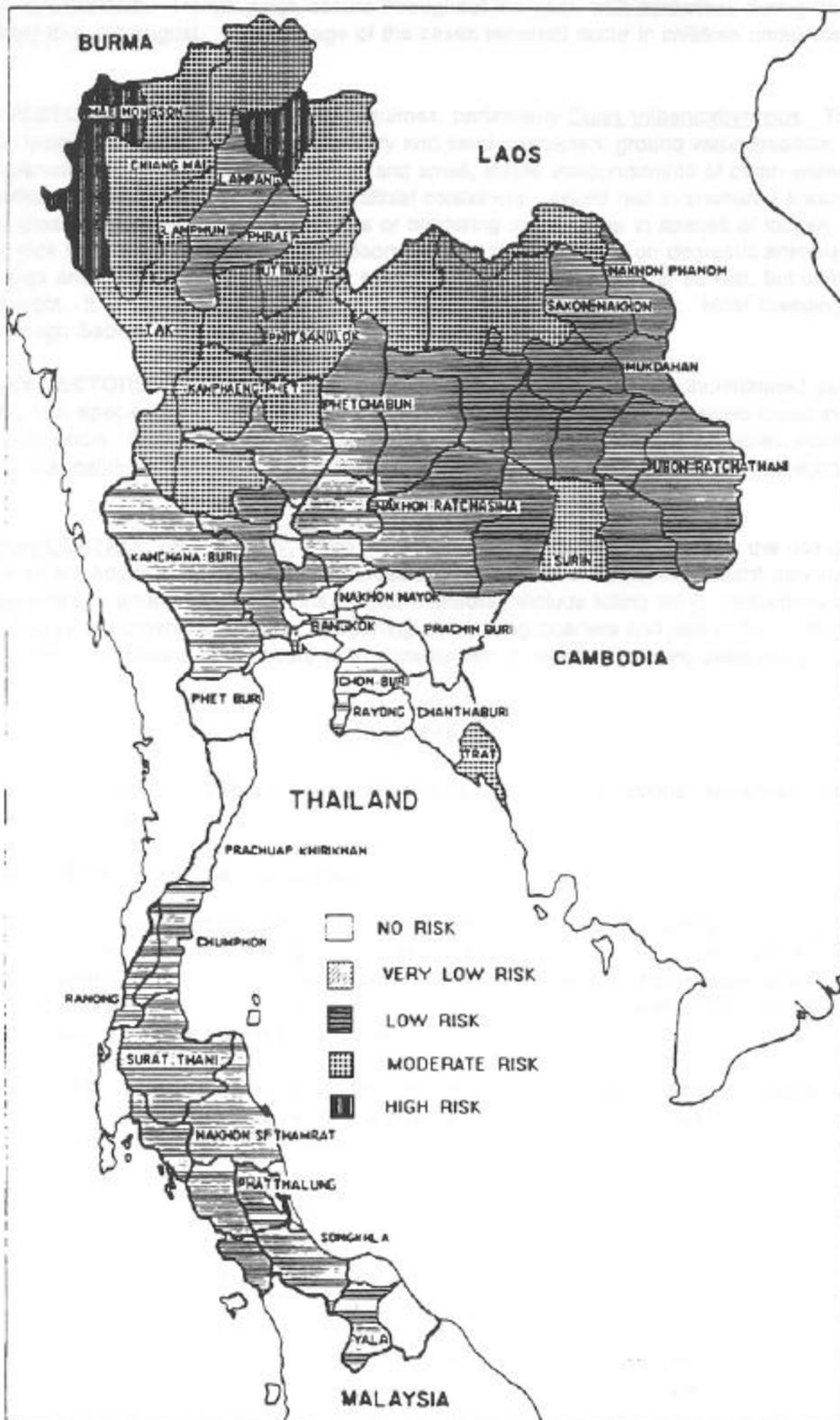
PREVALENCE/INCIDENCE: Until 1969 the disease was reported from only a few provinces and cases were few. In that year, however, the first large epidemic occurred during the rainy season in the Chiang Mai Valley and other nearby valleys in northern Thailand. The total number of reported cases in 1969 was 655 and 152 deaths. Since then, epidemics of encephalitis have been reported every year and have become one of the leading causes of death and/or disability due to infectious diseases. An annual average of 1,611 cases and 350 deaths was reported between 1970 and 1984. Then number of cases has fluctuated since 1984, but a decreasing trend has been observed. Although Japanese virus transmission occurs primarily in rural areas, transmission also occurs in suburban areas and in Bangkok.

SEASONAL INCIDENCE: Transmission occurs throughout the year, with epidemics during the rainy season in May through August. A high percentage of the cases reported occur in children under the age of 15.

PRIMARY VECTORS: Rice field breeding mosquitoes, particularly *Culex tritaeniorhynchus*. This species also breeds in a wide variety of temporary and semi-permanent ground water habitats, including stagnant marshes, tidal marshes of low salinity, and small, stable impoundments of clean water around cultivated fields. It is capable of adapting to artificial containers. Adults rest in sheltered areas in uncultivated grassy fields, especially on hillsides or bordering marshes, or in spaces of loosely constructed rock fences. It is rarely found indoors. Adults prefer to feed on domestic animals, particularly pigs and bovines, with biting activity peaking within three hours after sunset, but continuing through the night. It feeds on man during periods of high mosquito abundance. Most breeding occurs from May through September, usually peaking in June.

SECONDARY VECTORS: At least fourteen species of mosquitoes have been incriminated as vectors, although only four species have been incriminated in Thailand. Most of these species breed in rice fields or other ground pools. *Culex* spp. feed primarily at night. The three other vector species incriminated in Thailand are *Cx. gelidus* (suburban to rural areas), *Cx. vishnui* (rural areas), and *Cx. fuscescens* (rural areas).

FIG. 2. JAPANESE ENCEPHALITIS RISK BY PROVINCE, BASED ON MINISTRY OF HEALTH MORBIDITY DATA (1990)



PREVENTION/CONTROL MEASURES: The most important prevention is the use of a newly marketed vaccine. Adulticiding with residual aerosols using ground or aerial equipment may be useful in stopping emergency situations. Other measures include killing adult mosquitoes by space and residual spray of human habitations. Screening of sleeping quarters and use of bed netting can be effective adjuncts. Avoidance of exposure to vectors by use of repellents during peak biting hours is almost important.

SCRUB TYPHUS

SYNONYMS: Tsutsugamushi disease, mite-borne typhus fever, tropical typhus, Japanese river fever, chigger-borne rickettsiosis.

INFECTIOUS AGENT: *Rickettsia tsutsugamushi*.

RESERVOIR: Chigger mites of the genus *Leptotrombidium*, and possibly other trombiculid genera, act as both vector and reservoir through long-term transovarial transmission. Only larval stages of the chigger feed on vertebrates, indicating that those infective to man or other hosts have received the pathogen transovarially from the female parent. The role of rodents and other commonly infected mammals in the ecology of the disease is uncertain.

MODE OF TRANSMISSION: By the bite of infective larval chigger mite of the genus *Leptotrombidium* (Family: Trombiculidae). Other genera, e. g. *Blankaartia* and *Aschoschoengastia*, harbor the pathogen and also bite humans, and should be considered potential vectors.

CLINICAL FEATURES:

Incubation period – 6 to 21 days, usually 10 to 12 days.

Symptoms – This disease is characterized by a primary skin ulcer or eschar (non-painful sore with black, necrotic center) at the site of attachment of an infected mite followed within days by an acute fever, headache, profuse sweating and swelling of the lymph glands. Late in the first week of fever maculopapular rash usually (but not always) appears on the trunk and extends to the extremities. Mortality rates vary from 1 to 60% depending on the strain of pathogen and previous exposure to the disease. Treatment usually results in full recovery, but relapses are common if treatment occurs very early in the course of the disease.

GEOGRAPHIC DISTRIBUTION: Scrub typhus cases have been diagnosed for over 30 years. The disease appears nearly countrywide, with highest estimated transmission in northeaster and southern provinces (Fig. 3). However, it has the potential to occur everywhere the essential zoonotic components are present: 1) Vector mites, 2) wild rats in the genus *Rattus*, 3) the pathogen, and 4) disturbed environments with transitional secondary vegetation. These constitute the so-called “zoonotic tetrad.” The disease often is highly focal, with sharply delineated mite-infested areas of only a few square meters.

INCIDENCE/PREVALENCE: Serological surveys and isolation of *R. tsutsugamushi* from chiggers have demonstrated that the disease is widespread. Over 60 percent prevalence of antibody has been recorded in a number of villages in northern Thailand. This suggests a higher endemicity than reported by the ministry of Public Health. In recent years, scrub typhus cases have been reported at much higher levels (776 cases in 1989), partly because of enhanced awareness and diagnostic efforts, but also through the use of newer antibiotics for other infectious diseases that do not kill the scrub typhus. Some areas have little apparent disease because of natural immunity still present a high risk to non-immune soldiers.

VECTOR BIOLOGY: Eggs are laid singly and loosely on the open ground. About 1-5 eggs are laid daily for 6-12 weeks. The females then pause for 2-6 months, depending on climate, before resuming egg laying. The egg stages 5-7 days with the larva developing inside the cracked ovum for another 5-7 days. The 6-legged larva then emerges and remains in the immediate area until attaching to the host's skin. Larvae feed on serum exudate, rarely imbibing blood, for 2-3 days. Unlike non-vector

species, scrub typhus vectors cause little or no irritation to their hosts during feeding. Engorged larvae disengage, drop off, and enter a pupa-like stage for 7-10 days. The 8-legged, velvety nymph then emerges and feeds on arthropods and their eggs. Within two weeks another quiescent stage occurs lasting 12-15 days. Adults emerge and may live up to 15 months. Adults also feed on arthropod eggs. Mite populations often form highly localized aggregations (mite “pockets” or “islands”) which, in turn, often cause highly focal outbreaks.

PREVENTION/CONTROL MEASURES – Use of repellents (diethyltoluamide, DEET) on the skin and impregnation of uniforms with permethrin should reduce risks. Elimination of mites by application of acaricides to ground and/or burning vegetation in highly infested and bivouac areas should be a logical precautionary measure. Weekly administration doxycycline as a chemoprophylactic drug has been effective in controlled studies, although the work is still experimental.

OTHER VECTOR-BORNE DISEASES OF POTENTIAL MILITARY IMPORTANCE

MURINE TYPHUS: This flea-borne disease, caused by *Rickettsia typhi*, has a rodent reservoir, primarily rats, in Thailand, with the oriental rat flea (*Xenopsylla cheopis*) acting as the primary vector. *Rattus norvegicus* populations are high in Bangkok. Adult flea longevity in nature (1-2 years) permits flea-transmitted pathogens to persist in the absence of vertebrate reservoirs. The disease is transmitted through the infected feces of fleas, contaminating the bite site and other fresh skin wounds. Murine typhus occurs primarily in overcrowded rural areas (e.g. refugee camps) where sanitation is poor, although some cases have occurred in urban slums and dock areas in the past. After an incubation period of 1 to 2 weeks, there is a sudden onset of headache, chills, prostration, fever and general pain. Macular eruptions generally appear on the 5th or 6th day after onset of symptoms. Mortality is low (1% to 5%), less than 2% if treated. Infection confers immunity against future infection. The disease can occur year-round, although current incidence outside of refugee camps is very low.

FILARIASIS: *Wuchereria bancrofti* and *Brugia malayi* are the causative agents of this disease, which is prevalent only in a few areas. In Thailand *Wuchereria bancrofti* is transmitted primarily by *Aedes harinasutai*, and *Brugia malayi* primarily *Mansonia* spp. *Anopheles minimus* is another potential vector for *W. bancrofti*, although formal incrimination is still lacking. The reservoir is human infected with microfilaria. Clinically, an allergic and inflammatory manifestation may occur one month after infection, but the microfilariae may not appear in blood for 6 months to a year. Filariasis is not transmitted person-to-person, but may persist for 5 or more years after the initial infection. Chronic signs include gross enlargement of the limbs (elephantiasis), breasts and genitalia due to blockage of the lymphatic vessels. The delay in clinical signs, coupled with its low endemicity, make filariasis a disease of low military importance. Although some reports indicate a widespread distribution for filariasis, nearly all cases are reported from rural areas, with the most intense foci located along the Thai-Burmese border near Kanchanaburi and Tak Provinces (*W. bancrofti*) or the isthmus provinces in southern Thailand (*B. malayi*). Prevalence generally is considered low (1 to 2%), even in the most highly endemic province along the Burmese border.

CHIKUNGUNYA: An *Alphavirus*, family *Togaviridae*, is the causative agent, with man and monkeys probably the reservoirs. *Aedes aegypti* is responsible for the large epidemics that occur in urban areas. Chikungunya may have a forest cycle involving monkeys and forest *Aedes* spp. as vectors. *Ae. albopictus* should be regarded as an important potential vector in rural areas. After an incubation period of 3-5 days, acute febrile illness (which includes high fever, headache, polyarthralgia, weakness, and rash) last 3 to 5 days. Joint pain is the most striking feature and is generally more severe in adults. Hemorrhagic manifestations, known elsewhere for this disease, are rare in Thailand. Transmission may occur throughout the year and countrywide, although the last epidemic in the early 1960s occurred primarily in Bangkok. However, this disease is very cyclic, with long intervals of up to 15-20 years occurring between outbreaks. When outbreaks do occur, they infect large proportions of the population in a rapid, sweeping manner.

SCHISTOSOMIASIS: This disease, caused by *Schistosoma mekongi* in Thailand, has a very limited distribution. *Tricula aperta* is the intermediate snail host for *S. mekongi*. Its habitat is shallow water (depth less than two meters), under stones, weed, or branches. Suitable habitats are usually sunlit, highly oxygenated, clear water areas with a high pH (8.0 to 9.0). Humans are the principal reservoirs; dogs have been documented as important reservoirs of Khong

Island in Laos, but their role in Thailand is uncertain. Transmission occurs when human skin contacts water infested with cercariae. After an incubation period of 2-6 weeks, acute febrile period may occur. Chronic symptoms develop later, and may include diarrhea, enlarged tender liver, epigastric distress, pain the back, groin, and/or legs, and urticaria. Adult worms have a life span of many years in humans, living in mesenteric veins and producing eggs. These eggs cause most of the symptoms, depending on number and location of their deposition. Mortality is unusual but can occur in serious infestations in children. Transmission appears to be year-round, but only sporadic cases have been reported since 1967 – all near the Laotian frontier along the Mekong River. Up to 9% of Cambodian refugees in camps on the Thai border have been positive for *S. mekongi*. However these case do not appear to have been acquired indigenously, and the disease is primarily of academic interest at present.

SINDBIS VIRUS: This disease, caused by an Alphavirus, is uncommon in humans, with only sporadic cases suspected. The disease is amplified by ornithophilic *Culex* spp. mosquitoes, with birds being the main reservoir. However, it is likely that the relatively anthropophilic *Culex* spp. (including some JE vectors), *Ae. aegypti*, or *Ae. albopictus* transmit the disease to humans. Although the virus is widespread, its symptoms are relatively mild, including a trunk and limb rash, fever, malaise, and joint pain. It is a self-limiting disease, and mortality from it is unknown.

PLAGUE: Plague, caused by *Yersinia pestis*, and vectored by fleas (primarily *Xenopsylla cheopis*), has not been reported in the country since 1952, and is unlikely to return. However, since rodent (*Rattus* spp.) reservoirs are plentiful, as are flea vector species, reintroduction cannot be completely discounted. The disease produces severe fever, swelling of lymph nodes, and pneumonia, with resulting coma and death in 50% or more of untreated cases. The longevity of the zoonotic flea vectors, 1-2 years, would enable the agent to persist in nature even in the absence of reservoir hosts.

APPENDIX A. SAND FLIES REPORTED FROM THAILAND

Phlebotomus

*P. argentipes*¹
*P. major major*¹
P. philippinensis gouldi
P. stantoni
P. teshi

Nemopalpus

N. vietnamensis

Sergentomyia

S. anodontis
S. bailyi
S. barraudi
S. gemmea
S. hodgsoni
S. indica
S. iyengari
S. mahadevani
S. pertubans
S. punjabensis
S. silvatica

¹ Potential vectors of leishmaniasis, no indigenous transmission reported

APPENDIX B. TABANIDS REPORTED FROM THAILAND

Tabanus

T. aganoscibilis
T. anabates
T. birmanicus
T. brunnipennis
T. caduceus
T. dissimilis
T. granti
T. hybridus
T. indianus
T. juncundus
T. macdonaldi
T. monilifer
T. nigrotectus
T. praematurus
T. rufiscutellatus
T. siamensis
T. subhybridus
T. tonglai

Tabanus

T. aurilineatus
T. brunnicolor
T. ceylonicus
T. equinctus
T. euphanes
T. griseipalpis
T. hypomacros
T. konis
T. leuconematus
T. minimus
T. neographicus
T. oknos
T. pristinus
T. salvazai
T. striatus
T. thurmani
T. unicus

Chrysops dispar

C. fixissimus

Haematopota abacis

H. cilipes
H. pachycera
H. splendens
H. vimoli

APPENDIX C. CULICIDS REPORTED FROM THAILAND

Anopheles (Anopheles)

An. aberrans
An. argyropus
An. asiaticus
An. baezai
An. baileyi
An. barbirostris
An. barbumbrosus
An. bengalensis
An. bulkeyi
An. campestris
An. crawfordi
An. donaldi
An. fragilis
An. hodgkini
An. insulaeflorum
An. interruptus
An. kyondawensis
An. letifer
An. lindesayi cameronensis
An. montanus
An. nigerrimus
An. nitidus
An. palmatus
An. paraliae
An. pediataeniatus
An. pollicaris
An. pursati
An. roperi
An. separatus
An. sinensis
An. sintonoides
An. stricklandi
An. tigerti
An. whartoni
An. umbrosus
An. varuna

Aedeomyia catasticta

Aedes (Aedimorphus)

Ae. alboscuteellatus
Ae. caecus
Ae. culicinus
Ae. mediolineatus
Ae. orbitae
Ae. pallidostriatus
Ae. pampangensis

Aedes (Aedimorphus)

Ae. pipersalatus
Ae. vexans
Ae. vittatus

Anopheles (Cellia)

*An. aconitus*²
An. annularis
An. culicifacies B
*An. dirus*²
An. dirus B²
An. dirus C²
An. dirus D²
An. dravidicus
An. hackeri
An. indefinitus
An. introlatus
An. jamesii
An. jeyporiensis
An. karwari
An. kochi
An. leucosphyrus A
An. macarthuri
*An. maculatus*²
An. minimus A^{2,5}
An. minimus C²
*An. nemophilous*²
An. nivipes
An. notanandai
An. pampanai
An. philippinensis
An. pseudojamesi
*An. pseudowillmori*²
An. pujutensis
*An. sawadwongpomi*²
An. splendidus
An. stephensi
An. subpictus
*An. sundaicus*²
An. tessellatus
An. vagus
An. willmori

Aedes (Alanstonea)

Aedes treubi

Aedes (Ayurakitia)

Ae. griffithi
Ae. peytoni

Aedes (Bothaella)

Ae. eldridgei
Ae. helenae

Aedes (Finlaya)

Ae. shortti
Ae. simlensis
Ae. subniveus
Ae. togoi

Aedes (Cancraedes)
Ae. indonesiae
Ae. kohkutensis

Aedes (Diceromyia)
Ae. franciscoi
Ae. iyengari
Ae. pseudonummatus
Ae. scanloni
Ae. whartoni

Aedes (Finlaya)
Ae. albolateralis
Ae. alboniveus
Ae. albotaeniatus
Ae. assamensis
Ae. christophersi
Ae. chrysolineatjus
Ae. dissimilis
Ae. elsiae
Ae. feegradei
Ae. flavipennis
Ae. formosensis
Ae. ganaathi
Ae. greenii
Ae. harinasutai
Ae. harveyi
Ae. inermis
Ae. jugraensis
Ae. khazani
Ae. leonis
Ae. lophoventralis
Ae. macfarlanei
Ae. mikeokopion
Ae. niveoides
Ae. novoniveus
Ae. pexus
Ae. poicilius
Ae. prominens
Ae. pseudoniveus
Ae. pseudotaeniatus
Ae. reinerti

Aedes (Neomelaniconion)
Ae. lineatopennis

Aedes (Paraedes)
Ae. ostentaitio
Ae. thailandensis

Aedes (Scutomyia)
Ae. albolineatus

Ae. uncinatus

Aedes (Isoaedes)
Ae. cavaticus

Aedes (Mucidus)
Ae. laniger
Ae. quasiferinus

Aedes (Ochlerotatus)
Ae. vigilax

Ae. (Rhinokusea)
Ae. longirostris

Aedes (Christophersiomyia)
Ae. annulirostris
Ae. ibis
Ae. thomsoni

Aedes (Edwardsaedes)
Ae. imprimens

Aedes (Stegomyia)
*Ae. aegypti*³
*Ae. albopictus*³
Ae. annandalei
Ae. craggi
Ae. desmotes
Ae. gardnerii imitator
Ae. malayensis
Ae. malikuli
Ae. novalbopictus
Ae. patriciae
Ae. perplexus
Ae. pseudabopictus
Ae. seatoi
Ae. w-albus

Aedes (Lorrainea)
Ae. amesii
Ae. fumidus

Armigeres (Leicesteria)
Ar. annulipalpis
Ar. balteatus
Ar. dentatus
Ar. digitatus
Ar. dolichocephalus
Ar. flavus
Ar. inchoatus
Ar. longipalpis
Ar. magnus

Aedes. (*Verrallina*)

Ae. adustus
Ae. andamanensis
Ae. atrius
Ae. butleri
Ae. clavatus
Ae. cytolabis
Ae. dux
Ae. gibbosus
Ae. hispidus
Ae. incertus
Ae. indecorabilis
Ae. latipennis
Ae. lugubris
Ae. notabilis
Ae. phnomus
Ae. protuberans
Ae. pseudodiurnus
Ae. sohni
Ae. torosus
Ae. uncus
Ae. vallistris
Ae. yusafi

Armigeres (*Armigeres*)

Ar. aureolineatus
Ar. bhayungi
Ar. jugraensis
Ar. kesseli
Ar. kuchingensis
Ar. malayi
Ar. maximus
Ar. moultoni
Ar. subalbatus
Ar. theobaldi

Ar. omissus
Ar. pectinatus
Ar. vimoli

Heizmannia (*Heizmannia*)

Hz. aureochaeta
Hz. chengi
Hz. communis
Hz. complex
Hz. covelli
Hz. demeilloni
Hz. macdonaldi
Hz. mattinglyi
Hz. persimilis
Hz. propinqua
Hz. proxima
Hz. reidi
Hz. scanloni
Hz. scintillans
Hz. taiwanensis

Heizmannia (*Mattinglyia*)

Hz. achaetae
Hz. catesi
Hz. thelmae

Udaya argyrurus

Culex (Culex)

Cx. alienus
Cx. alis
Cx. barraudi
Cx. bitaeniorhynchus
Cx. edwardsi
*Cx. fuscocephala*⁴
*Cx. gelidus*⁴
Cx. hutchinsoni
Cx. infula
Cx. jacksoni
Cx. longicornis
Cx. mimeticus
Cx. mimulus
Cx. murrelli
Cx. perplexus
Cx. pseudosinensis
Cx. pseudovishnui
Cx. quinquefasciatus
Cx. sinensis
Cx. sitiens
*Cx. tritaeniorhynchus*⁴
*Cx. vishnui*⁴
Cx. whitei
Cx. whitmorei

Culex (Lophoceraomyia)

Cx. aculeatus
Cx. alphus
Cx. bengalensis
Cx. bicornutus
Cx. cincetllus
Cx. curtialpis
Cx. demissus
Cx. eukrines
Cx. ganapathi
Cx. gracicornis
Cx. hirtialpis
Cx. incomptus
Cx. infantulus
Cx. lucaris
Cx. macdonaldi
Cx. mammilifer
Cx. minor
Cx. minutissimus
Cx. paioji
Cx. peytoni
Cx. pholeter

Culex (Culiciomyia)

Cx. bailyi
Cx. barrinus
Cx. dispectus
Cx. fragilis
Cx. harrisoni
Cx. lampangensis
Cx. nigropunctatus
Cx. pallidothorax
Cx. papuensis
Cx. sasai
Cx. scanloni
Cx. spathifurca
Cx. spiculothorax
Cx. termi
Cx. thumanorum
Cx. viridiventer

Culex (Eumelanomyia)

Cx. brevialpis
Cx. foliatus
Cx. hinglungensis
Cx. kiriensis
Cx. malayi
Cx. oresbius
Cx. otachati
Cx. phangnage
Cx. richei
Cx. tenuialpis

Culex (Lutzia)

Cx. fuscianus
Cx. halifaxii

Ficalbia minima

Mimomyia (Etorleptomyia)

Mi. elegans
Mi. luzonensis

Mimomyia (Ingramia)

Mi. fusca

Mimomyia (Mimomyia)

Mi. aurea
Mi. chamberlaini
Mi. chamberlaini metallica
Mi. hybrida

Cx. pilifemoralis

Cx. quadripalpis
Cx. reidi
Cx. rubithoracis
Cx. spiculosus
Cx. traubi
Cx. tuberis
Cx. variatus
Cx. whartoni

Orthopodomyia

Or. albipes
Or. Andamanensis
Or. anopheloide
Or. siamensis
Or. wilsoni

Topomyia (Suaymyia)

To. apsarae
To. cristata
To. houghtoni
To. suchariti
To. vanbarensis

Topomyia (Topomyia)

To. aenea
To. angkoris
To. inclinata
To. lindsayi
To. svastii

Tripteroides (Rachionotomyia)

Tp. affinis
Tp. aranoides
Tp. tenax

Tripteroides (Tripteroides)

Tp. aeneus
Tp. caeruleocephalus
Tp. denticulatus
Tp. hybridus
Tp. indicus
Tp. powelli
Tp. proximus
Tp. similis
Tp. tarsalis

Hodgesia

Ho. lampangensis
Ho. malayi

Coquillettidia (Coquillettidia)

Cq. crassipes
Cq. nigrosignata
Cq. novochracea
Cq. ochracea

Mansonia (Mansonoides)

Ma. annulata
*Ma. annulifera*⁵
Ma. bonneae
Ma. dives
*Ma. indiana*⁵
*Ma. uniformis*⁵

Malaya

Ml. jacobsoni
Mi. genurostris

Toxorhynchites (Toxorhynchites)

Tx. albipes
Tx. bickleyi
Tx. gravelyi
Tx. leicesteri
Tx. magnificus
Tx. manopi
Tx. splendens
Tx. sunthorni

Uranotaenia (Pseudoficalbia)

Ur. abdita
Ur. albipes
Ur. approximata
Ur. bicolor
Ur. bimaculata
Ur. demeilloni
Ur. enigmatica
Ur. gouldi
Ur. hirsutifemora
Ur. koli
Ur. lutescens
Ur. maxima
Ur. modesta
Ur. nivipleura
Ur. nocticola

Uranotaenia (Pseudoficalbia)

Ur. novobscura

Ur. obscura

Zeugomyia gracelis

Uranotaenia (Uranotaenia)

Ur. annandalei

Ur. bimaculiala

Ur. campestris

Ur. diraphati

Ur. edwardsi

Ur. hebes

Ur. longirostris

Ur. macfarlanei

Ur. metatarsata

Ur. orientalis

Ur. prajimi

Ur. rampae

Ur. sombooni

Ur. testacea

Ur. trilineata

² Incriminated vector of malaria

³ Incriminated vector of dengue

⁴ Incriminated vector of Japanese encephalitis

⁵ Incriminated or suspected vector of filariasis

APPENDIX D. TICKS REPORTED FROM THAILAND

Family Argasidae

Argas (Carios)

A. pusillus

Argas (Pearsicargas)

A. robertsi

Ornithodoros (Alectorobius)

O. capensis

Ornithodoros (Reticulinasus)

O. batuensis

Haemaphysalis (Haemaphysalis)

H. darjeeling

Amblyomma

Am. cordiferum

Am. cyprium cyprium

Am. geoemydae

Am. helvolum

Am. javanense

Am. supinoi

Am. testudinarium

Family Ixodidae

Haemaphysalis

H. traguli

Haemaphysalis (Kaiseriana)

H. anomala

H. bispinosa

H. hystricis

H. lagrangei

H. nadchatrami

H. obesa

H. papuana

H. semermis

H. shimoga

H. wellingtoni

Aponomma

A. gervaisi

A. patoni

A. varanensis varanensis

Boophilus

B. microplus

Dermacentor (Indocentor)

D. atrosignatus

D. auratus

Ixodes (Afrixodes)

I. radfordi

Haemaphysalis (Rhipistoma)

H. asiatica

H. canestrinii

H. heinrichi

H. koningsbergeri

Ixodes (Eschatocephalus)

I. vespertilionis

Haemaphysalis (Ornithophysalis)

H. bandicota

H. doenitzi

H. megalaimae

H. ornithophila

Ixodes (Ixodes)

I. acutitarsus

I. granulatus

I. spinicoxalis

Ixodes (Lepidixodes)

I. kopsteini

Haemaphysalis (Aborphysalis)

H. aborensis

H. atherurus

H. capricornis

Ixodes (Partipalpiger)

I. ovatus

Haemaphysalis (Garnhamphysalis)

H. calvus

APPENDIX E. SIMULIIDS REPORTED FROM THAILAND

Simulium (Eusimulium)

S. aureohirtum
S. sp. A
S. sp. B

Simulium (Himalyum)

S. nigrogilvum

Simulium (Simulium)

S. barnesi
S. chamlongi
S. Chiangmaiense
S. digrammicum
S. nekhonense
S. nitidithorax
S. nodosum
S. rufibases
S. sakishimaense
S. sp. D.
S. sp. E
S. thailandicum

APPENDIX F. CULICOIDES REPORTED FROM THAILAND

Subgenus *Trithecoides*

Culicoides anophelis
Cu. barnetti
Cu. elbeli
Cu. flavescens
Cu. forade
Cu. gewertzi
Cu. macfiei
Cu. palpifer
Cu. paraflavescens
Cu. raripalpis
Cu. tenuipalpis

Subgenus (*Haemophorctus*)

Cu. calcaratus
Cu. hoffmanoides
Cu. nitens

Subgenus (*Hoffmania*)

Cu. andrewsi
Cu. bubalus
Cu. indianus
Cu. innoxias
Cu. liui
Cu. malayae

Subgenus (*Avaritia*)

Cu. actoni
Cu. bigeminus
Cu. boophagus
Cu. brevipalpus
Cu. circumbasalis
Cu. clavipalpus
Cu. corti
Cu. distinctus
Cu. dryadeus
Cu. fulvus
Cu. geminus
Cu. hewetti
Cu. huffi
Cu. imicola
Cu. jacobsoni
Cu. kepongensis
Cu. maculatus
Cu. nigripes
Cu. niphanae
Cu. okinawensis
Cu. orientalis
Cu. oxystoma
Cu. pampangensis
Cu. peliliouensis

Cu. peregrinus
Cu. recurvus
Cu. signipennis
Cu. sumatrae
Cu. tenuifasciatus

Cu. pungens
Cu. shermani
Cu. shorti
Cu. similis
Cu. yasumatsui

Subgenus (Meijerhelea)

Cu. arakawae
Cu. guttifer
Cu. hegneri
Cu. histrico

Subgenus (Beltranmyia)

Cu. circumscriptus
Cu. halonostictus

Monoculicoides
homotomus

Pontoculicoides
kampupi

APPENDIX G. FLEAS REPORTED FROM THAILAND

Ctenocephalides felis

Lagaropsylla nicula

Maerostylophora hastatus

Stivalius

S. akale
S. aparus
S. klossi
S. new species

Thaumopsylla breviceps orientalis

Thrassis bacchi consimilis

Xenopsylla astia

X. cheopis
X. variabilis

APPENDIX H. TROMBICULIDS REPORTED FROM THAILAND

TRIBE: TROMBICULINI

Trombicula

T. calva
T. keechongi
T. megaderma
T. siamensis
T. taphozous

Leptotrombidium

L. akamushi
L. andrei
L. aramataum
L. arvina
L. atractimorphe
L. binbium
L. burmense
L. deliense
L. dendrium
L. elisbergi
L. fulleri
L. gateri
L. globosum
L. hanseni
L. harrisoni
L. hastatum
L. imbricatum
L. keukenschrijveri
L. lepismata
L. macacus
L. macrosphenum
L. magnum
L. manooni
L. mastigophorum
L. micula
L. monstrosum
L. nakatae
L. oreophilum
L. paniculatum
L. panitae
L. peniculatum
L. pilosum
L. rapmundi
L. santasiri
L. scanloni
L. scutellare
L. sibynatum
L. striatum
L. thurmani
L. variaculum

Toritombicula densipiliatum

Eutrombicula wichmanni

Blankaartia acuscutellaris

Heaslipia gateri

Neotrombicula scorpionis

Siseca

S. rara
S. subrara

Myotrombicula vercammeni

Miyatrombicula benesnoni

Microtrombicula

M. chamlongi
M. munda
M. spicea

Chiroptella

C. nocticola
C. revelae
C. sandoshami

TRIBE: SCHOENGASTIINI

Schoengastia

S. kanhaensis
S. vieta

Walchiella

W. asonluca
W. hanseni
W. harinastai
W. lacanosa
W. oudemansi
W. traubi

Aschoschoengastia

A. audyi
A. canus
A. ctenacarus
A. globosa
A. indica
A. kittii
A. leechi
A. lorius
A. roluis
A. tafia

Tecomatlana melvini

Trombigastia harrisoni
t. roussetti

TRIBE: SCHOENGASTIINI

Kayella novita

Helenicula

H. cardigani
H. kohlsi
H. lanius
H. mutabilis
H. scanloni

Neoschoengastia

N. heynemanai
N. longipes
N. struthidia
N. thomasi

Doloisia

D. bachypus
D. browning
D. domrow
D. hooperi
D. intermedia
D. jadini
D. manipurensis

Scoutedenichia centralkwangtunga

Riedlinia lipoxena

Cheladonta

C. gouldi
C. neda
C. prachonage
C. traubi

TRIBE: GAHRLIEPIINI

Gahrlepieia

G. alpestris
G. cetrata
G. chinensis
G. cuspidata
G. dismina
G. disparungius disparungius
G. disparungius pingue
G. elbeli

TRIBE: GAHRLIEPIINI

Gahrlepieia

G. ewingi lupella
G. fenestrulata
G. fletcheri
G. insigne
G. isonychia
G. khuyingi
G. kritochaeta
G. lewthwaitei
G. ligula
G. marshi
G. micropelta
G. mirabilis
G. rutila
G. simulata
G. starki
G. suvajrai
G. tenella
G. tessellata
G. tylana

Odontacarus audyi

Whartonia

W. brevis
W. carobangsis
W. maai
W. prima

Babangia permifera

Herpetocarus leprochaeta

APPENDIX I. SCORPIONS REPORTED FROM THAILAND

Buthidae

Lychas

L. feae?

L. mucronatus

L. sanutillis?

L. shoplandi?

Isometrus

I. maculatus

I. vittatus?

Chaerilus birmanicus?

Scorpiopsidae

Scorpiops oligotrichus

S. atracinus

S. linstroemi?

S. longimanus binghamis?

Ischnuridae

Liocheles

L. australasiae

Scorpionidae

Heterometrus bengatensis

H. laoticus

H. petersii petersii?

H. spinifer spinifer

APPENDIX J. PESTICIDE RESISTANCE

SPECIES	LOCALITY	INSECTICIDE	STAGE	DATE	STATUS
<i>Aedes aegypti</i>	Surat Thani, Koh Samui	DDT	L	1967	R
<i>Ae. aegypti</i>	Lopburi, Koh Samong	DDT	L	1968	R
<i>Ae. aegypti</i>	Nakon Sawan, Tah Tako	DDT	L	1968	R
<i>Ae. aegypti</i>	Chiang Mai, Muang	DDT	L	1968	R
<i>Ae. aegypti</i>	Chiang Rai, Muang	DDT	L	1969	R
<i>Ae. aegypti</i>	Bangkok, Soi Aree	DDT	L	4/67	R
<i>Ae. aegypti</i>	Bangkok, Thonburi	Dieldrin	L	3/67	R
<i>Ae aegypti</i>	Bangkok, Din Daeng	Lindane	L	10/67	R
<i>Anopheles conitus</i>	Phayao, Jadee KumV9	DDT	A	9/81	R
<i>An. aconitus</i>	Chiang Rai, Mae Prik V10	DDT	A	10/81	R
<i>An. aconitus</i>	Phavao, Jadee Kum	DDT	A	8/82	R
<i>Xenopsylla cheopis</i>	Kanchanaburi Muang	Dieldrin	A	2/66	
<i>X. cheopis</i>	Bangkok, Klong Toey	DDT	A	5/69	R
<i>X. cheopis</i>	Surat Thani, Koh Samui	Dieldrin	A	9/69	R

6 Recent test reported by other sources indicate that nearly all major vectors in most areas of Thailand are resistant to DDT and related compounds. An. dirus has been shown to have behavioral resistance, attributed to apparent avoidance of DDT-treated areas. At last check, resistance to malathion, fenitrothion and permethrin was not reported.

APPENDIX K. LEECHES REPORTED FROM THAILAND

Terrestrial and aquatic leeches occur throughout most of Thailand in swamps, ditches, and tropical rain forests. Their effect is both physical and psychological. Large numbers of leeches cause extensive blood loss, and the attachment sites are susceptible to secondary infection. The psychological effect is perhaps more important, since there are numerous exaggerations about leeches invading the nostrils and urethra

The aquatic leeches (family Hirudidae) may reach up to 6 inches in length and include the genera *Hirudo*, *Poecilobella*, *Limnatis*, and *Dinobdella*. When a person enters an infested ditch or swamp, leeches quickly swim toward the source of disturbance, adhere to the skin, and begin exploring the host for a minute or two prior to attaching. Once attached, the leech may engorge in a relatively short time (often less than 15 minutes) and drop off after reaching several times its normal size. However, the attachment site may continue to bleed for hours because of anticoagulant injected in the site. The habits of land leeches of the genus *Haemadipsa* (family Haemadipsidae) are similar except for the host-seeking behavior. Land leeches usually are found in rain forests on the ground or on low vegetation, where high humidity prevents them from desiccating. Brushing against vegetation stimulates their immediate and frenetic host-seeking action. Because of their need for high humidity, land leeches are usually encountered only during rainy season.

Personal protection against leeches is afforded by proper wearing of the uniform and extended formulation DEET repellent, which is particularly effective against land leeches. However, land leeches can penetrate relatively small openings, including boot eyelets. DEET has not been effective against aquatic leeches, probably because it is quickly removed by water. Leeches should not be pulled off (their mouthparts are likely to remain attached); instead, they should be forced to disengage by dropping iodine, vinegar, or salt on them, or by touching them with a hot object. Treatment for wounds involves the use of a styptic pencil to stop bleeding, followed by application of an antibiotic solution.

APPENDIX L. VENOMOUS SNAKES OF THAILAND

Colubridae – This family contains rear fanged snakes whose bites produce only local swelling and pain. Species present in Thailand are:

Rhabophis chrysargus
R. subminiatus
R. tigrinus

Elapidae – The cobras, kraits and coral snakes are all considered dangerous. Venoms are primarily powerful neurotoxin.

Bungarus spp. – Kraits are slender, cylindrical snakes four to seven feet in length with small flattened heads. They are smooth scaled and glossy. Most of them have a vivid pattern of cross bands. Kraits are strongly nocturnal but become very quiet and sluggish during the day. They are responsible for few snake bites, but the fatality rate is high. The banded krait (*B. fasciatus*) is found throughout Thailand. It is quiet, inoffensive snake curls up and hides its head beneath its coils when annoyed. The Malayan krait (*B. candidus*) and red-headed krait (*B. flaviceps*) occur only in southern Thailand. The red-headed krait has very distinctive coloring. The head and tail are bright red; the body is black with narrow stripes low on the side and a narrow stripe or rows or dots down the middle of the back. It inhabits jungles, usually in or mountainous country.

Calliophis spp. – Oriental coral snakes. These small (usually less than three feet long), brightly colored snakes with patterns consisting of complete rings of yellow (or white), black and usually red. The color pattern shows marked individual and species variation. They are snakes of forested jungle habitats, ranging well into the mountains. They occasionally occur in suburban areas. Oriental coral snakes are considered uncommon, but this may reflect their shy and secretive nocturnal nature. They are quite, unaggressive, and reluctant to bite, but their venom is deadly. All species should be considered potentially dangerous. *C. maculiceps* occurs throughout Thailand, while *C. gracilis* and *C. maclelandii* are found in the south and north, respectively. Maticora coral snakes differ from *Calliophis* spp. in having venom glands that extend throughout the anterior one-third of their

body. They are generally dark brown to blue-black with narrow light stripes. Two species of long-glanded coral snakes, *M. bivigata* and *M. intestinalis*, occur throughout southern Thailand. They are nocturnal and secretive, but their venom is potentially lethal.

Naja spp. (cobras) – Except for the very distinctive king cobra, all central and South Asian populations are considered subspecies of *Naja naja*. There are significant differences in morphology, coloration, behavior and venom composition between subspecies. The Asian cobras are found in most types of terrain, except dense rain forest. Flat grassy areas and scattered tree groves are preferred habitat, but they also occur in rice fields and other agricultural land. Since they prey on rats, they occur commonly in villages and cities, often in crumbling walls, old buildings and gardens. Cobras avoid human contact; if cornered, they rear up and spread their hoods. They are most dangerous when surprised at close range. Large cobras may have over 500 mg of venom (a lethal dose is estimated at 20 mg), but generally inject very little venom when biting defensively. Some populations produce venom with strong narcotizing but weak systemic effects. The monocellate cobra (*Naja naja kaouthia*) occurs throughout Thailand and attains a length of eight feet. The king cobra (*Ophiophagus hannah*) may reach 18 feet or more in length and is one of the world's most dangerous snakes. It is found throughout Thailand in open, hilly terrain, especially cultivated areas. King cobras are active during the day and night and may frequent trees or water. This species has the unique habit of constructing an elaborate nest of dead leaves and other decaying vegetation. Fortunately, it is scarce throughout its range and bites humans infrequently.

Viperidae – Snakes with triangular heads and vertically elliptical pupils.

Russell's viper (*Vipera russelli*) – Identified by its distinctive pattern of large, black-ringed ovals on an olive or gray background. This viper averages 40-50 inches but may attain a length of over 5 feet. It occurs primarily in rural northern Thailand near hilly forests. This species is mainly nocturnal but may be active during cool days. It moves slowly but will strike rapidly and aggressively when disturbed. Russell's viper is a leading cause of snake bite, but more fatalities result from kraits and cobras.

Crotalidae – Moccasins and Asian pit vipers. The Malayan pit viper (*Agkistrodon rhodostoma*) averages 2.5 feet in length and likes a climate with well-marked wet and dry seasons. It inhabits forested and cultivated areas at low elevations and is common on rubber plantations. It is a bad-tempered snake that is quick to bite despite its sedentary habits. It is responsible for many snakebites throughout Southeast Asia but produces few fatalities (less than 2% of people bitten).

Trimeresurus spp. – This large genus comprises the Asian lance-headed vipers. All have large, triangular heads, loreal pits and vertically elliptical pupils. Bites from these snakes are frequent, although the fatality rate is low. Species present in Thailand are:

T. albolabris
T. kranburiensis
T. monticola meridionalis
T. poperoum
T. puniceus

Hydrophidae – This family contains the sea snakes, some species may also be found in estuaries. Although not normally aggressive, these snakes are numerous in tropical waters. Most victims are fishermen. Aside from their highly toxic venom, these snakes are dangerous because the bite is often painless, more like a pin prick or sting. Over a dozen species occur in the coastal areas of the Gulf of Thailand and Bay of Bengal. Sea snakes are laterally flattened, having oarlike tails. Most have nostrils opening on the top of the head.

SNAKEBITE

Laboratory experiments show that snake venoms contain a complex mixture of toxic factors, but the primary clinical signs of snakebite poisoning in humans are usually distinctive; viper venom is mainly vasculotoxic, elapid venom neurotoxic, and sea snake venom myotoxic. Venomous snakes have two types of bite: 1) a bite inflicted when the snake is seeking prey, in which a victim dies rapidly following injection of a large quantity of venom,

and 2) a defensive bite, with little or no venom injected, the snake's object being to escape. Studies of snakebite patients in various parts of the tropics confirm that when venomous snakes bite humans, the bites are nearly always of the second type. More than half the victims have minimal or no poisoning. Only about a quarter experience serious systemic reactions.

The commonest reaction following snakebite, whether or not the snake is poisonous, is fright. Fear, to some degree, is present in all snakebite victims and often dominates the clinical picture. Emotional symptoms emerge rapidly, within minutes of the injury while symptoms of systemic poisoning rarely appear until a half hour or after the bite. The frightened patient may appear semiconscious, with cold, clammy skin, feeble pulse, and rapid, shallow breathing. These symptoms resolve quickly after a placebo injection.

Snakebites are grossly underreported in Thailand, but official statistics recorded 2673 cases in 1984 with 7 deaths.

FIRST AID

1. Get the victim away from the snake. Keep victim calm and quiet. Do not handle the snake or put yourself at risk of being bitten. Identify the snake if possible. If it has been killed, keep it.
2. Immobilize the site of the bite. If possible, keep the site of the bite below the level of the heart.
3. Do not give the victim anything to eat or drink.
4. If the bite is on one of the upper limbs, remove any rings or jewelry from that side.
5. Arrange immediate evacuation. If there is no evidence of venom, keep the victim quiet and under observation.
6. If there is evidence of venom (swelling, spreading pain, bruising, symptoms remote from the bite area), and LESS than 30 Minutes have passed since the bite, place a band about 4 inches above the bite. Tighten it just to the point that you can only get one finger beneath it. Do not remove the band but, if swelling develops, be prepared to adjust it so that it get no tighter.
7. An ice pack can be used immediately to reduce pain. DO NOT pack a limb in ice or immerse it in ice water.

For information on snakebite, including sources of antivenins worldwide, contact the Arizona Poison and Drug Information Center, phone number (602) 626-6016. The local source of information and antivenin is the Red Cross Society, Queen Saovabha Memorial Institute, Rama 4 Road, Bangkok, Thailand.

APPENDIX M. POISONOUS AND VENOMOUS PLANTS

Euphorbiaceae

Aleurites fordii - The tung oil tree, used in furniture finishes, produces seed which can cause a moderate gastroenteritis.

Euphorbia spp - A number of species of spurge in the region produce sap which causes gastroenteritis if ingested or is blinding if it contacts the eyes.

Manihot esculentus - The cassava, a much-cultivated plant in the region, contains amygdalin and hydrocyanic acid in its sap which act together as skin vesicant.

Excoecaria agallocha - This mangrove type of tree (the milky mangrove) produces a poisonous sap that can cause blistering and temporary blindness, depending on where the sap is contacted.

Excoecaria oppositifolia - Has poisonous sap with effects similar to previous species.

Ricinus communis - The castor bean contains ricin, an irritant that can cause severe urticaria and conjunctivitis on contact or vomiting and apoplexy if ingested.

Urticaceae

Laportea bulbifera - The tree nettle possesses siliceous hairs which break off upon contact, leaving behind a skin irritant and vesicant which can persist for weeks.

Laportea interrupta - Has a skin irritant and vesicant similar to the previous species.

Palmae

Arenga pinnata - The sugar plum contains stinging crystals in its fruits which cause severe swelling of the throat and mouth if ingested.

Calamus spp. - Rattan, most known for its utility in furniture-making, growing thickly in wet jungle areas and has thorns that may break off in the skin and cause severe dermatitis and swelling at the contact for several days.

Caryota mitis - The tufted fishtail palm contains crystals in the fruit, pulp and juice that are very irritating to skin.

Araceae

Alocasia spp - The elephant's ear plant, often seen as a house plant, grows naturally in marshes and swamps. The high content of calcium oxalate crystals make contact with it extremely irritating to the skin.

Leguminosae

Erythrina variegata orientalis - The gao-gao (coral bean) is a bean-like bushy plant which produces poisonous substances in all its parts. The bark and leaves may produce diarrhea and act as a central nervous system depressant, while the pods produce hallucinogenic effects.

Mucuna pruriens - The pods of this plant contain thousands of brittle, barbed hairs which detach easily upon contact, causing intense itching.

Derris elliptica - This shrub species can be used to prepare an insecticide. Its clinical features indicate that is a skin irritant. Contact also causes increased salivation, numbness of the tongue, and loss of speech.

Derris malaccensis Features similar to previous species.

Gramineae

Bambusa - The bamboo plant possesses red hairs on its young shoots which can cause mechanical injury to the gastrointestinal tract.

Solanaceae

Solanum nigrum - The nightshade has leaves and berries which contain the potent, and sometimes fatal, poison solanine.

Capsicum spp. - Hot pepper plant leaves can cause severe, rather short-lived, inflammation of the eyes if contacted either directly or with contaminated hands.

Meliaceae

Anamirta cocculus - This plant produces a fruit used as fish poison. It also causes an eruption on the body and arms if applied to the scalp.

Moraceae

Antiaris toxicariae - This mulberry tree, used to feed silkworms, contains a cardioactive glycoside in its sap, but must be injected to take effect.

Apocynaceae

Nerium oleander - This dogbane species is poisonous in all its parts, including leaves, wood, and sap.

Cerbera manghas - The latex of this plant causes blindness if it gets into the eyes.

Anacardiaceae

Melanorrhoea usitata - The wood, leaves, and fruit of the Rengas tree are toxic, giving rise to intractable skin eruptions on contact. The wood causes irritation of the mouth, nose, and throat in people in closed rooms, even if it is the form of old furniture.

Asclepiadaceae

Calotropis gigantea - This giant milkweed has bark. Its stems contain a proteolytic latex which is irritating and caustic to the skin and eyes.

Loganiaceae

Buddleia asiatica - This plant is the well-known source of strychnine, a deadly poison if consumed.

Styraceae

Strychnos nux-vomica - This plant also contains the poison strychnine in its seed coats.

APPENDIX N. PERSONAL PROTECTIVE MEASURES

Personal protective measures are the first line of defense against arthropod-borne disease and may be the only protection for military personnel deployed in the field. Proper wearing of the uniform and appropriate use of repellents can provide high levels of protection against blood-sucking arthropods. The uniform fabric provides a significant mechanical barrier to mosquitoes, ticks and other blood-sucking insects. The uniform should be worn cover as much skin as possible, as weather and physical activity permit.

Protection provided by the properly worn uniform can be greatly increased by the use of two newly developed repellents. An aerosol formulation of permethrin (NSN 6840-01-278-1336) can be applied to the uniform but not the skin according to label directions. This will provide both repellent and insecticidal properties to the uniform material, and will remain effective through several washings. A new extended lotion formulation of diethyl-m-toluamide (DEET) (NSN 6840-01-284-3982) has been developed to replace the 2/oz. bottles of 70% DEET in alcohol. The new formulation contains less active ingredient and does not have to be applied as often as the old formulation. It is less irritating to the skin, has less odor and is generally more acceptable to the user. Combined use of extended duration DEET lotion on exposed skin and permethrin on uniform items has been demonstrated in laboratory and field studies to provide nearly 100% protection against a variety of blood-sucking arthropods. In addition permethrin may be applied to bednets, tentage and other field items as needed. Recent field studies in several countries have shown that bed nets treated with pyrethroids are highly effective against mosquitoes and a variety of other blood-sucking arthropods.

When operating in tick infested areas, the pants should be bloused into the boots to prevent access to the skin by ticks and other crawling arthropods, such as chiggers. Check yourself frequently when walking through tick-infested areas, remove all clothing and examine yourself for ticks. Infected ticks usually require several hours of feeding before pathogens are transmitted. Therefore, attached ticks should be removed as soon as possible. If ticks become attached, the simplest and best method of removal is by a slow, steady pull with a pair of tweezers or forceps. Do not squeeze the body, but grasp the tick where the mouthparts enter the skin and pull firmly until the tick is extracted. Be careful not to break off the mouthparts and leave them in the skin. Wipe the bite area with an antiseptic. If you have touched the tick during removal, wash them thoroughly with soap and water or an antiseptic, since tick secretions may contain pathogens.

The U. S. Army Environmental Hygiene Agency's Illustrated Technical guide #174, entitled **Personal Protective Techniques Against Insects and Other Arthropods of Military Significance**, is an invaluable reference available from:

U. S. Army Environmental Hygiene Agency
Entomological Science Division
Aberdeen Proving Ground, MD 21010-5422
DSN 584-3613 Commercial (301) 671-3613.

APPENDIX O. CHEMICAL CONTROL OF PESTS AND VECTORS

More detailed recommendations for the selection, application and use of pesticides in field situations worldwide, during contingency operations or military exercises can be found in the Contingency Pest Management Pocket Guide. This guide is a concise reference on: National Stock Number (NSN)-listed pesticides available through military supply channels and designated for contingency use by one or more of the Armed Services; their uses, dosages, and application methods; pesticide dispersal equipment; information on surveillance, trapping, and safety equipment; personal protective equipment against disease vectors; air-transport of pesticide that do not meet transportation requirements; pesticide dilution and dosage formulation; and U. S. Army military points of contact overseas who can provide information on vector-borne disease control in their respective areas of the world.

Copies of the **Contingency Pest Management Pocket Guide** (also known as Technical Information Memorandum #24) can be obtained free of charge from DPMIAC.

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